TRANSACTIONS

OF THE

ROYAL SOCIETY OF VICTORIA.

VOL. II. PART I.

1890.

CONTENTS.

EDITED BY PROFESSOR W. BALDWIN SPENCER, M.A., HON. SEC.

MELBOURNE.

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ARTICLE I.—The Transverse Sections of Petioles of Eucalypts as aids in the Determination of Species, by D. McAlpine, F.C.S., and J. R. Remfry. (With Plates 1, 2, 3, 4, 5, and 6.)

(Read Thursday, November 14th, 1889.)

I.—Introductory.

The Eucalypts form such a prominent feature in the Australian vegetation, and have such varied uses, that any addition to our knowledge of their characters is sure to be welcomed.

The primary object of the present paper is to show how transverse sections of the petioles of Eucalypts may be used as valuable aids in the determination of species. Sections of thirty different kinds are here described and photographed, and they show unmistakably, along with a general resemblance, differences which are more or less constant, and readily recognisable for each species.

Anatomical characters of the leaf have already been successfully used in the discrimination of species belonging to other divisions of the vegetable kingdom.* Of course such characters, depending on a single organ, and apart from the aggregate of characters, are apt to be more or less artificial; but, when we consider that the parts shown in transverse section of the petiole are in organic connection with, and form an essential portion of, the vital machinery of the plant, it need not excite surprise that they should vary in the different species, and be, to a certain extent, characteristic for each.

We know that the leaf is simply a lateral expansion or extension of the stem or branch, usually bearing a bud in its axil, and its tissues are, as a rule, continuous with those of the stem, so that in it we have an epitome of the parts concerned in vegetative life—a point deserving of special notice in this connection. Besides, the petiole, with which we are more particularly concerned, is capable of reproducing the entire plant from a small portion of it, as in the well-known instance of the ipecacuanha plant. The vegetative organs which, in some form or another, are absolutely necessary for the life of the individual, have been too little used in the discrimination of genera and species, while the reproductive organs have been too often almost exclusively relied upon. The anatomist (dealing with internal structure) and the systematist (often entirely occupied with external characters) must combine their results in order to arrive at a proper conception of the true system of nature.

* See De Bary, Comp. Anat. of Phanerogams and Ferns, p. 298.

Perhaps one result of this investigation will be to direct attention to the distinctive nature of the tissues of the leaf in other groups of plants as well as the Eucalypts. This has already been done, for instance, in the Gnetaceae and Coniferae by Dr. C. E. Bertrand* and Prof. M'Nab.† The latter confined his attention to the Coniferae, and, in addition to the general anatomic structure of the transverse section of the leaf, noted the distribution and number of the resin-canals, and the arrangement of stomata on the surface, as aids in his diagnosis.

While we have likewise described and drawn the transverse section as a whole, and found the total characteristics of the section of any species to be of great value for identification, there are certain features very useful for that purpose, even when taken alone. Thus, the cortical cavities, whether many or few, large or small; the size and shape of the section; the relative thickness of the epidermis, &c.; but it is the woody-tissue forming characteristic figures which is the most striking part. This *wood-pattern* is fairly constant for each, so that the most enduring part of the entire section fortunately gives a clue to the affinity sought for.

It would appear that even from an economic standpoint some reliable means are much needed for determining a given species of Eucalypt, from a readily accessible portion of the plant, such as the leaf. It is highly desirable, in the interests of trade, not to speak of science, that one species should not be confounded with another, for the timber has such specific variations that serious loss and mischief might in many cases ensue.

Mr. Maiden, of the Technological Museum, Sydney, in his recently published work on the "Useful Plants of Australia," writes on this subject, at p. 427, in very decided terms:—"Scarcely a branch of Australian economic botany is in a more confused state than that which pertains to the timber of the Eucalypts. The genus is, perhaps, the most difficult one in the world, intrinsically, and also because of accidental circumstances, *i.e.*, difficulty of obtaining flowers and fruit, and irregular flowering seasons; moreover, the trees vary, according to climate and soil, to such an extent as to render a definition of the species rather expansive, and, as this difficulty often extends to the wood, timbers of totally different character are sometimes reckoned under the same species."

Such a state of matters calls for some remedy, and it is evident that the present investigation tends in that direction. The leaves being evergreen are a constant, and not an accidental circumstance. The deep-seated characters revealed by the section are not so variable as others more dependent on soil and climate; and a definition which is included in, and shown by, the transverse section of a petiole, can hardly be called expansive.

* Anatomie Comparée des Tiges et des Feuilles chez les Gnetacees et les Coniferes. Paris, 1874.

† Proc. Roy. Irish Acad., Series II., Vol. II., 1875-77. Remarks on the Structure of the Leaves of certain Coniferae, and a Revision of the Species of Abies.

In the masterly monograph on the Eucalypts of Australia and adjoining islands, the "Eucalyptographia," by Baron von Mueller, there are numerous references to the anatomic structure, both of the wood and the leaf-blade, although none of them are concerned with the petiole. In one instance (Decade 7) he has given transverse sections of Eucalyptus wood, accompanied by the remark:—"These microscopic sections are given to aid in the discrimination of mercantile Eucalyptus timber of doubtful origin, such as sometimes occurs in the trade." Here we have a distinct recognition of the idea, and a practical expression of it, that the minute structure of the wood may be useful in determining species, and be serviceable from the timber merchant's point of view. Similarly in the wood-pattern of the leaf-stalk, there are serviceable characters for the same purpose.

It may be noted here that the existence of such a work as the "Eucalyptographia" invests the present investigation with a special importance. There the different species of Eucalypts are fully described and carefully drawn, and we have the advantage of working out a genus from which we can select numerous well-defined species.

The species selected on the present occasion are such as were conveniently obtainable from the Melbourne Botanic Gardens. Our best thanks are due to Mr. Guilfoyle, F.L.S., Director of the Gardens, for kindly supplying us with fresh specimens when required. Thirteen of these are Victorian, and as there are 38 altogether, according to the "Key to the System of Victorian Plants," we hope to deal with the remainder in a future paper.

We are also much indebted to J. Bosisto, Esq., C.M.G., for supplying us with the leaves of some of the oil-yielding species from their native habitats, and for information contained in various papers read at different times before learned societies.

Above all, we have to thank Baron von Mueller for verifying each of the species used in this investigation, and thereby enhancing the value of the work—the determination coming from such an undoubted authority on this special group of plants.

The type sections were prepared and the photographs taken by Mr. Remfry.

Since the work has been in hand for over four years (the first sections having been cut about September, 1885), it has been possible to show the structure of the leaf-stalk at different seasons, and even in different years; and, as over a thousand sections have been made, a fair idea of the incidental variation is likewise given.

LIST OF FORMS INVESTIGATED, ALPHABETICALLY ARRANGED.

	Botanical Name.	Common Name.
1.	E. alpina, Lindley	V. Alpine Gum
2.	,, amygdalina, Labillardière	V. {Giant Eucalypt / Peppermint Gum Tree
3.	,, calophylla, R. Brown	Calophyllum-like Eucalypt
4.	,, citriodora, Hooker	Lemon-scented Eucalypt
5.	,, cornuta, Labillardière	"Yate"
6.	,, corynocalyx, F. v. M.	V. Sugary Eucalypt
7.	,, diversicolor, F. v. M.	"Karri"
8.	,, ficifolia, F. v. M.	Scarlet-flowered Eucalypt
9.	,, globulus, Labillardière	V. Blue Gum Tree
10.	,, gomphocephala, Candolle	"Touart"
11.	,, pachypoda, F. v. M.	Thick-stalked Eucalypt
12.	,, gunnii, J. Hooker	V. Cider Eucalypt
13.	,, lehmanni, Preiss	Lehmann's Eucalypt
14.	,, leucoxylon, F. v. M.	V. Victorian Ironbark Tree
15.	,, macrorrhyncha, F. v. M.	V. Victorian Stringybark Tree
16.	,, maculata, Hooker	Spotted Eucalypt
17.	,, marginata, Smith	"Jarrah"
18.	,, megacarpa, F. v. M.	West Australian Blue Gum Tree
19.	,, melliodora, Cunningham	V. Yellow Box Eucalypt
20.	,, obcordata, Turczaninow	"Maalok"
21.	,, obliqua, l'Heritier	V. Messmate Stringybark Tree
22.	,, occidentalis, Endlicher	Flat-topped Yate
23.	,, punctata, Candolle	Leather Jacket
24.	,, rostrata, Schlechtendal	V. Red Gum Tree
25.	,, rudis, Endlicher	Swamp Gum Tree of Western Australia
26.	,, saligna, Smith	Grey Gum
27.	,, stuartiana, F. v. M.	V. Apple-scented Eucalypt
28.	,, tereticornis, Smith	V. Flooded Gum Tree
29.	,, tetraptera, Turczaninow	Four-wing-fruited Eucalypt
30.	,, viminalis, Labillardière	V. Manna Eucalypt

Thirteen Victorian species (V), out of a total of thirty-eight, recorded in "Key to the System of Victorian Plants," by Baron Ferd. von Mueller.

II.—Mode of Preparation and Mounting of Sections.

From the fresh branches not less than five of the most vigorous-looking leaves were selected. They were taken from different parts of the branch, but never from the growing points. The petioles, with a portion of the lamina attached to each to show the direction of growth, were placed in methylated spirit, and after a few days were usually found in good condition for cutting. If still too hard they were boiled in water for a short time.

The sections were taken from the basal half of the leaf-stalk—from a point nearer to its base than its junction with the blade. Those intended to be sketched by the camera lucida were cut by hand, the thinnest being selected from a large number taken from each petiole, and examined in a mixture of equal parts of glycerine and spirit.

The sections for the permanent type-slides were cut with a microtome, after embedding in paraffin in the usual way. To clear the sections for these mounts, a mixture of glycerine and caustic soda solution was generally used. Warming in nitric acid was in some instances attended with brilliant results, while in other cases the sections were ruptured and distorted by its action.

Most of the sections were photographed without any preparatory staining. Indeed, in some instances, especially in the case of petioles kept for many months in ordinary tank rain water (and some kept for over three years were not in the least decomposed or affected by fungus growths), the colour acquired by the specimens—a rich yellowish-brown tint—was itself a stain not to be surpassed for the purposes of actinic contrast. When this tint was not acquired, and in the case of fresh material, the sections were, if necessary, bleached by the action of free chlorine, and then faintly stained with the stain first proposed by Dr. Frances Hoggan.* It is prepared by adding pyrogallic acid to tincture of steel. This was found more easy of application than the iron stain, composed of pyrogallic acid and protosulphate of iron, recently recommended in the Journal of the Royal Microscopical Society,† which, however, gave equally good results to the eye and on the photographic plate.

The Hoggan iron stain was originally recommended as especially suitable for the treatment of cartilage, in which the desired depth of colour could be produced in a few minutes.

We found that the time required for the proper treatment of the sections of petioles varied from five minutes to half an hour, the stain here taking a longer time to penetrate.

The source of illumination was a clock-work petroleum lamp with a one-inch wick, and the light was all that could be desired, but a blue glass modifier was used in every case, whether the object was stained or not.

Of the mounting media tried, glycerine jelly was found the most suitable. Balsam was used in a few cases, but it was invariably found to render the epidermal layers too transparent, and consequently somewhat indistinct. It may be mentioned that it was found to be essential for purposes of comparison and identification that the sections should be quite thin, showing little more than one layer of cells in the cortical ground tissue.

* Marsh, "Microscopical Section-cutting," 2nd Ed., p. 131.
† Journ. Roy. Micro. Soc., 1888, p. 157.

III.—Classification of Tissues.

Before describing the sections, it will be well to settle the system of classification to be adopted for the tissues.

Various methods have been proposed, and more or less generally used. Of these we will briefly glance at four of the most important, and indicate the one most convenient for our present purpose.

One system which has been very widely used is the *topographical* of Sachs. In this the tissues are mapped out according to their relative positions—the *dermal* tissue, the ground or *fundamental* tissue inside, and the fibro-vascular bundles or *fascicular* tissue studding the ground tissue. This threefold division is certainly very simple and easily applied, but it is not scientific, for geographical position does not always reveal the essential character of a tissue.

A second system is the *developmental* of Hanstein, and, at first sight, it seems to be thoroughly scientific, being based upon development. In this classification certain meristem layers form certain tissues, and these get special names. There is a threefold arrangement of the primary layers, as in animals, viz., *dermatogen*, forming the epidermis; *periblem*, forming the cortex; and a central cylinder of *plerome*, forming vascular bundles and pith. But the objection to this system is that it does not always hold good, for, as instances, in perforations of the leaf in many aroids, and in splitting of the leaf into segments in palms, the original epidermis is replaced by another, derived from the underlying tissue.

The *morphological* system of De Bary is purely descriptive, and, therefore, the safest to adopt in the present state of our knowledge. We know so little of function as yet that we can do little more than place together parts agreeing in structure, although they may have little else in common, or no physiological relationship. Parenchyma is thus one kind of tissue, sclerenchyma another, and so on, and this is the classification most convenient for present use.

But convenience is only a make-shift, and sooner or later *function* and structure together will determine the true position of any system of tissues. This brings us to the last system to be mentioned, viz., the *functional* of Schwendener and Haberlandt, in which a certain structure is associated with a certain function or functions. The function is here brought to the front, and such terms as bast, cambium, &c., are used to denote tissues performing special functions, and not as is usually the case, tissues having special positions. Certain tissues may have a certain position by virtue of their function and consequent structure, but that is an accidental, and not an essential circumstance. Relative position and structure are not considered apart, but as dependent on function. As already stated, function is as yet so little understood that the determination of it is often but a guess at the truth, but this guess can either be verified or proved erroneous, and so advance in this direction will be made. This mode of classification will be the final outcome of all our studies, and to show its superiority we cannot do better than take the fibro-vascular bundle as an example.

The F. V. B.,* according to the ordinary view, and as the name bundle indicates, is a unity, and treated as such. It is composed of a variety of cells, usually having a definite relation to each other, and either hard and fibrous, or soft and parenchymatous or vascular.

On the functional view, the F. V. B. is not a unity, but composed of at least two main elements—a part for mechanical support, or *skeleton*, and another part for *circulation*. The skeleton and the circulating tissues are often associated, just as the blood vessels have a certain relation to the skeleton in the animal body—the hard and firm to protect and support the soft and yielding parts.

In describing the sections generally we will adopt a combination of the two latter modes of classification, giving the separate parts, along with their respective functions. Perhaps this might be called, for distinction's sake, the *biomorphic* system, as both structure and function are taken into account, and it is undoubtedly the most scientific of all, for the structure did not precede and the use follow, but most probably the necessity for the use arose and the structure was forthcoming. Since life is the cause and not the consequence of organisation, and as life may be regarded as the sum total of the functions, and organisation as the sum total of the structure of the plant or animal body, therefore structure is dependent on—is a manifestation of—function.

The biomorphic classification of the tissues is based upon the structure, taken in conjunction with the function, the mechanism in connection with its use, and it is added mainly to show the importance of certain structures for purposes of classification. When it is remembered that in a transverse section of even a petiole, we have structures which serve for protection and support, for the manufacture and the transport of food materials, and in fact, for nearly all the vegetative functions of the plant, as distinguished from the reproductive, then such structures become invested with a higher meaning, and with a corresponding classificatory value.

Adopting a convenient arrangement of parts, which can be seen at a glance in any of the sections, and which will afterwards be further subdivided, they will be as follows from the outside inwards :—

1. Epidermis or protective tissue.
2. Cortex, or principally starch-manufacturing tissue.

Fibro-vascular bundle {
3. Hard bast, or supporting tissue.
4. Soft bast, or albuminoid-forming tissue.
5. Wood tissue, or circulatory and supporting tissue.

* F. V. B. is used instead of repeating in full the expression, Fibro Vascular Bundle.

With the much-debated question, whether the hard bast really belongs to the vascular bundle or not, we have at present nothing to do. These bundles of bast fibres always accompany the vascular tissue in these transverse sections, and while they are often absent in other cases, and may be unessential, yet as a matter of convenience, and without entering upon the general question, we will use the current expression of fibro-vascular bundle to include the hard bast and the soft bast, as well as the woody tissue.

IV.—Sections Described Generally.

E. globulus taken as a type.

As each section is photographed and accompanied by its appropriate description, it will only be necessary here to notice the general character of the sections. For this purpose we will take *Eucalyptus globulus* as a type, and compare the others with it.

When an ordinary hand-cut transverse section is mounted direct in Schulze's solution, the differentiation of the tissues is clearly shown. Taking a general view of the section before entering into details, it is seen to be of an oval shape, one and a half lines broad, by one line thick, or one and a half times broader than thick. The epidermis appears as an orange-yellow, or it may be pale crimson border, edged by a continuous pale yellow line, this latter indicating the presence of a cuticle. Beneath the epidermis is the purple-coloured cortex, composed of cells with walls varying in thickness, and as the colour indicates, of cellulose. Next comes the hard bast, with its orange-yellow lignified cell walls, succeeded by the purple-coloured soft bast; then the clearly-marked bright yellow cells and vessels of the wood, traversed by narrow radiating lines, composed of elongated cells of a darker colour. These are the parenchymatous cells of the wood resembling medullary rays. Next there is a continuation of the soft bast on the other side of the wood, succeeded by the hard bast, and then the other tissues as above. In short, if we start from the curve of the wood, which is more or less central, forming a woody core, there is a succession of envelopes more or less thick. The soft bast surrounds the wood, and is wedged in between it and the hard bast, which is surrounded in turn by the cortex, and the epidermis envelopes all.

Each of the above parts will now be specially dealt with in succession.

1. *Epidermis* or Protective Tissue.—The cells of the epidermis are well-defined, and distinct from the underlying tissue. It consists of a single layer of cells, measuring in thickness 1-570in., and the breadth of each cell on an average is about 1-800in. (Fig. 1, *a*.)

The outer wall is moderately thickened to prevent excess of evaporation, and generally to provide against injury. In the ordinary unstained cell there may be distinguished outside of the round or oval cell cavity a distinct clear band externally, and a somewhat turbid-looking portion abutting on the cell cavity. As the outer band is coloured a pale yellow by Schulze's solution, it represents a cuticle, which is continued right round the section, forming a slight convexity on the outside of each cell. It is on an average from 1-3200in. to 1-2400in. in thickness, and shows no sign of striation.

The turbid-looking portion of the wall is coloured a deeper yellow by Schulze's solution, and may even pass into orange-yellow or pale crimson, according to the amount of colouring matter present. Hence it may be concluded that beneath the fine sheet of cuticle, which is of the nature of cork, there is a cuticularised layer, a sort of transition between cellulose on the one hand and cuticle on the other. The use of the cuticle and cuticularised layer is evident, principally for the purpose of preventing evaporation. It is very thick on desert plants. Plants in rainless regions, and Australian plants generally, are well provided with it. The sections of the Mallee scrub species, to be afterwards referred to, will show this clearly.

The lateral walls unite the cells together, and are relatively thin. They terminate outwardly at the cuticle, and leave no gaps between. No contrivances for admitting air were found, although carefully looked for. The inner wall is likewise thin, and may be composed of cellulose, being coloured purple by Schulze's solution, thus allowing nutritive substances to pass in and nourish the living cell. Or it may be, like the outer wall, coloured yellow, and thus cut off from nutritive supplies, so that no further growth or expansion can take place. In the one case the epidermal cell is living, and capable of further growth, in the other it has reached maturity, and become surrounded by a corky wall.

From the relative thickness and breadth of each epidermal cell, it may be inferred that it has the form of a prism perpendicular to the surface, and the cuticle covering produced by each, forms a continuous layer all round the outside.

2. *Cortical Tissue*, or starch-manufacturing tissue principally.—Immediately beneath the epidermis there is a single layer of cells, which may or may not have their outer and lateral walls cuticularised, and which form a more or less distinct outer border to the cortex proper. This may be called the *Hypodermal layer* (Fig. 2).

The remaining cells are of irregular outline, with walls of various degrees of thickness. The cortical parenchyma contains chlorophyll, and it is here the manufacture of starch is carried on, as evidenced by the contents of the cells containing numerous starch granules. When the section is treated with iodine this portion becomes visibly violet, showing the presence of starch in abundance.

As the hard bast is approached the walls usually thicken considerably, and the cell cavity is correspondingly diminished (Fig. 2*a*). The purple colouration by Schulze's solution shows, however, that the cell walls are of cellulose. Here we are specially concerned with that form of thick-walled parenchyma, known as *Collenchyma*, or collenchymatous parenchyma.

Sometimes the walls are thickened at the angles, or often completely round. While the epidermis is a protective tissue, this is a supporting one, serving to strengthen the comparatively slender petiole. It is common in parts of plants, such as the leaf-stalks, where provision has to be made for increase of length as well as for strength, and so the cells must be living, and have thin places to admit the necessary nutriment—they are living mechanical cells. In the old and fully-formed leaf, the thickening may extend all round (as seen in Fig. 4). If the living protoplasm were then to disappear, and the walls become thickened and lignified, this tissue would pass into that of the hard bast.

The cortical tissue is excavated by large and numerous *cavities*, and *crystals* are very frequent, both of which will now be specially noticed (Figs. 2 and 3).

These cavities may be named according to their position, rather than that of their contents (which has yet to be accurately determined), and so we may speak of them as *cortical cavities*. In contrast to these cavities, which are not continuous lengthwise, and so vary in their number and arrangement at different parts of the petiole, there are in some species canals which are constant and continuous, and from their position inside the wood curve, they may be termed *central canals*.

The contents of these cavities or canals cannot be called resins, for they are soluble, sometimes very readily in water ; nor can they be called oleo-resins, for the petioles yield no oil on distillation. They may be spoken of as kinoid, until their chemical nature is more accurately determined.

The kinos of the Eucalypts have been, and are being, investigated by Maiden,* and he finds that they are divisible into groups according to their behaviour with water and spirit. These groups will be referred to in connection with classification.

Cortical Cavities.—These cavities, usually roundish or oval in shape, occur at irregular intervals, and at some little distance from the epidermis (Fig. 2). They vary in size and in number. The largest is about 1-80in. in diameter. They are distinctly visible to the naked eye when held up to the light. The number is usually from 7 to 8.

* Proc. Linn. Soc., N.S.W. Vol. IV., Series 2.

The contents are usually of a yellowish, but in some instances of a dark-red colour, readily dissolved by alcohol, and deeply stained by tincture of alkanet. But if allowed to harden by keeping in water for a lengthened period, neither alcohol nor ether affects them.

Each cavity is bounded by much-compressed cells, with their flat faces towards the cavity. From the appearance presented by these intercellular spaces or excavations, they appear to be formed by the rupture and disorganisation of the cells at that particular spot, and are hence of *lysigenous* origin.

In some species there are special *canals*, not cortical, but enclosed by the curve of the wood, which will be noticed in their proper place.

Crystals.—Crystals of the well-known octahedral form are seen in great profusion scattered through the cortical cells (Fig. 3). They vary considerably in size, sometimes reaching 1-600in. in length, and, judging from the usual tests, as well as from their crystalline form, consist of oxalate of lime. Numerous crystals, similar to the above, likewise occur in the soft bast, but they are much smaller on the whole. No species examined was entirely free from crystals, although in some instances they were very scarce.

Longitudinal Section.—Although it is not the object of this paper to give a complete account of the histology of the petiole, it was thought necessary to examine longitudinal, as well as transverse sections, at least in one or two cases.

A longitudinal median section of the petiole of *E. globulus*, taken through the shorter axis of the crescentic bundle, revealed the ordinary succession of the various parts.

The epidermis, after prolonged staining with Schulze's solution, stood out as a somewhat pale, lemon-yellow border. The breadth of each cell varied from 1-760in. to 1-830in., and the length was just a little less, or about 1-920in.

The purple-coloured cortex exhibited much smaller cells towards its outer than its inner portions, the hypodermal layer usually quite distinct beneath the epidermis. Cortical cells adjoining the hard bast were often relatively large (Figs. 2*a* and *b*).

The cortical cavities had the same form as in transverse section, being irregularly round, or oval, or pear-shaped, and the size was about the same. Two adjoining cavities were measured, one of which was 1-190in., and the other 1-115in. in length. The F. V. B. showed the hard bast usually in two distinct layers (an outer and an inner), with intervening soft bast, and the wood with its numerous spiral and annular vessels (Fig. 5). The soft bast was carefully examined, and found to consist of cambiform cells and sieve-tubes (Figs. 6 and 7). The cambiform cells varied considerably in shape and size. Often they were brick-shaped, and even somewhat roundish; at other times they were much more elongated and thinner-walled. Directly adjoining the wood the cells were clearly marked off from the latter, and sufficiently thin-walled in some cases to resemble cambium.

The sieve-tubes are shown in longitudinal section. (Fig. 7.) The iron stain, as well as Schulze's solution, serves to differentiate them.

Fibro-vascular Bundle.

This is a convenient collective term for the group of tissues already separately mentioned as hard bast, soft bast, and wood tissue, or if the bast and wood be simply contrasted, then phloem and xylem may be used.

Since the bundles form the most striking feature of these sections, and are the parts from the form of which the species of Eucalypts are chiefly determined, they will be expected to receive a large share of attention and illustration.

The special *form* of the bundles, or rather of the woody portion of them, will be considered in the next section devoted to the determination of species, so little will be said here upon that point.

It is to be premised, first of all, that the xylem portion of a leaf bundle is, as a rule, towards the upper surface, and the phloem portion towards the lower surface, just as would naturally happen in a lateral expansion of these tissues of the stem. Also, that the upper or inner surface of the petiole has often a different contour to the lower or outer surface. In this instance the upper surface is flattish, while the under surface is rounded. But in cases such as the fig and walnut, where the petiole is cylindrical, the bundles are likewise arranged in a circle, and form a cylinder.

As is well known, in most Eucalypts the blade of the leaf is not spread out horizontally, as is usually the case, but vertically in relation to the leaf-bearing axis. In the young condition, however, it has the normal position, and it is by subsequent twisting of the leaf stalk that the changed position is brought about. In the course of this twisting process, stomata are developed on the upper surface, in addition to those already existing on the under surface, and palisade parenchyma is developed beneath the lower epidermis as well.* But it appears that the bundle of the leaf

* Bower and Vines, Practical Botany, Part I., 2nd Ed., p. 148.

stalk is unaffected by the change, or at least not rendered symmetrical, so that in every example investigated it does not form a complete circle, but a curve open upwards, with the two ends approaching, but never meeting.

A section of the base of the midrib of the young sessile leaf (Fig. 8) likewise shows the curve open upwards, whereas a section of the young square stem of the same plant (Fig. 9) exhibits a symmetrical quadrangle, corresponding with the outline of the stem, and continuous right round.

An attempt to account for the generally different distribution of the wood in the stem and in the leaf-stalk is made by Herbert Spencer in his "Principles of Biology."* After noticing that there is a direct relation between mechanical stress and the formation of wood, and that the general arrangement in stems is that of a cylinder, he says :—" While axes are on the average exposed to equal strains on all sides, most leaves, spreading out their surfaces horizontally, have their petioles subjected to strains that are not alike in all directions ; and in them the hard tissue is differently arranged. Its transverse section is not ring-shaped, but crescent-shaped ; the two horns being directed towards the upper surface of the petiole. That this arrangement is one which answers to the mechanical conditions, is not easy to demonstrate ; we must satisfy ourselves by noting that here, where the distribution of forces is different, the distribution of resisting tissue is different. And then, showing conclusively the connection between these differences, we have the fact that in petioles growing vertically and supporting peltate leaves—petioles which are therefore subject to equal transverse strains on all sides—the vascular bundles are arranged cylindrically, as in axes."

That this is only a partial explanation is shown by the fact that in many instances the cylindrical arrangement of the wood occurs where the distribution of forces is different from that of the stem, as in the leaves of fig and walnut, already mentioned. It is true, however, that in all the petioles of Eucalypts examined the crescentic form prevailed, and was not appreciably interfered with by the twisting of the leaf-stalk. In some cases, such as that of *E. ficifolia*, where the horns of the crescent may approach so very close as to make the wood practically a cylinder, the outline was not cylindrical, and there was less twisting of the leaf-stalk than in many other species. Indeed, in one petiole of this species the wood formed a compressed hemisphere, the two horns abutting, but as four central canals were present, this petiole was evidently somewhat abnormal.

The bundle will now be considered under three separate divisions, viz., hard bast, soft bast, and wood.

* Vol. II., p. 261.

3. *Hard Bast.*—This tissue is very easily recognised in transverse section from its position and structure. It forms an irregular, interrupted ring of exceedingly thick-walled cells. It passes not only round the outside of the bundle on its lower surface, but curves round the upper surface, and after dipping towards the centre of the bundle, and forming a thickened mass, it continues in a graceful curve.

Treated with Schulze's solution, the bright, yellow girdle is made to stand out in bold relief.

The hard bast, which has received various other names, such as sclerenchyma, bast fibres, prosenchyma, &c., is one kind of mechanical or supporting tissue—a skeleton in fact. This particular kind of tissue may occur elsewhere than in this region, wherever, indeed, a strengthening of the parts becomes necessary, but in order to prevent confusion the name of hard bast or bast-fibres will invariably mean with us the skeleton accompanying, supporting, and protecting the soft bast.

4. *Soft Bast.*—The soft bast, all but completely enclosed by the hard bast, is a ring of tissue immediately adjoining and surrounding the wood. It consists of cells of much smaller diameter than those of the hard bast, and relatively thin-walled. In a section treated with Schulze's solution, this tissue is strikingly shown as a purple patch, between the bright yellow of the hard bast on the one hand, and that of the woody tissue on the other, which it completely envelopes as with a mantle.

The thin-walled cells, many of them with large cavities, and all with cellulose walls, have evidently a different function from that of the hard bast. The soft bast is composed of two main elements—the cambiform cells and the sieve-tubes, both of which have already been dealt with in considering the longitudinal section.

5. *Woody Tissue.*—The wood forms the central figure of the section, and with its graceful infolding at each side gives rise to characteristic patterns. It sometimes resembles the inverted volute of an Ionic capital, or simply a capital ↄ lying flat, or to change the figure, when, with Schulze's solution, the radiating lines are made to stand out dark upon the yellow back-ground, it resembles a caterpillar coiled up at either end, with its body divided into numerous segments by beaded rings. When the two horns curve round the central canals, as in *E. maculata*, there is something of an owl-like appearance about it, when viewed upside down.

In a section treated with Schulze's solution it is easy to resolve the woody tissue into three elements—

(a.) Wood fibres.
(b.) Wood parenchyma.
(c.) Vessels.

The wood fibres, forming mainly the outer half of the woody curve, are recognised by their thickened walls and comparatively small cavity. They are on an average 1-3000in. in diameter.

The wood parenchyma consists of small elongated cells, arranged in radiating lines so as to resemble medullary rays. They stain of a dark colour, and hence stand out clearly from the surrounding yellow. The radiating lines are usually just sufficiently equidistant to allow room between for a radiating row of vessels. The average length of each cell is about 1-2000in.

The vessels, conspicuous by reason of their large cavities, are arranged in radial rows, and form mainly the inner half of the woody curve. A larger or smaller number of vessels generally appear on the outer border, at the central and thickest portion of the wood. The diameter of the vessels varies considerably, the largest being about 1-750 in., and the average diameter about half that. In a longitudinal section the vessels are seen to be spiral and annular.

From the foregoing brief description of the parts of the F. V. B. in the petiole of *E. globulus*, it will be seen that the bundle here is different from the normal bundle. Usually the phloem and xylem follow each other in the same radius, the phloem being outside and the xylem inside, so that when a bundle is traced into the leaf stalk, the phloem portion is towards the outer or lower surface, and the xylem portion towards the inner or upper surface. In this instance, however, there is phloem not only on the outer but also on the inner side of the wood, and continued round, so that the wood is in the centre completely surrounded by the phloem. In most cases the phloem forms a narrow band, where it curves round to become continuous. Such a bundle, with the xylem completely surrounded by the phloem, is called *concentric*. With the normal arrangement of phloem and xylem, the form of the bundle is *collateral*, and when there is phloem outside and inside the xylem it is distinguished as *bicollateral*. According to De Bary,* the latter is the form of the bundle in all investigated species of Eucalyptus, and "*Eucalyptus globulus* decidedly belongs to this series." As far as the petiole is concerned in this, and we may add, in the other species investigated, the bundle belongs to the concentric type.

Having seen the mode of arrangement of the parts of the F. V. B., we will now endeavour to explain the use of this arrangement and structure.

The hard bast all round is evidently, from its very nature and position, a mechanical support and protection.

The wood fibres in the centre likewise play the part of mechanical support, and the soft bast is safely placed between the hard bast and the inflexible wood.

The cambiform cells of the soft bast have thin walls, to allow of the circulation of *diffusible* substances, but as the thin walls might collapse and thick walls would pre-

* Comp. Anat. of Phanerogams and Ferns, p. 338.

vent diffusion, a compromise has to be effected. The walls are thickened here and there, and diffusion occurs in the thin places.

The sieve tubes, with their sieve plates, allow of the transport of *indiffusible* substances, such as albuminoids. Just as the blood in our blood vessels is carried bodily along, so is there a direct bodily transport of these indiffusible substances through the meshes of the sieve.

The next step is to vessels proper in the wood tissue, where there is no longer even a sieve plate, but the transverse partitions are removed completely. In that case the walls want special strengthening to prevent collapse, and so there are all the admirable contrivances of annular and spiral vessels. The vessels technically belong to the wood, but they are circulating tissue. They are for quick transport, the quickest of all; the cambiform cells the slowest, working by the slow process of diffusion; and the sieve tubes intermediate. The fibrous cells, or wood fibres, especially the younger, have probably the task of conveying water, for they readily take it in and readily give it off, so that the F. V. B., with its varied cells, resolves itself into a contrivance for mechanical support on the one hand, and a means of circulation on the other.

To show the importance of the soft bast, it may finally be mentioned that it is probably there albuminoids are manufactured, as well as conveyed to their destination. It contains more albuminoid matter than other parts, and it is thickly bestrewn with crystals of oxalate of lime. The albuminoid matter thus produced is not living protoplasm, but it is a necessary preliminary to it. The exact composition of this raw material of life occurring in the soft bast is not known. It is quite possible, however, that any living cell favourably situated may manufacture living protoplasm when the proper material is supplied to it, for the final touch is the touch of vitality to convert the lifeless mass into the living protoplasm.

Before glancing at the other transverse sections in a comparative way, the effects of the application of Schulze's solution on the different constituents of the transverse section of E. globulus may be briefly summarised. The cuticle of the epidermis is generally stained yellow and orange; the cuticularised layer of a ruby-red; the cortical portion purple; the lignified cells of the hard bast, orange; the soft bast, purple; and the woody tissue, orange, with a tint of brown. The contents of the cortical cavities seem to be unaffected, and the crystals are dissolved.

In the other transverse sections, the epidermis is generally a well-defined layer of cells, with more or less thickened outer walls. In some this thickness is excessive, specially in *E. tetraptera*, *E. obcordata*, *E. pachypoda*, and *E. uncinata*. It is worthy of remark that these four are shrubs, or at most small trees, that the two former are confined to Western Australia, while the two latter belong to desert country, and constitute a portion of the Mallee scrub.

There is a kino-like exudation often met with in some, such as *leucoxylon*, *lehmanni*, *occidentalis*, and *alpina*, being quite a feature in the last form. The hypodermal layer, noted in *globulus*, is decidedly absent in many, but indications of it in some, such as *grossa*. In *ficifolia* there is a decided and well-marked hypoderma, usually consisting of *two* layers of cells. The cortex may be compared as to the number and size of cortical cavities in it. This is shown in Table I., so that it is unnecessary to dwell further upon it. In one case at least *(E. tetraptera)*, the cortical cells are continued into the organic centre of the section by means of two narrow and adjoining lines of cells.

The hard bast is more or less dense in different sections, forming usually an interrupted or broken ring.

The soft bast, on the other hand, usually surrounds the wood completely, but it is sometimes discontinuous.

The wood-curve may be continuous or discontinuous, with a thinner or thicker body, and longer or shorter horns, but, on the whole, so varied in character as to serve in many cases as one of the characteristic features of the section.

Broken curves occur in all the species—in some they are the rule, as in *lehmanni*, in many they are exceptional, as in *globulus*, which was the most constant in its features of all the types investigated.

This will be the most appropriate place to compare the essential features in the transverse section of a young stem and a young leaf of *E. globulus*. The leaf being sessile, it was necessary to take the base of the midrib instead (Figs. 8 and 9).

	Young Stem.	Young Leaf.	Old Leaf.
		Base of Midrib.	*Petiole.*
Epidermis— Thickness.. ..	$\frac{1}{1500}$ in.	$\frac{1}{1150}$ in.	$\frac{1}{570}$ in.
Cortical Cavities—			
Number	14 at least	4	7 or 8
Shape	round	round	round
Size (largest) ..	$\frac{1}{140}$ in.	$\frac{1}{210}$ in.	$\frac{1}{80}$ in.
Hard Bast—	Dense and continuous on outside of F.V.B. In patches inside, and absent from corners.	Very sparingly developed in both layers.	Well developed and dense.
Soft Bast—	Continuous outside and inside of wood, but thinnest at the corners.	Continuous round wood and well developed, particularly on inside of crescent.	Continuous round wood.
Wood—	Forming a square, with slight inward depression on each side of square.	Crescentic, with horns well curved in.	Crescentic, with horns curving inward.
Vessels—	Distributed mostly towards inner surface of wood, and moderately numerous. Largest towards exterior of wood.	Numerous, and distributed towards inner part of wood.	Numerous, and distributed mostly in upper half of wood.
Size (widest) ..	$\frac{1}{830}$ in., an elongated oval.	$\frac{1}{830}$ in., elongated ellipse	$\frac{1}{700}$ in.
Average	$\frac{1}{2300}$ in.	about $\frac{1}{2300}$ in.	about $\frac{1}{1400}$ in.

The above table shows a contrast in various respects between the young *square stem* and the midrib of the young *sessile leaf*.

In the stem—1st. The epidermis is thinner.
2nd. The number and size of cortical cavities is greater.
3rd. The hard bast is much denser.
4th. The wood forms a square, and not a crescent.

The width of the vessels is about the same in both. The *upright* growing stem and the *lateral* growing leaf are necessarily unequally acted on by various forces, hence the symmetrical and stronger F. V. B. of the stem, as compared with that of the leaf.

If the comparison is made between the *young* and the *old* leaf, with its twisted petiole, there are a few striking differences along with general agreement; but it will be seen that the differences are simply those between a young and tender organ, and the same arrived at maturity. In the old leaf, the epidermis is about twice as thick, the cortical cavities are increased and immensely enlarged, the hard bast is now strongly developed, and the vessels are a trifle larger.

The twisting of the petiole seems to have produced no noticeable difference in the general arrangement of the tissues, particularly the vascular. The twisting of a leaf-stalk round a support, in the case of leaf-climbers, has been shown by Darwin to increase the growth. The pressure here has acted as a stimulus, but it is worthy of note that while in the free petiole the bundles form an open curve, in the clasping petiole they form a closed cylinder.

The mere twisting of the petiole in Eucalypts has not produced any curving of the bundles greater than that met with in the young and sessile leaf, and even in those cases where the horns of the crescent most closely approach, as in *ficifolia* and *calophylla*, the leaf-stalk is less twisted than in ordinary cases.

Further, the statement made by Mr. Darwin, on the authority of Dr. Masters, that "the semi-lunar band of vessels is confined to petioles channelled along their upper surface," is not countenanced by these researches, for it is in the most channelled leaf-stalks that the wood curve most approaches the complete ring.

* Darwin, "On the Movements and Habits of Climbing Plants," p. 43.

V.—Characteristics of Each Species as Derived from the Transverse Sections.

Baron von Mueller, in his "Eucalyptographia," as well as in his humbler "Botanic Teachings," has adopted two principal expedients for helping to determine the numerous species of Eucalypts, viz., the nature of the bark and the nature of the anthers.

We now add a third, and although it has only been rigorously applied to thirty different kinds, and to a few more casually, there is every reason to believe that the principle will hold good throughout that extensive genus of plants. It is based upon the form and arrangement of the structures revealed in a transverse section of a well-developed and fully formed leaf stalk, taken in conjunction with external characters of the leaf.

While the learned Baron has given a leading place in his classification to the two principles just mentioned, his fertile mind and wide knowledge have suggested a number of others which he has partially applied. Thus the size of the pollen-grains has been found to vary in different species, but to be more or less constant in each.

Again, the number and distribution of the stomata have enabled him to form three series—1st, according to the presence of stomata on the under surface only (*hypogenous*); 2nd, their presence on both surfaces, but less numerous above than below (*heterogenous*); or 3rd, their presence on both surfaces, but approximately equal in number above and below (*isogenous*). Then again the fruit has been suggested as a basis of classification, and each of these methods has its own special advantages, and its suitability for different purposes.

The Carpologic system has this advantage, "that any species might thus be defined from fruiting specimens alone, which latter, through the long persistence of the fruit, are always obtainable in collecting journeys, whereas flowering specimens can be got only at some period of the year, subject even to fluctuations and uncertainties." (Euc. VIII.)

The Cortical system is adapted "to the technic requirements of woodmen, who could not be expected to enter on a discrimination of the various species from such purely scientific differences, on which descriptive botany would rely." (Euc. I.) Of course this system likewise suits the general seeker after a knowledge of these plants.

The Anthereal system "has proved the most convenient for easy-working with museum material, so long as it was the main object to ascertain the name of any species." (Euc. I. "Introduction.")

There is another system recently propounded which ought to be noticed here, viz., the "Kino system" of Maiden.* It is a chemical check, which he merely offers as a supplement to other systems.

The three groups at present recognised are :—

1. Ruby group, with ruby-coloured kinos, soluble either in cold water or spirit; *E. macrorrhyncha*, *obliqua*, and *amygdalina*, investigated by us, belong to this group.

2. Gummy group, containing gum, and therefore imperfectly soluble in spirit, but soluble in cold water. *E. leucoxylon* and *saligna* belong to this.

3. Turbid group, soluble in hot water or alcohol, but the solution becomes turbid on cooling.

With regard to the present system, we consider that it has many advantages and few disadvantages. The Eucalypts being evergreens their leaves are readily obtainable, and where the leaf happens to be sessile the section of the base of the midrib may serve the purpose. The resemblance in habit of many different Eucalypts is often misleading and always confusing, and the basing of characters upon the internal anatomy, which is not so subject to fluctuation as the external, is an advantage.

Again, the most persistent part of the petiole—the wood—is often sufficient for purposes of discrimination, and it may be used, therefore, for the determination of museum material.

It has, moreover, this great advantage, that it enables us in doubtful and difficult cases to decide whether the balance of evidence is in favour of specific identity or merely varietal distinction.

It may be an objection that the above are not naked-eye characters, and that the system is suited rather to the laboratory than the field, but while less minute characters may be used for rough discrimination, the final test for specific distinction must be based upon essential characters that do not always lie upon the surface. Moreover, the internal structure has been hitherto too much neglected by systematists, just as anatomists have in like manner paid too little attention to the characters recognised by the former. If the whole truth is to be expressed by our classification, then all the features, external and internal, must be taken into account.

* Pharm. Jour. XX., p. 221.

The accompanying drawings almost render description unnecessary, but as this is the main portion of the paper, the determining characters of each form examined will be briefly given.

Before doing so, however, it will be necessary to fix upon some definite arrangement, and a geographical one may be followed, in order to see how far anatomical and geographical relations agree.

Table I. exhibits the thirty different forms investigated, variously arranged as far as the data will permit. It is hardly needful to state that the necessary information has been obtained from the "Eucalyptographia," and we have simply thrown it into tabular form. The only exception is the arrangement according to cortical cavities, central canals, and wood curve, which has been deduced from our own researches.

Table II. starts with the forms arranged according to their geographical distribution, and places opposite each the characters respectively deduced from the transverse section of petiole, the leaves, stomates, fruit, anthers, pollen, and bark.

The very different affinities shown by these various systems of arrangement only emphasises the fact that it is not by solitary characteristics affinities are determined, but by the complex of characters, which go to the making up of an individual whole.

The transverse sections will likewise show that along with a certain amount of variability there is sufficient constancy to give them a characteristic appearance for the different species. The most striking features are: Size and shape of section, relative thickness of epidermis, size and number of cortical cavities, frequency or scarcity of crystals, density and continuity, or the reverse, of hard bast, pattern of the wood, and size and distribution of the vessels.

Since all these details are only necessary for complete description, the *characteristic features* are given at the end as a sort of summary of characters, serving for all practical purposes.

As regards the central canals, they occur in only a few of the investigated species, viz., *E. calophylla*, *ficifolia*, and *maculata*, with its variety *citriodora*.

Two seems to be the normal number, but since each may divide in a forked manner, the number is sometimes increased to four, or even six (*maculata*). (See remarks in description of each species.)

In stating the characteristic features of the various sections, it is often found necessary to speak of the relative sizes of different parts, such as the section of the petiole, the epidermis, cortical cavities, central canals, and vessels, and in using the expressions "large," "small," or "moderate in size," it all depends upon what is considered an average size.

While it is not advisable to lay down a hard and fast line, it is well to have a general understanding of the meaning of the relative terms.

It may be stated generally that the *average section* is reckoned as being about 1 line X 1 line or $\frac{3}{4}$ line, and above or below that will be large or small respectively.

The size of the section seems to be rather a constant and trustworthy feature. The absolute size is first given, then the relative breadth and thickness.

The thickness of the epidermis only varies within certain limits, and cannot often be used as a characteristic, but when it is thicker than about $\frac{1}{800}$ in., or thinner than $\frac{1}{1000}$ in., it may be regarded as above or below the average. The cortical cavities and central canals may be considered large up to $\frac{1}{100}$ in., moderately large up to $\frac{1}{200}$ in., and small beyond that. The size of the *largest* in each species only is given.

The vessels have a wide range of variation. In settling the average size it is largely a matter of judgment, and the largest size given in each case has to be taken into account. Roughly, when the largest size is $\frac{1}{1000}$ in. or more, and the average not too low, the vessels might be described as "large," while at $\frac{1}{1500}$ in., or less, and a corresponding average, they would be "small," and the intermediate would be "moderately large," or medium-sized.

Of course the standard of measurement is confined to the petioles of Eucalypts, and has no reference to the absolute sizes of the parts mentioned in any other plants.

The size of the cavities and canals varies in different parts of the petiole, and likewise the width of the vessels, so that too much importance must not be attached to the actual measurements given. The general results of these measurements may be given here.

Size of section varies in breadth from $\frac{1}{2}$ to $1\frac{3}{4}$ lines (*tetraptera*), and in thickness from $\frac{1}{3}$ line (*stuartiana*) to $1\frac{1}{2}$ lines (*tetraptera*).

Epidermis varies in thickness from $\frac{1}{1150}$ in. (*viminalis* and *stuartiana*) to $\frac{1}{290}$ in. (*tetraptera*). A very common thickness is $\frac{1}{500}$ — $\frac{1}{600}$ in.

Cortical cavities vary from $\frac{1}{880}$ in. (*diversicolor*) to $\frac{1}{80}$ in. (*globulus*), reckoning only the largest in each species.

Central canals vary among the four forms possessing them, from $\frac{1}{210}$ in. (*ficifolia*) to $\frac{1}{80}$ in. (*calophylla*), taking the largest in each case for comparison.

The vessels varied in width from $\frac{1}{1800}$ in. (*lehmanni*) to $\frac{1}{660}$ in. (*gomphocephala*), comparing only the largest in each species.

Thus the largest section and thickest epidermis was found in *tetraptera;* the widest cortical cavity in *globulus*, although it is closely approached by *cornuta* ($\frac{1}{90}$ in.), and the greatest width of vessel in *gomphocephala*, but *globulus*, *tetraptera*, and *citriodora* almost equal it, with a width each of $\frac{1}{700}$ in.

The characteristic nature of the wood-curve has already been insisted on, and it may be added that the extent of development of the hard bast in the different species seems to be a very constant feature.

I.—Forms Confined to Western Australia.

The following descriptions of the various sections are not merely based upon the type-sections photographed, but are drawn in each case from a considerable number of independent sections, of which camera lucida drawings were made. The usual method followed was to make outlines of several sections from the same petiole as that which supplied the type section, then from different petioles, and lastly from herbarium specimens, at least three years old, to test the capability of the system for determining museum material.

1. *E. occidentalis*, Endlicher; flat-topped Yate.

Shrub or tree, rising to 120ft.

Leaves.—Of thick consistence, equally green on both sides.

Size of Section.—1 line broad by $\frac{3}{4}$ line thick, or about $1\frac{1}{4}$ times broader than thick.

Outline of Section.—Round to oval.

Epidermis.—Thickness, $\frac{1}{560}$ in.; breadth, $\frac{1}{1150}$ — $\frac{1}{1500}$ in.

Cortical Cavities.— $\frac{1}{140}$ in., roundish, numbering from 8 to none, and therefore variable.

Crystals.—Numerous.

Hard Bast.—Interrupted ring, sometimes only 1 cell thick.

Wood-curve (see Fig. 11).—Body thickened at centre, short horns, and sharply or gently inturned.

Vessels.—Largest, $\frac{1}{1150}$ in. in dia.

Average, $\frac{1}{1500}$ in.

Comparatively large and numerous, and distributed pretty regularly.

Characteristic features:

Section.—Average size.

Cortical cavities.—Moderately large, generally few.

Hard Bast.—Interrupted and thin.

Wood-curve.—Body elongated, and short horns sharply inturned.

Vessels.—Moderately large, numerous, and regularly distributed.

2. *E. cornuta*, Labillardière; the ordinary Yate.

Tree.—Of moderate size.

Leaves.—Of thick consistence, and nearly equally green on both sides.

Size of Section.—$\frac{3}{4}$ line broad by $\frac{1}{2}$ line thick, or about $1\frac{1}{2}$ times broader than thick.

Outline of Section.—Oval, and somewhat irregular, flattened on upper surface.

Epidermis.—Thickness, $\frac{1}{500}$ — $\frac{1}{570}$ in.

Breadth, $\frac{1}{1150}$ in.

Cortical Cavities.— $\frac{1}{90}$ in. oval, numbering from 9 to 3.

Crystals.—Moderately numerous.

Hard Bast.—Pretty generally continuous, and several cells thick.

Wood-curves (see Fig. 12).—Body slightly thickened at the centre, and short horns gently or somewhat sharply incurved.

Vessels.—Largest, $\frac{1}{1150}$ in.

Average, about half that.

Somewhat large, and most numerous towards upper portion of wood.

Characteristic features:

Section.—Relatively small.

Cortical Cavities.—Large, numerous, often quite close together, and almost occupying breadth of cortex.

Hard Bast.—Continuous and thick.

Wood-curve.—Horns sharply incurved, and one or both often separated from body-curves.

Vessels.—Moderately large, and aggregated towards middle and upper surface of wood.

3. *E. cornuta, var lehmanni*, Preiss.

Tree.—Of moderate size.

Leaves.—Of thick consistence, and equally green on both sides.

Size of Section.—About 1 line broad by $\frac{1}{2}$ line thick, or twice as broad as thick.

Outline of Section.—An irregular oval, elongated laterally.

Epidermis.—Thickness, $\frac{1}{570}$ — $\frac{1}{760}$ in.

Breadth, $\frac{1}{1150}$ in.

Cortical Cavities.—$\frac{1}{135}$ in., oval to round, numbering from 11 to 3.

Hard Bast.—Generally in isolated contiguous patches, a few or several cells thick.

Wood-curve (see Fig. 13).—Slender elongated body, almost always broken, and with sharply incurved horns.

Vessels.—Largest, $\frac{1}{1800}$ in.

Average about $\frac{1}{3000}$ in.

Small, few, and regularly distributed.

Characteristic features:

Size of Section.—Twice as broad as thick.

Cortical Cavities.—Moderately large and numerous.

Hard Bast.—Isolated contiguous patches.

Wood-curve.—Generally broken, with slender body, and sharply incurved horns.

Vessels.—Few and small.

4. *E. obcordata*, Turczaninow; "Maalok."

Tall shrub or small tree.

Leaves.—Thick, broad, blunt, equally green on both sides.

Size of Section.—About 1 line broad and thick, or as broad as thick.

Outline of Section.—Round to oval, the greatest diameter sometimes dorso-ventral.

Epidermis.—Thickness, $\frac{1}{380}$ — $\frac{1}{460}$ in.

Breadth, $\frac{1}{760}$ — $\frac{1}{920}$, or half the thickness.

Cortical Cavities.—$\frac{1}{100}$ in. roundish, numbering from 10 to 6.

Crystals.—Numerous.

Hard Bast.—Very feebly developed, often consisting merely of isolated cells at distant intervals.

Wood-curve (see Fig. 14).—With somewhat thickened body, graceful incurving, and moderate-sized horns.

Vessels.—Largest, $\frac{1}{1500}$ in.

Average, about half that.

Small, not very numerous, in radiating lines, and mostly towards upper portion of wood.

Characteristic features:

Section.—Average size, as broad as thick.

Cortical Cavities.—Large, and comparatively numerous.

Hard Bast.—Feebly developed.

Wood-curve.—With thickened body and graceful incurving horns.

Vessels.—Comparatively small, not very numerous, and distributed mostly towards upper portion of wood.

5. *E. marginata*, Donn; Jarrah.

Tree, averaging 100ft. in height.

Leaves.—Somewhat paler beneath.

Size of Section.—About 1 line broad by $\frac{1}{2}$ line thick, or fully twice as broad as thick.

Outline of Section. Laterally elongated, ovoid usually.

Epidermis.—Thickness, $\frac{1}{570} - \frac{1}{760}$ in.

Breadth, $\frac{1}{920} - \frac{1}{1150}$ in.

Cortical Cavities.—$\frac{1}{130}$ in., almost round, numbering from 9 to 3.

Crystals.—Numerous.

Hard Bast.—More or less continuous, and generally one or a few cells thick.

Wood-curve (see Fig. 15).—Elongated laterally and slender, sometimes slightly thickened about the middle, incurving somewhat sharply, and horns usually relatively short.

Vessels.—Largest, $\frac{1}{1150}$ in.

Average, about half that.

Medium-sized, moderately numerous, and distributed pretty regularly.

Characteristic features :

Section.—Fully twice as broad as thick.

Cortical Cavities.—Moderately large and numerous.

Hard Bast.—Continuous; a few cells thick.

Wood-curve.—With slender, elongated body, and usually short slender horns.

Vessels.—Medium-sized, moderately numerous, and regularly distributed.

6. *E. diversicolor*, F. v. M.; Karri.

Tree.—Very tall and straight.

Leaves.—Elongated, much paler beneath.

Size of Section.—About $\frac{3}{4}$ line broad by $\frac{1}{2}$ line thick, or about $1\frac{1}{2}$ times broader than thick.

Outline of Section.—Oval to round, usually flattened on upper surface.

Epidermis.—Thickness, $\frac{1}{570}$ in.

Breadth, about half the thickness.

Cortical Cavities.—$\frac{1}{380}$ in., roundish, numbering from 7 to 2, or sometimes none.

Crystals.—Few.

Hard Bast.—Poorly developed, very discontinuous, often consisting merely of single isolated cells.

Wood-curve (see Fig. 16).—Body may be either short and stout, or elongated and slender, with gentle incurving and somewhat stoutish horns.

Vessels.—Largest, $\frac{1}{1300}$ in.
Average, $\frac{1}{2300}$ in.
Comparatively small, not very numerous, generally distributed in radiating lines, absent from lower portion of wood.

Characteristic features:
Section.—Comparatively small.
Cortical Cavities.—Small, and often few.
Hard Bast.—Poorly developed.
Vessels.—Medium-sized, not numerous, distributed in upper portion of wood.

7. *E. gomphocephala*, De Candolle; Tooart.

A good-sized tree.
Leaves.—Thick, shining, slightly paler beneath.
Size of Section.—About $\frac{3}{4}$ line broad and thick, or of equal breadth and thickness.
Outline of Section.—From round to oval.
Epidermis.—Thickness, $\frac{1}{600}$ — $\frac{1}{760}$ in.
Breadth, $\frac{1}{1150}$ in.
Cortical Cavities.—$\frac{1}{150}$ in., elongated oval, numbering from 4 to none.
Crystals.—Very numerous.
Hard Bast.—Forming a pretty continuous ring, generally several cells thick.
Wood-curve (see Fig. 17).—Body usually exceedingly thick, with large and stout horns, often well curved inward and approaching each other.
Vessels.—Largest, $\frac{1}{660}$ in. and several $\frac{1}{760}$ in.
Average, $\frac{1}{1150}$ — $\frac{1}{1500}$ in.
Large and comparatively numerous, distributed mostly towards middle and upper surface.

Characteristic features:
Section.—Of equal breadth and thickness.
Cortical Cavities.—Moderately large, but few.
Hard Bast.—Continuous and thick.
Wood-curve.—With exceedingly thickened body, and large and stout horns.
Vessels.—Large, numerous, and distributed largely in upper half of wood.

8. *E. megacarpa*, F. v. M.; West Australian Blue Gum.

Tree.—Medium-sized.
Leaves.—Of pleasant odour, and equally green on both sides.
Size of Section.—1 line broad by $\frac{1}{2}$ line thick, or twice as broad as thick.

Outline of Section.—Generally oval and laterally expanded, sometimes roundish or angular, flattened on upper and under surface.

Epidermis.—Thickness, $\frac{1}{570}$ — $\frac{1}{760}$ in.

Breadth, $\frac{1}{1150}$ — $\frac{1}{1500}$ in., or half the thickness.

Cortical Cavities.—$\frac{1}{160}$ in. round, numbering from 7 to 2.

Crystals.—Very few.

Hard Bast.—Generally continuous, but irregular in thickness, giving it a zig-zag appearance.

Wood-curve (see Fig. 18).—Elongated, thickened at centre, with gentle inturning, and horns of medium length.

Vessels.—Largest, $\frac{1}{830}$ in.

Average, about half that.

Moderately numerous, wide variations in size, lower portion of wood comparatively free from them.

Characteristic features :

Section.—Flattened, about twice as broad as thick, tending to angularity.

Cortical Cavities.—Moderately large.

Hard Bast.—Generally continuous, but irregular in thickness.

Wood-curve.—Slender, slightly thickened in centre, and short horns gently incurved.

Vessels.—Moderately large and numerous.

9. *E. tetraptera*, Turczaninow ; four-winged-fruited Eucalypt.

Shrub, seldom exceeding 10ft. in height.

Leaves.—Very thick and equally green on both sides.

Size of Section.—1¾ line broad by 1½ thick, or nearly 1¼ broader than thick.

Outline of Section.—Circular to oval.

Epidermis.—Thickness, $\frac{1}{90}$ in.

Breadth, $\frac{12}{1150}$ in. or about ¼ thickness.

Cortical Cavities.— $\frac{1}{180}$ in. round to oval, numbering from 4 to 2.

Crystals.—Numerous.

Hard Bast.—Continuous except where wood-curve is broken, and usually several cells thick.

Wood-curve (see Fig. 19).—Body thickened in middle, and gently incurved horns of medium size.

Vessels.—Largest, $\frac{1}{700}$ in. and several $\frac{1}{760}$ in.

Average, $\frac{1}{900}$ — $\frac{1}{1150}$ in.

Large, numerous, and distributed pretty regularly.

Characteristic features:

Section.—Very large.

Epidermis.—Very thick.

Cortical Cavities.—Moderately large and few.

Hard Bast.—Continuous, and usually several cells thick.

Vessels.—Large, numerous, and regularly distributed.

10. *E. rudis*, Endlicher; flooded or swamp Gum of Western Australia.

Tree.—Usually not very tall.

Leaves.—Generally thin, and equally green on both sides.

Size of Section.—About $\frac{3}{4}$ line broad by $\frac{1}{2}$ line thick, or $1\frac{1}{4}$ times broader than thick.

Outline of Section.—Roundish, and flattened on top.

Epidermis.—Thickness, $\frac{1}{570}$ in.

Breadth, $\frac{1}{1150}$ in., or about half the thickness.

Cortical Cavities.— $\frac{1}{300}$ in., roundish, numbering from 9 to 2.

Crystals.—Few.

Hard Bast.—Very poorly developed, often just represented by straggling cells.

Wood-curve (see Fig. 20).—Elongated, and with short or medium-sized horns.

Vessels.—Largest, $\frac{1}{1500}$ in.

Average, $\frac{1}{2300}$ in.

Comparatively small, moderately numerous, and mostly distributed about middle.

Characteristic features:

Section.—Small.

Cortical Cavities.—Small.

Hard Bast.—Very poorly developed.

Wood-curve.—With body elongated and short horns.

Vessels.—Small, and mainly distributed in middle of wood.

11. *E. pachypoda*, F. v. M.

Shrub.

Leaves.—Equally green and pale on both sides.

Size of Section.—About 1 line broad and thick, or equally broad and thick.

Outline of Section.—Round, sometimes slightly elongated.

Epidermis.—Thickness, $\frac{1}{320}$ in.; oval, numbering from 4 to 2.

Breadth, about $\frac{1}{760}$ in.

Cortical Cavities.—$\frac{1}{130}$ in.

Crystals.—Few.

Hard Bast.—Irregularly developed, discontinuous, many-celled, or only 1 cell thick.

Wood-curve (see Fig. 21).—Body thickened, with the two short horns gently incurved, and approaching each other.

Vessels.—Largest, $\frac{1}{1000}$ in.

Average, about half that.

Medium-sized, regularly distributed, but not crowded.

Characteristic features :

Section.—Average size, equally broad and thick.

Epidermis.—Relatively thick.

Cortical Cavities.—Moderately large, but few.

Hard Bast.—Weak and irregularly developed.

Vessels.—Medium-sized, and very regularly distributed.

12. *E. calophylla*, Brown ; Calophyllum-like Eucalypt.

Tall Tree.

Leaves.—Broad, acute, thick, more horizontal than vertical, and much paler beneath.

Size of Section.—$1\frac{1}{2}$ lines broad by $1\frac{1}{4}$ lines thick, or nearly $1\frac{1}{4}$ times broader than thick.

Outline of Section.—Oval to round, and usually flattened on upper surface.

Epidermis.—Thickness, variable in same section from $\frac{1}{570}$ in. to $\frac{1}{650}$ in.

Cortical Cavities.—Largest, $\frac{1}{110}$ in., round or oval, numbering from 14 to 3.

Central Canals.—Normally two, oval, one $\frac{1}{90}$ in., other $\frac{1}{80}$ in., or sometimes half that.

Crystals.—Moderately numerous.

Hard Bast.—Very sparingly developed, only in small isolated patches.

Wood-curve (see Figs. 22 and 22*a*).—Generally somewhat slender, and of nearly equal thickness throughout ; the horns often approaching each other.

Vessels.—Largest, $\frac{1}{880}$ in.

Average, $\frac{1}{1500}$ in.

Comparatively large and numerous, and distributed in radiating lines mostly towards upper portion.

Characteristic features :

Section.—Large.

Cortical Cavities.—Generally large and numerous.

Central Canals.—Usually two ; very large, relatively to the others.

Hard Bast.—Very sparingly developed.

Wood-curve.—With moderately-thickened body and horns often approaching.

Vessels.—Large, numerous, and distributed mostly towards upper portion of wood.

Remarks.—While two is the normal number of central canals, there may be only one, or as many as four.

The sections from one petiole showed only a single canal near the base, but the normal number (2) near the leaf-blade. The two main canals were also found in several instances to divide into four on passing into the midrib. Probably this is a normal occurrence in this species.

The contents of the canals were tested with various reagents. When treated perfectly fresh they readily dissolved, but after long steeping in water, they became hardened and insoluble in the ordinary reagents. Under these circumstances they would not dissolve either when warmed in nitric acid or in potash and glycerine. Nitric acid gave a red tint, and potash a brown, but that was all the change observed.

In the section of the young stem it is interesting to observe that central canals are absent, while the cortical cavities are present. The latter are very numerous, just as in some sections of the leaf stalk. The hard bast is not of equal thickness throughout, nor is it always continuous, although it is shown thus in the drawing for simplicity. Only the larger vessels of the wood are figured.

13. *E. ficifolia*, F. v. M.; scarlet-flowered Eucalypt.

Tree.—Seldom exceeding height of 50ft.

Leaves.—Generally resembling preceding, but not so broad in proportion to length.

Size of Section.—1¼ lines broad by 1 line thick, or 1¼ times broader than thick.

Outline of Section. Varying from round to oval to a much depressed semi-circle.

Epidermis.—Thickness, $\frac{1}{460}$ — $\frac{1}{570}$ in.

Breadth, $\frac{1}{760}$ in.

Hypoderma.—Equal to epidermis in thickness, and usually a two-celled layer.

Cortical Cavities.—About $\frac{1}{280}$ in., few in number, or absent.

Central Canals.—Normally 2, but occasionally 3 or 4; roundish.

Largest, about $\frac{1}{210}$ in.

Crystals.—Numerous.

Hard Bast.—In irregular patches, a few cells thick.

Wood-curve (see Figs. 23 and 23*a*).—Generally slender, and with horns curving gently, and sometimes almost meeting.

Vessels.—Largest, $\frac{1}{830}$ in.

Average, about $\frac{1}{1500}$ in.

Comparatively large and numerous, and distributed towards upper and middle portions of wood.

Characteristic features:

Section.—Large.

Hypoderma.—Generally two cells thick.

Cortical Cavities.—Small and few.

Central Canals.—Normally two, but liable to variation; about same size as the largest of the cortical cavities.

Hard Bast.—In irregular patches.

Wood-curve.—Slender, and horns approaching each other, sometimes very closely.

Vessels.—Comparatively large, numerous, absent from lower portion of wood.

Remarks.—Cortical cavities are certainly present in this species, but they are few in number, and many sections of a series show none. They are likewise small, indeed the smallest of any species examined.

The normal number of central canals is two, but occasionally there may be three or even four, as in one of the sections photographed. The occurrence of four canals is rather interesting in view of the fact that they were found in sections taken near the base of the leaf-blade. It would appear that while the normal number of two usually occurs in the body of the petiole, as the lamina is approached each divides into two before entering the mid-rib.

II.—Form Confined to Victoria.

14. *E. alpina*, Lindley; alpine gum.

Shrub.

Leaves.—Very thick, broad, blunt, equally green on both sides.

Size of Section.—About 1¼ lines broad and thick, or as broad as thick.

Outline of Section.—Usually rounded.

Epidermis.—Thickness, $\frac{1}{570}$ in. below, $\frac{1}{760}$ in. above.

Cortical Cavities.—$\frac{1}{190}$ in. roundish, numbering from 15 to 6.

Crystals.—Very few.

Hard Bast.—Well-developed, generally continuous, and several cells thick.

Wood-curve (see Fig. 24).—With thickened body and gently incurved short horns.

Vessels.—Largest, $\frac{1}{1150}$ in.

Average, $\frac{1}{3000}$ in.

Medium-sized and moderately numerous, principally occupying middle tract of wood.

Characteristic features :

Section.—Large, as broad as thick.

Cortical Cavities.—Moderately large, and numerous.

Hard Bast.—Well-developed, and generally continuous.

Wood-curve.—With thickened body and gently incurved short horns.

Vessels.—Medium-sized, principally distributed in middle tract of wood.

III.—Form Confined to New South Wales.

15. *E. punctata*, De Candolle ; leather-jacket.

Tree.—Attaining a height of 100ft. or more.

Leaves.—Paler beneath.

Size of Section.—About $\frac{1}{2}$ line broad and thick, or as broad as thick.

Outline of Section.—Round, with slight flattening on upper surface.

Epidermis.—Thickness, $\frac{1}{570}$ — $\frac{1}{760}$ in.

Breadth, about $\frac{1}{150}$ in.

Cortical Cavities.—$\frac{1}{150}$ in., elongated oval, numbering from 8 to 1.

Crystals.—Very few.

Hard Bast.—Very sparsely developed.

Wood-curve (see Fig. 25).—Nearly always found entire; body thickened, and horns very gently incurved and short.

Vessels.— Largest, $\frac{1}{1500}$ in.

Average, $\frac{1}{3000}$ in.

Relatively few, small and scattered.

Characteristic features :

Section.—Small, as broad as thick.

Cortical Cavities.—Moderately large.

Hard Bast.—Very poorly developed.

Wood-curve.—Nearly always found entire, with thickened body and short horns.

Vessels.—Few, small, and scattered.

IV.—Forms Confined to Queensland.

16. *E. maculata*, var. *citriodora*, Hooker ; lemon-scented Eucalypt.

Tree.—Only differing from *maculata* in the lemon-scented foliage.

Size of Section.—$1\frac{1}{4}$ line broad by 1 line thick, or $1\frac{1}{4}$ times broader than thick.

Outline of Section.—Oval, somewhat irregular in outline, and flattened or depressed on top.

Epidermis.—Thickness, $\frac{1}{820}$ — $\frac{1}{920}$ in.

Breadth, $\frac{1}{1380}$ in.

Cortical Cavities.—Largest, $\frac{1}{160}$ in., oval to round, numbering from 8 to 0.

Central Canals.—Normally 2, oval and round; largest about the same size as cortical cavity.

Crystals.—Moderately numerous.

Hard Bast.—Very poorly developed, just represented at intervals by a few straggling cells.

Wood-curve (see Fig. 26).—Usually of equal thickness throughout and slender, with very gently incurved horns, each about one-third body-length.

Vessels.—Largest, $\frac{1}{700}$ in.

Average, about $\frac{1}{1150}$ in.

Numerous, large (about twice the size of those of *maculata*), and generally distributed.

Characteristic features:

Section.—Large.

Cortical Cavities.—Moderately large, variable in number.

Central Canals.—Normally two, and same size as cortical cavities.

Hard Bast.—Very poorly developed.

Wood-curve.—Of equal thickness throughout, with very gently incurved horns.

Vessels.—Large, numerous, and generally distributed.

REMARKS.—A petiole was noticed showing only *one* central canal near the base or point of attachment to the stem, but the normal number (two) towards the leaf-blade. Another petiole showed one only in all the sections examined.

V.—FORM BELONGING TO SOUTH AUSTRALIA AND VICTORIA.

17. *E. corynocalyx*, F. v. M.; sugary Eucalypt; sugar gum.

Tree.—Finally tall, said to be the largest tree growing in South Australia.

Leaves.—Shining, somewhat paler beneath.

Size of Section.—About $\frac{3}{4}$ line broad by $\frac{1}{2}$ line thick, or $1\frac{1}{4}$ times broader than thick.

Outline of Section.—Round to oval, usually flattened on upper surface.

Epidermis.—Thickness, $\frac{1}{570}$ in.

Breadth, $\frac{1}{1150}$ in.

Cortical Cavities.—$\frac{1}{250}$ in., round or slightly oval, numbering from 4 to 13.

Crystals.—Few.

Hard Bast.—Sparingly developed, sometimes consisting of isolated cells.

Wood-curve (see Fig. 27).—Usually with slender, elevated horns, dipping inward.

Vessels.—Largest, $\frac{1}{920}$ in.

Average, about $\frac{1}{2300}$ in.

Rather small on the whole, comparatively few, somewhat scattered, and mostly absent from lower portion of wood.

Characteristic features:

Section.—Small.

Cortical Cavities.—Numerous, but comparatively small.

Hard Bast.—Sparingly developed.

Wood-curve.—Usually symmetrical and entire, with slender and very gently incurved horns.

Vessels.—Comparatively small.

VI.—Forms Belonging to Victoria, New South Wales, and Queensland.

18. *E. melliodora*, Cunningham; honey-scented Eucalypt, or yellow box tree.

Tree.—Middle-sized.

Leaves.—Equally dull-green on both sides.

Size of Section.—About ½ line broad and thick, or as broad as thick.

Outline of Section.—Round or oval, and flattened on upper surface.

Epidermis.—Thickness, $\frac{1}{600}$—$\frac{1}{760}$ in.

Breadth, about $\frac{1}{1150}$ in.

Cortical Cavities.—$\frac{1}{250}$ in., round, numbering from 4 to 1 or none.

Crystals.—Very numerous, and frequently in groups.

Hard Bast.—Continuous, and generally two cells thick.

Wood-curve (see Fig. 28).—Always found unbroken, with thickened body and sharply inturned short horns.

Vessels.—Largest, $\frac{1}{1000}$ in.

Average, about $\frac{1}{2300}$ in.

Medium-sized, numerous, and equally distributed.

Characteristic features:

Section.—Small; as broad as thick.

Cortical Cavities.—Small and few.

Hard Bast.—Continuous, and generally a two-celled layer.

Wood-curve.—Always found unbroken, with thickened body and short horns.

Vessels.—Medium-sized, numerous, and equally distributed.

19. *E. tereticornis*, Smith; flooded gum-tree.

Tree.—Tall, handsome, seldom exceeding 100ft. in height.

Leaves.—Equally green on both sides.

Size of Section.—About $\frac{3}{4}$ line broad by $\frac{1}{2}$ line thick, or $1\frac{1}{4}$ times broader than thick.

Outline of Section.—Irregularly round to oval.

Epidermis.—Thickness, $\frac{1}{760}$ in.

Breadth, $\frac{1}{920}$ — $\frac{1}{1150}$ in.

Cortical Cavities.—$\frac{1}{230}$ in., round to oval, numbering from 10 to none, but on an average about 5.

Crystals.—Very numerous.

Hard Bast.—Sparingly developed, discontinuous, in many places 1 cell thick.

Wood-curve (see Fig. 29).—Body moderately thickened and horns gently incurved; always found entire.

Vessels—Largest, $\frac{1}{1500}$ in.

Average, about half that.

Comparatively small, moderately numerous, distributed loosely towards upper portion, and generally absent from lower portion of wood.

Characteristic features:

Section.—Small.

Cortical Cavities.—Small.

Hard Bast.– Sparingly developed.

Wood-curve.—Symmetrical, and always found entire.

Vessels.—Comparatively small, moderately numerous, and distributed loosely towards upper portion of wood.

VII.—Forms Belonging to New South Wales and Queensland.

20. *E. saligna*, Smith; grey gum-tree.

Tree.—Tall.

Leaves.—Tapering, much paler beneath.

Size of Section.—$\frac{3}{4}$ line broad by $\frac{1}{2}$ line thick, or $1\frac{1}{2}$ times as broad as thick.

Outline of Section.—Rounded, with flattened upper surface.

Epidermis.—Thickness, $\frac{1}{760}$ in.

Breadth, about $\frac{1}{1150}$ in.

Cortical Cavities.—$\frac{1}{180}$ in., round to elongated, numbering from 7 to 6.

Crystals.—Numerous.

Hard Bast.—Very poorly developed, and in many places entirely absent.

Wood-curve (see Fig. 30).—Body thickened and elevated, horns generally not much incurved.

Vessels.—Largest, $\frac{1}{920}$ in.

Average, about half that.

Moderately large, numerous, and generally distributed.

Characteristic features:

Section.—Small.

Cortical Cavities.—Moderately large and numerous.

Hard Bast.—Feebly developed.

Wood-curve.—With thickened body, and generally elevated horns.

Vessels.—Moderately large, numerous, and generally distributed.

21. *E. maculata*, Hooker; spotted gum.

Tree.—Tall, handsome.

Leaves.—Often very large and coarse, and equally green on both sides.

Size of Section.—1 line broad by $\frac{3}{4}$ line thick, or about $1\frac{1}{4}$ times broader than thick.

Outline of section.—Oval, flattened on upper surface.

Epidermis.—Thickness, about $\frac{1}{920}$ in.

Breadth, about half that.

Cortical Cavities.—$\frac{1}{180}$ in. oval to round, numbering from 6 to 2.

Central Canals.—Normally 2, oval to round; largest, about $\frac{1}{190}$ in., or generally the size of the cortical cavities.

Crystals.—Numerous.

Hard Bast.—In closely adjoining patches, generally a few cells thick.

Wood-curve (see Fig. 31).—Usually of equal thickness throughout, with very gently incurved horns, each about one-third of body-length.

Vessels.—Largest, about $\frac{1}{1300}$ in.

Average, $\frac{1}{1900}$ — $\frac{1}{2300}$ in.

Moderately large and numerous, confined almost exclusively to upper and middle portion of wood.

Characteristic features:

Section.—Of average size.

Cortical Cavities.—Medium-sized, not very numerous.

Central Canals.—Normally 2, about same size as cortical canals.

Hard Bast.—In contiguous patches, a few cells thick.

Wood-curve.—Of equal thickness throughout, with very gently incurved horns.

Vessels.—Moderate in size and number, and absent from lower portion of wood.

REMARKS.—The number of central canals varies occasionally, due probably to the splitting up of the normal number (two). Thus, in nine successive sections taken from about the middle of the leaf stalk, there were four, two on each side; and in another petiole, the sections showed five, three on one side and two on another. And, as if to complete the series, a third petiole exhibited no less than six canals—three on either side, one of each being about the normal size, and the other two rather smaller.

VIII.—FORM BELONGING TO SOUTH AUSTRALIA, VICTORIA, AND NEW SOUTH WALES.

22. *E. macrorrhyncha*, F. v. M.; Victorian stringy-bark.

Tree.—Tall.

Leaves.—Elongated, equally green on both sides.

Size of Section.—1 line broad by $\frac{3}{4}$ line thick, or about $1\frac{1}{4}$ times broader than thick.

Outline of Section.—Oval, or nearly round.

Epidermis.—Thickness, $\frac{1}{760}$ in.
Breadth, $\frac{1}{760}$ — $\frac{1}{920}$ in.

Cortical Cavities.—$\frac{1}{130}$ in., oval and round, numbering from 8 to 2.

Crystals.—Few.

Hard Bast.—Well-defined layer, several cells thick.

Wood-curve (see Fig. 32).—Body exceedingly thick and short; horns stout, upright, or sharply inturned; always found entire.

Vessels.—Largest, $\frac{1}{760}$ in.
Average, $\frac{1}{1150}$ in.
Large and numerous; pretty equally distributed, but most thickly towards upper portion of wood.

Characteristic features:

Section.—Average size.

Cortical Cavities.—Moderately large.

Hard Bast.—Well-defined, and several cells thick.

Wood-curve.—Always found unbroken, with much-thickened body, and short stout horns.

Vessels.—Large, numerous, distributed mostly towards upper portion of wood.

IX.—Form Belonging to Tasmania, Victoria, and New South Wales.

23. *E. globulus*, Labillardière; blue gum.

Tree.—Very tall.

Leaves.—Thick, elongated, equally green on both sides.

Size of Section.—A little over 1 line broad and 1 line thick, or slightly broader than thick.

Outline of Section.—Oval, slightly flattened on upper surface.

Epidermis.—Thickness, $\frac{1}{570}$ in.

Breadth, $\frac{1}{760}$—$\frac{1}{900}$ in.

Cortical Cavities.—$\frac{1}{80}$ in., oval to round, numbering usually 7 or 8.

Crystals.—Very numerous.

Hard Bast.—Strongly developed, continuous, and usually dense.

Wood-curve (see Figs. 32 and 33*a*).—Body thickened, particularly at the centre, and gently incurved horns, each about one-third length of body, and directed towards it at the tip.

Vessels.—Largest, $\frac{1}{700}$ in.

Average, about half that.

Comparatively large and numerous, radially arranged, and distributed mainly in upper half. A number of large vessels usually scattered about lower portions of wood.

Characteristic features:

Section.—Average size, slightly broader than thick.

Cortical Cavities.—Large, and numbering about 7 or 8.

Crystals.—Very numerous.

Hard Bast.—Well-developed and dense.

Wood-curve.—With thickened body, and horns curving gently inward.

Vessels.—Large, numerous, and distributed mostly in upper half, but sparingly along lower margin of wood.

Remark.—In one petiole examined, all the sections showed an isolated bundle at one side of the ordinary curve.

This species, however, shows as little tendency to broken and isolated wood-curve as any other examined.

X.—Forms Belonging to South Australia, Tasmania, Victoria, and New South Wales.

24. *E. obliqua*, L'Heritier; messmate.

Tree.—Lofty.

Leaves.—Very inequilateral at base, equally green on both sides.

Size of Section.— $1\frac{1}{4}$ lines broad by 1 line thick, or $1\frac{1}{4}$ times broader than thick.
Outline of Section.—Oval to circular, sometimes flat on upper surface.
Epidermis.—Thickness, $\frac{1}{460}$ — $\frac{1}{570}$ in.
Breadth, about $\frac{1}{1150}$ in.
Cortical Cavities.—$\frac{1}{110}$ in., roundish, numbering from 7 to 2.
Crystals.—Few.
Hard Bast.—Well developed, continuous, and many cells thick.
Wood-curve (see Fig. 34).—Comparatively slender body, with short horns elevated or gently incurved.
Vessels.—Largest, $\frac{1}{760}$ in.
Average, about half that.
Large, numerous, and pretty regularly distributed, but most numerous towards upper portion of wood.

Characteristic features:
Section.—Large.
Epidermis.—Thickish.
Cortical Cavities.—Large.
Hard Bast.—Well developed and dense, especially between the horns.
Wood-curve.—With slender body and short horns.
Vessels.—Large, numerous, and pretty regularly distributed.

25. *E. amygdalina*, Labillardière; giant Eucalypt, Dandenong peppermint, mountain ash.
Reputed to be the tallest of trees.
Leaves.—Thin, equally green on both sides, with copious and transparent oil-dots.
Size of Section.—About $\frac{1}{2}$ line broad and thick, or equally broad and thick.
Outline of Section.—Oval to round, with occasionally a flattened upper surface.
Epidermis.—Thickness, $\frac{1}{700}$ — $\frac{1}{760}$ in.
Breadth, $\frac{1}{1150}$ — $\frac{1}{1500}$ in.
Cortical Cavities.—$\frac{1}{230}$ in., oval or round, numbering from 7 to 2.
Crystals.—Numerous.
Hard Bast.—Sparingly developed, one or a few cells thick.
Wood-curve (see Fig. 35).—Body excessively thick, with short stout horns elevated or slightly incurved; always found entire.
Vessels.—Largest, $\frac{1}{1150}$ in.
Average, about half that.
Small, moderately numerous, on radiating lines, generally equally distributed, but scanty towards lower margin.

Characteristic features:

Section.—Exceptionally small, equally broad and thick.

Cortical Cavities.—Small.

Hard Bast.—Composed of few cells, but strongly thickened.

Wood-curve.—Always found entire, with excessively stout body and short, stout horns.

Vessels.—Small, moderately numerous, and pretty regularly distributed.

Remarks.—In proportion to the size of the section, the wood-curve is the thickest of any yet investigated. This is of interest in connection with such a very tall tree, since the water must be raised so great a distance to reach the topmost boughs. It was also observed that the leaves from this tree did not, in the least, discolour the water in which they were kept for some months, although all other species examined did so, more or less.

26. *E. viminalis*, Labillardière; Manna-Eucalypt.

Tree.—Tall, and sometimes even gigantic.

Leaves.—Thin, equally green on both sides.

Size of Section.—Either 1 line broad by $\frac{3}{4}$ line thick, or of equal breadth and thickness.

Outline of Section.—Round to egg-shaped, or flattened on top, so as to become somewhat hemispherical.

Epidermis.– Thickness, $\frac{1}{1150}$ in.

Breadth, as broad as thick, and sometimes broader.

Cortical Cavities.—$\frac{1}{110}$ in. in some sections, and only half that in others; roundish to oval; numbering from 7, often 2, and sometimes absent.

Crystals.—Numerous, and sometimes large.

Hard Bast.—Moderately developed; slightly discontinuous; 1 sometimes, but mostly several cells thick.

Wood-curve (see Figs. 36 and 36*a*).—Body straight and thickened, with short, sharply incurved, and usually broken horns. Occasionally a distinct isolated bundle at side of one of the horns.

Vessels.—Largest, from $\frac{1}{1300}$ — $\frac{1}{1800}$ in.

Average.—$\frac{1}{1300}$ in.

Small, comparatively few or moderately numerous, mostly distributed towards upper portion of wood, and generally absent from horns.

Characteristic features:

Section.—Average size.

Epidermis.—Relatively thin, composed of cells at least as broad as thick.

Cortical Cavities.—Medium size, often few.

Wood-curve.—Straight and thickened body, with short, sharply incurved horns, often in detached parts.

Vessels.—Small, and distributed on upper portion of wood, generally absent from horns.

27. *E. gunnii*, J. Hooker; swamp gum or cider Eucalypt.

Tree.—Usually not tall.

Leaves.—Equally dark green on both sides.

Size of Section.—1¼ lines broad by 1 line thick, or 1¼ lines broader than thick.

Outline of Section.—Oval to round, sometimes flattened on top.

Epidermis.—Thickness, $\frac{1}{610}$ — $\frac{1}{760}$ in.

Breadth, about $\frac{1}{1150}$ in.

Cortical Cavities.—$\frac{1}{100}$ in., round or oval, numbering from 9 to 2.

Crystals.—Few.

Hard Bast.—Well developed, nearly continuous, and several layers of cells thick.

Wood-curve (see Fig. 37).—Body thickened (thickness sometimes $\frac{1}{115}$ in.), with short and sharply incurved horns directed towards body.

Vessels.—Largest, $\frac{1}{830}$ in.

Average, $\frac{1}{1500}$ in., or about half the largest.

Moderately large and numerous, and pretty equally distributed with large ones at lower portion of wood as in *globulus*.

Characteristic features:

Section.—Relatively large.

Cortical Cavities.—Large and moderately numerous.

Hard Bast.—Somewhat dense.

Wood-curve.—With thickened body and short horns directed towards it.

Vessels.—Moderately large, numerous, and pretty generally distributed.

XI.—Form Belonging to South Australia, Tasmania, Victoria, New South Wales, and Queensland.

28. *E. stuartiana*, F. v. M.; apple-scented Eucalypt.

Tree.—Moderate-sized.

Leaves.—Equally dark-green on both sides.

Size of Section.—About ½ line broad by ⅓ line thick, or about 1½ times broader than thick.

Outline of Section.—Oval.

Epidermis.—Thickness, $\frac{1}{1150}$ in.

Breadth, $\frac{1}{1380}$ — $\frac{1}{1150}$ in., or sometimes as broad as thick.

Cortical Cavities.—$\frac{1}{250}$ in., oval to irregularly round, numbering about 6.

Crystals.—Moderately numerous.

Hard Bast.—Almost continuous, regular, generally two or three cells thick.

Wood-curve (see Fig. 38).—Body curved and moderately thickened (thickness sometimes $\frac{1}{160}$ in.), with short and sharply incurved horns.

Vessels.—Largest, $\frac{1}{1150}$ in.

Average, about half that.

Small, numerous, and generally distributed towards upper and middle portion of wood.

Characteristic features:

Section.—Small.

Epidermis.—Relatively thin, component cells often as broad as thick.

Cortical Cavities.—Small.

Hard Bast.—Regular, but not very dense.

Wood-curve.—Moderately thick, and horns somewhat sharply incurved.

Vessels.—Small, numerous, and distributed towards upper and middle portion of wood.

XII.—Form Belonging to South Australia, Victoria, New South Wales, and Queensland.

29. *E. leucoxylon*, F. v. M.; Victorian ironbark.

Tree.—Moderate size.

Leaves.—Equally dull-green on both sides, with copious, pellucid oil-dots.

Size of Section.—1½ lines broad by ¾ line thick, or twice as broad as thick.

Outline of Section.—Roundish, flattened, or somewhat quadrangular.

Epidermis.—Thickness, $\frac{1}{760}$ in.

Breadth, $\frac{1}{1150}$ — $\frac{1}{1500}$ in.

Cortical Cavities.—$\frac{1}{110}$ in. oval, numbering from 9 to 1, or none.

Crystals.—Moderately numerous.

Hard Bast.—Poorly developed; in many places entirely absent.

Wood-curve (see Figs. 39 and 39*a*, *b*, *c*).—Body variable in thickness, and longer or shorter horns, gently incurved.

Vessels.—Largest, $\frac{1}{1000}$ in.

Average, $\frac{1}{1600}$ in.

Medium-sized and numerous, radially arranged, and regularly distributed.

Characteristic features:

Section.—Large, twice as broad as thick.

Cortical Cavities.—Large.

Hard Bast.—Scantily developed.

Vessels.—Medium-sized, numerous, and regularly distributed.

XIII.—Form Belonging to Western Australia, South Australia, Victoria, New South Wales, Queensland, and North Australia.

30. *E. rostrata*, Schlechtendal; red gum.

Tree.—Of moderate size, often attaining a height of over 100ft.

Leaves.—Equally green on both sides.

Size of Section.—About $\frac{1}{2}$ line broad and thick, or equally broad as thick.

Outline of Section.—From round to irregular oval, generally with somewhat flattened upper surface.

Epidermis.—Thickness, $\frac{1}{760}$ in.

Breadth, about $\frac{1}{1150}$ in.

Cortical Cavities.—$\frac{1}{210}$ in., roundish, numbering from 8 to none.

Crystals.—Moderately numerous.

Hard Bast.—Sparingly developed, discontinuous; one or a few cells thick.

Wood-curve (see Fig. 40).—Thickened body, and stout short horns, usually gently incurved.

Vessels.—Largest, $\frac{1}{1000}$ in.

Average, $\frac{1}{1800}$ in.

Moderately large and numerous, mainly distributed in upper portion.

Characteristic features:

Section.—Small, equally broad and thick.

Cortical Cavities.—Small and variable in number.

Hard Bast.—Scanty.

Wood-curve.—Moderately thickened, and short, stout horns.

Vessels.—Medium-sized, numerous, and mainly distributed in upper portion of wood.

XIV.—Forms Belonging to West Australia, South Australia, Victoria, and New South Wales.

We are indebted to Mr. Bosisto for specimens of the leaves of *E. uncinata* (Turczaninow) and *E. oleosa* (F. v. M.), from the district between Dimboola and Lake

Hindmarsh. They constitute large portions of the "Mallee Scrub," and along with *E. incrassata*, Labillardière, and its smaller variety, *E. dumosa*, are the only species of Eucalypt with the above Australian distribution, according to present knowledge.

They are all shrubby, or at most somewhat arboreous, with leaves equally green on both sides.

Only a few sections were made of *uncinata* and *oleosa*, but there is a decided difference between the wood-curve of each, so that they are thereby easily distinguished. (Figs. 41 and 42.)

It is believed that the foregoing descriptions, with the accompanying drawings, when taken in conjunction with external leaf characters, will materially aid in the discrimination of the investigated species. Various specimens have been taken at random and tested, and referred to their respective types.

As a very instructive example of this, no better could be given than the following:—One of us had a few leaves sent without any information as to their nature or locality, and sections were made in due course, and the following notes:— "The leaf looks like that of *citriodora*, but the characteristic odour is wanting. The first section shows two canals, and fairly numerous cortical cavities; outline somewhat like *citriodora*. A second section from another petiole has very irregular outline, but otherwise agrees with the first. A third section was cut from another petiole, which was still more like *citriodora*, a third canal tube appearing as in one of the type specimens of that species. I conclude that this specimen is either a variety of *citriodora*, or another very closely allied species." The leaf belonged to *E. maculata*, thus justifying, from quite an independent source, Baron von Mueller's determination of *citriodora* as a variety of that species.

And, in the practical test to be presently described, the utility of the method will be more fully shown. But, apart altogether from the practical utility of this investigation, there is new light thrown on the histology of this important genus.

M. L. Petit* has described the structure of the petiole of Dicotyledons in 48 families, including 300 genera and nearly 500 species, one of the families being the Myrtaceæ, to which the Eucalypts belong.

He found the form of the petiole to be always convex below and concave on the upper face, whereas our observations show, in the twisted petioles of Eucalypts, that while this is often the case it is not invariably so. Thus, in *obcordata* and *alpina* the upper surface of the section is more convex than the lower, and in *grossa* and *rostrata* the section is round. The lower surface is generally convex and the upper flat.

* Mem. Sci. Phys. and Nat. Bordeaux III. (1887).

As to the fibro-vascular system, it is observed that aggregation of the bundles generally occurs in woody plants, as we found to be the case, and that bicollateral bundles occur in the Myrtaceæ, among others. In the genus Eucalyptus, at any rate, the bundles are concentric.

However, the importance of the structure of the petiole for taxonomic purposes is clearly established in this paper, and he naturally insists on the importance of the petiole for purposes of classification.

A few of the facts recorded in the various suggestive and instructive papers on the Eucalypts by J. Bosisto, Esq., C.M.G., read at different periods before this Society,* may be noticed in connection with our present subject. He is led to the important conclusion that the volatile oil is the base of other products, such as resin-like substances, inasmuch as those species, great in the production of the oil, vigorously supply it to the atmosphere, and thus do not allow sufficient time for the formation of resinoid bodies, which require the absorption of oxygen by the leaf; and, conversely, those species less vigorous in oil production allow time for such a purpose, and so become well stored.

This suggested to us that there might be some relation between the size and number of cortical cavities, and the greater or less production of oil or resinoid bodies respectively. Two of the chief oil-producing species are *amygdalina* and *globulus*, and of kino-producing species, *leucoxylon* and *rostrata*. On referring to the detailed description, *amygdalina* is found to have the smallest and fewest cavities of any of these, being even surpassed by *viminalis*, which yields the least oil. *Globulus* has certainly large and moderately numerous cavities, but, on the other hand, *leucoxylon* is not far behind it, which yields kino to the extent of even 22 per cent. from fresh bark.

We have observed that as a rule the notable producers of oil do not show numerous cortical cavities in their petioles, so that we may perhaps conclude that the production of kino in the leaf-stalk is not immediately dependent on the production of oil in the leaf-blade. It is in the leaf-blade alone that the oil is manufactured, as it was proved to be absent from the petiole, so that, contradictory as it may appear, it is in the leaf-blade, with its two surfaces equally exposed to sun and air, that the least oxidised constituent—the volatile oil—is made. To prove the absence of oil from the leaf-stalk (at least in *amygdalina*, and presumably in the others), a simple experiment was made, which may be briefly described.

Branchlets of fresh leaves were kindly supplied by Mr. Slater, of Mitcham Grove, such as he is in the habit of using for distilling his well-known oil. The largest and best leaves were selected, and 1000 petioles carefully snipped off and

* See Trans. and Proceedings of Roy. Soc. of Vict., Vol. XII., &c.

weighed, amounting to a little over 200 grains. They were distilled by passing a current of steam through them for some time, but not a trace of oil, not even the smell of it, was obtained.

Hence it would appear that the volatile oil is confined to the leaf blade, the flower-buds, and the fruit-capsules.

The presence of central canals or reservoirs throughout the length of the petiole in *calophylla*, and its close ally *ficifolia*, *maculata*, and its variety *citriodora*, it is not easy to explain. When it is known whether they occur in any, and in what other forms, one may perhaps venture on an explanation. It is noteworthy that in *calophylla* the kino is a liquid of treacle-like consistence, and obtained in considerable quantity by tapping the tree (Euc. Dec. X.), and that of *maculata* is readily soluble in hot water (Dec. III.)

While weighing the leaf-stalks for the above purpose the weight of the leaf-blades belonging to them was likewise determined. The blades were sometimes imperfect from the ravages of insects or decay, so that the relative weight errs on the side of defect; 1000 leaf-blades were found to weigh 4832½grs., and the corresponding leaf-stalks 212grs., so that, on an average, each stalk has to bear a weight at least 23 times that of its own.

VI. A Practical Test.

In order to settle how far the transverse section of the petiole alone was capable of determining species, we decided to submit the matter to a practical and very searching test. The names of the 30 kinds investigated by us were handed to Mr. Guilfoyle, and he selected specimens of leaves of *six* of them. These were sent to us with numbers attached, while the names were retained by him. It will be seen that the test was really very severe, even more so than would occur in actual practice. In the first place the *locality* of the tree would be known, when met with in its native state, and by referring to the Table of Geographical Distribution (Table I.), the area of selection would be limited. In the next place, there are certain characters belonging to the leaf *as a whole*, which would help to settle specific nature. These two features are taken into account in the next section, dealing with a scheme for determining species, but we thought it well to settle how far anatomic structure of the leaf-stalk, apart from other characters, could be depended on for specific distinction. This trial justifies us in our belief, that while sections of the leaf-stalk may be valuable *aids* in the discrimination of species, it would be unsafe to rely upon them exclusively.

The result of this test was that four were named correctly and two wrongly, as shown in the following, sent by Mr. Guilfoyle :—

		YOURS.		MINE.
No. 1	....	E. cornuta	....	E. cornuta
,, 2	....	,, corynocalyx	....	,, corynocalyx
,, 3	....	,, gomphocephala	....	,, gomphocephala
,, 4	....	,, megacarpa	....	,, megacarpa
,, 5	....	,, viminalis	....	,, occidentalis
,, 6	....	,, melliodora	....	,, punctata

It will not be necessary to say much about the first four, which were correctly named, but the two latter incorrectly named deserve further notice. The following remarks are meant to show the principal points which guided us in coming to a decision.

No. 1. *E. cornuta* showed the characteristic features in the size and shape of the section; the large and numerous cortical cavities quite close together; crystals moderately numerous; the wood-pattern continuous or often discontinuous at the horns, which are sharply incurved (as in Fig. 12), and the vessels distributed towards the middle and upper portion of wood.

No. 2. *E. corynocalyx* showed numerous but comparatively small cortical cavities; crystals rather few; relatively few hard bast cells; symmetrical and generally entire wood-pattern, with slender, short, and gently incurved horns. (Fig. 27.)

No. 3. *E. gomphocephala* showed few and moderately large cortical cavities; wood-pattern, with very stout body and horns well curved in, and approaching each other; and the vessels large and numerous, and mostly in upper portion of wood. The large proportion of wood is a feature of Gomphocephala. (Fig. 17.)

No. 4. *E. megacarpa* showed flattened section, tending to angularity, and nearly twice as broad as thick; hard bast irregular, and cells arranged in patches; wood-pattern, with slender body, slightly thickened in middle, and short horns gently incurved. (Fig. 18.)

No. 5. *E. occidentalis* (determined as *E. viminalis).* Since *E. occidentalis* is confined to Western Australia, and *E. viminalis* does not occur there, it is evident that the locality of the specimen would have prevented that mistake.

As this particular specimen was somewhat puzzling to determine, it received special attention, and the following diagnosis of it was made by one of us :—

Outline of Section.—Oval; flattened on upper surface.

Outer wall of Epidermis.—$\frac{1}{1500}$ in., relatively thin.

Cortex.—Consisting of rather loose tissue.

Crystals.—Very numerous and in clusters.

Cortical Cavities.—Five is a common number; sometimes very large, about $\frac{1}{90}$ in.

Wood-pattern.—Always unbroken.

Vessels.—Moderately numerous; distributed towards upper portion and middle of wood; largest about $\frac{1}{600}$ in.

Body of curve is thickened about middle, and the two short horns curve gently and symmetrically upward and inward.

The *thinness* of the epidermis, the number and relative size of the cortical cavities, the loose tissue of the cortex, the hard bast of few cells, but regularly distributed, the wood-pattern, and the distribution of the large and numerous vessels, seemed to point to *viminalis*. But the specimen turns out to belong to a tree which is exceedingly variable; "so variable," as Baron von Mueller expresses it, "as to change much of former ideas as regards the precincts of Eucalyptus species," and therefore it would have been a mere accident to have determined it accurately from the construction of the leaf-stalk alone.

No. 6. *E. punctata* (determined as *E. melliodora*). There is a general agreement between these two forms in the small size and round shape of the section, the thickness of epidermis, the number and size of cortical cavities, the hard bast composed of few cells, and the general features of the wood-curve. But in the former the vessels of the wood are relatively few, small, and scattered; and in the latter twice the size, numerous, and equally distributed. Further, crystals are very few in *punctata*, but very numerous in *melliodora*.

It is thus shown in a practical way how the minute structure of the leaf-stalk may be employed in the acknowledged difficult task of determining Eucalyptus species. As might be anticipated, this structure will vary according to differences in soil and climate, heat and moisture, but there is still a certain amount of constancy in the internal characters which renders their aid valuable. It is not the failure of the system adopted, but the imperfection of it, which prevents its wider application. Taking the characters of the leaf as a whole, and not merely sections of the petiole, it is believed that specific distinctions might be decided thereby.

VII.—Scheme for Determining Species.

As our investigations proceeded it became evident that some scheme of arrangement might be devised, whereby the different species could be more or less completely separated, by taking all the characters derivable from the leaf. In framing this scheme we took the external leaf-characters principally from Baron von Mueller's "Eucalyptographia," where the most minute peculiarities are clearly noted, and combined them with such characters as were peculiar to the section of the leaf-stalk.

It will be understood that this scheme is by no means meant to be final, since it is concerned with thirty species selected at random from the whole range of genera; but it is merely given to show *how* such a scheme might be constructed for any definite and restricted section of the Eucalyptus-species. Thus, when all the Victorian species have been investigated as to the structure of their petioles, it will be possible so to arrange them that the different species will be more or less clearly marked out.

With this qualification, the scheme applicable to the thirty species will now be indicated, and may be generally represented as follows :—

Section I.—Central Canals present.
,, II.— ,, ,, absent.

Section I.

A. Cortical Cavities large—

1. Hard Bast well developed—

1. E. maculata.

2. Hard Bast feebly developed—

2. E. maculata, var. citriodora.
3. E. calophylla.

B. Cortical Cavities small—

4. E. ficifolia.

Section II.

A. Leaves equally green on both sides—

1. Cortical Cavities large—

a. Hard Bast well-developed—

A. Vessels of Wood relatively large—

5. E. cornuta.
6. E. tetraptera.
7. E. obliqua.
8. E. gunnii.
9. E. megacarpa.
10. E. macrorrhyncha.
11. E. globulus.

B. Vessels of Wood small—

12. E. alpina.
13. E. viminalis.

b. Hard Bast feebly developed—

A. Vessels of Wood relatively large—

14. E. leucoxylon.
15. E. grossa.
16. E. occidentalis.

B. Vessels of Wood small—

17. E. cornuta var. lehmanni.
18. E. obcordata.

2. Cortical Cavities small—

a. Hard Bast well developed—

19. E. stuartiana.
20. E. melliodora.

b. Hard Bast feebly developed—

21. E. amygdalina.
22. E. rostrata.
23. E. rudis.
24. E. tereticornis.

B. Leaves unequally green on both sides—

1. Cortical Cavities large—

a. Hard Bast well developed—

25. E. gomphocephala.
26. E. marginata.

b. Hard Bast feebly developed—

27. E. saligna.
28. E. punctata.

2. Cortical Cavities, small—

Hard Bast feebly developed—

29. E. corynocalyx.
30. E. diversicolor.

The first and most general division is based upon the presence or absence of central canals.

Then such a limited Section as I. is comparatively easily disposed of. The cortical cavities are either large or small.

SECTION I.

A. Cortical Cavities large—
  1. Hard Bast well developed—
    1. E. maculata.
  2. Hard Bast poorly developed—
    a. Leaves, lemon-scented, and equally green on both sides—
      2. E. maculata, var. citriodora.
    b. Leaves unequally green on both sides—
      3. E. calophylla.

B. Cortical Cavities small—
  4. E. ficifolia.

In Section II. the first division may be based upon the leaves being equally or unequally green on both sides.

SECTION II.

A. Leaves equally green on both sides—
  1. Cortical Cavities large—
    a. Hard Bast well-developed—
      A. Vessels of Wood relatively large—
        (1) Section small—
          5. E. cornuta.
        (2) Section large—
          (*a*) Epidermis very thick—
            6. E. tetraptera.
          (*b*) Epidermis thickish and wood-curve slender—
            7. E. obliqua.
          (*c*) Epidermis thinner and wood-curve thicker—
            8. E. gunnii.
        (3) Section of average size—
          (*a*) Section twice as broad as thick—
            9. E. megacarpa
          (*b*) Wood-curve always entire, and exceedingly thickened—
            10. E. macrorrhyncha.

(*c*) Wood-curve almost always entire, and ordinarily thick—

11. E. globulus.

B. Vessels of Wood small—

(1) Section large and epidermis of average thickness—

12. E. alpina.

(2) Section of average size and epidermis thin—

13. E. viminalis.

b. Hard Bast poorly developed—

A. Vessels of Wood relatively large—

(1) Section large, twice as broad as thick—

14. E. leucoxylon.

(2) Section of average size—

(*a*) Epidermis relatively thick—

15. E. grossa.

(*b*) Epidermis of average thickness—

16. E. occidentalis.

B. Vessels of wood small—

(1) Section twice as broad as thick—

17. E. cornuta, var. lehmanni.

(2) Section as broad as thick—

18. E. obcordata.

2. Cortical Cavities small—

a. Hard Bast well-developed—

A. Epidermis relatively thin—

19. E. stuartiana.

B. Epidermis of average thickness—

20. E. melliodora.

b. Hard Bast feebly developed—

A. Wood-curve excessively thick—

21. E. amygdalina.

B. Vessels medium-sized—

22. E. rostrata.

C. Vessels comparatively small—

(1) Epidermis thicker—

23. E. rudis.

(2) Epidermis thinner—

24. E. tereticornis.

Section II. B. may be further subdivided according to the size of the cortical cavities and the development of the hard bast.

B. Leaves unequally green on both sides—
- 1. Cortical Cavities large—
  - *a.* Hard Bast well-developed—
    - A. Wood-curve exceedingly thickened—
      25. E. gomphocephala.
    - B. Wood-curve slender—
      26. E. marginata.
  - *b.* Hard Bast feebly developed—
    - A. Vessels moderately large and numerous—
      27. E. saligna.
    - B. Vessels small and few—
      28. E. punctata.
- 2. Cortical Cavities small—
  - *a.* Comparatively numerous—
    29. E. corynocalyx.
  - *b.* Relatively few and very small—
    30. E. diversicolor.

VIII. Species Compared and Contrasted.

Before instituting comparisons between different species, it seemed advisable to give the characters for all the species as derived from the transverse sections, and then one was in a position to say where resemblances might be traced. Of course it must be borne in mind that out of 134 recorded species, only 30 different kinds are here considered, so that the range is rather limited for making perfectly just comparisons ; still, as far as it goes, it will be useful to take a comparative view, at least for some of the species.

In the "Eucalyptographia," the affinity between certain species (and even probable identity) is often pointed out, and we will now select some of the more important of these, in order to see how far we agree with, and wherein we differ from, Baron von Mueller, in his views of affinity, views which are based upon other characters, and are the result of prolonged, and careful, and exhaustive study of this special group. It will facilitate this comparison if we give a brief abstract of the allied species. In the following table (III.) the principal affinities are classified, and short reference is made to each :—

TABLE III.

SPECIES AND THEIR ALLIES (According to Baron von Mueller).

SPECIES.	ALLIED SPECIES.	REMARKS.
1. Globulus	Alpina Megacarpa	
2. Rostrata	Viminalis Tereticornis Rudis	"Instances occur when Rostrata merges almost into Viminalis, and completely into Tereticornis. It is also almost linked by exceptional transit forms with E. rudis." (Dec. 4.)
3. Viminalis	Rostrata Stuartiana	"E. viminalis is closely allied as well to E. rostrata as to E. stuartiana." (Dec. 10).
4. Stuartiana	Gunnii Viminalis	
5. Ficifolia	Calophylla	
6. Maculata	Citriodora	"Citriodora can only be considered a variety differing merely in the exquisite lemon-scent of its leaves." (Dec. 3.)
7. Cornuta	Lehmani	"Specifically inseparable." (Dec. 9.)
8. Occidentalis	Cornuta Obcordata	"The lines of demarcation between these three are not always very clear." (Dec. 6.)

1. As regards *E. globulus* and *E. alpina*, it is stated *E. alpina* "stands to that species in nearest systematic affinity" (Decade 2), and *E. megacarpa* likewise "bears in some respects alliance to *E. globulus*" (Dec. 6). If the sections are compared there is a suggestion of resemblance between these three species, but in alpina the smaller vessels and more numerous cortical cavities distinguish it, while in *megacarpa* the cortical cavities are generally smaller. In both the comparatively few crystals contrast with the large number in *E. globulus*.

2. Again, it is said of *E. rostrata* and *E. tereticornis* that "both might be regarded as forms of one species" (Dec. 9), and of *E. rostrata* and *E. rudis* that they are "also almost linked by exceptional transit-forms" (Dec. 4). It is further stated, "On the whole this is one of the most easily recognised of all species; still instances occur when it merges almost into *E. viminalis*, and completely into *E. tereticornis*" (Dec. 4).

On referring to the preceding scheme of arrangement it will be seen that *rostrata*, *rudis*, and *tereticornis* are grouped together, but *viminalis* does not seem to be very closely allied. On comparing the sections it is found that they exhibit resemblance in the following order:—*Rostrata*, *tereticornis*, *rudis*.

It is likewise interesting to note that both *E. rostrata* and *E. tereticornis* have their leaves sometimes devoured by the same insect (Dec. 9).

When *rostrata* and *tereticornis* are compared as regards the minute structure of the leaf-stalk (and it may be mentioned that the characters of each were drawn out quite independently), it is found that their close affinity, determined on other grounds, is borne out.

Summarising the principal differences between them, as given in the "Eucalyptographia," and in the more recent "Key to the System of Victorian Plants," as well as those deduced from the transverse section of the petiole, they are as follows :—

	Rostrata.	Tereticornis.
Calyx-tube	Nearly hemispherical	Almost semi-ovate.
Calyx-lid	Hemispheric and sharp-pointed at top..	Elongate-conical—longer and blunter at top.
Stamens	Outer inflexed before expansion ..	Outer straight before expansion (room for straightening in the longer calyx-lid).
Section of Petiole—		
Crystals	Moderately numerous	Very numerous.
Vessels	Moderately large	Comparatively small.

Such small differences completely justify *tereticornis* being regarded as merely a variety of *rostrata*, but the latter, being the most cosmopolitan of all the Eucalypts as far as Australia is concerned, might be expected to have undergone some modification of structure in order to adapt it to its wider environment.

3. *E. viminalis* is said to be closely allied to *E. stuartiana* as well as to *E. rostrata* (Dec. 10). The thicker epidermis of *E. rostrata*, the generally smaller cortical cavities, the feebly developed hard bast, and the relatively larger vessels distinguish it. *Stuartiana* agrees, on the other hand, generally in the thinness of the epidermis, the development of the hard bast, and the small size of the vessels, but the cortical cavities are much smaller.

4. When *stuartiana* and *gunnii* are compared, the differences are clearly marked. In *gunnii* the thicker epidermis, the larger cortical cavities, and the wider vessels form a contrast, but in the development of the hard bast, and the thickness and curving of the wood, there is general agreement.

5. *Ficifolia* and *calophylla* are nearly allied, and it is said of the latter that it is "the only species to which *E. ficifolia* bears very close alliance" (Dec. 7).

The sections reveal a very close general agreement indeed, the presence of two internal canals normally in each, showing this. *Calophylla* has a much thicker wood-pattern, and large and numerous cortical cavities, while in *ficifolia* they are very few and very small, but the greater size of the former tree, as compared with the latter, might account for this difference.

6. *Maculata* and *citriodora* may be considered here, since both possess the internal canals. It is stated that "*citriodora* can only be considered a variety of *maculata*, differing merely in the exquisite lemon-scent of its leaves" (Dec. 3). And

it is a striking corroboration of this that a study of the two sections leads to the same conclusion. Further, there is a remarkable resemblance between the relations of the sections of *maculata* and *citriodora*, and *calophylla* and *ficifolia*. There is the similar stout and slender wood-pattern respectively in both, although the cortical cavities are about equally numerous and equally large in *maculata* and *citriodora*. In *ficifolia* it would appear that the stunted habit of the tree had rendered large and numerous cortical cavities less necessary, and so they have dwindled down in size and numbers, whereas the variety of *maculata* has lost nothing of its stateliness. Such are some of the affinities which have been noted by Baron von Mueller, and which are borne out as well by the transverse sections of petioles. Let us turn now to some others which do not agree with our sections.

The affinities of *E. viminalis* have already been discussed.

7. *E. lehmanni* is said to be "specifically inseparable from *E. cornuta*" (Dec. 9), but a glance at the two sections would not suggest it. There is resemblance in the large and numerous cortical cavities, and in the much broken wood-pattern, but the vessels in *cornuta* are much larger and more numerous, and the wood-curve is considerably thicker. Altogether, the resemblances in the sections would not justify their being classed together as the same species, or the one as a variety of the other.

How are we to regard a discrepancy of this sort? Are we to regard the deep-seated characters of the leaf-stalk as delusive? External resemblances and allied internal anatomy do not always go together, for there may be fundamental difference, accompanied by superficial resemblance, just as there may be fundamental resemblance with superficial difference. We consider that the relationship may still hold between *E. cornuta* and *E. lehmanni*, the latter being a variety of the former, even in spite of seeming contradiction from the section, when it is remembered what aberrant and extreme forms are assumed by some species, and the extent of their variability. That this applies here will now be shown. In arranging our sections independently of external characters in the first instance, *E. occidentalis* was placed next to *E. lehmanni*, which naturally formed the last term of the present series. The section of the petiole of *E. occidentalis* exhibits a wood-pattern of such an irregular nature that it is difficult to say what it resembles exactly, and yet it is suggestive of resemblance to a number of forms. It is, in short, just such a form of section as might easily develop into several of the others, and so we were unable to correlate it with any. In considering the affinities of *E. occidentalis* in the "Eucalyptographia" (Dec. 6), much light is thrown on the present difficulty.

First of all, we are informed that *E. cornuta*, *E. obcordata*, and *E. occidentalis* "seem to be the only three entitled to specific rank in the series of *cornuta* or *orthostemoneae*, and even the lines of demarcation between these three are not always very clear." So this brings *E. occidentalis* into some sort of affinity with *E. cornuta*, and, by implication, with its variety, *E. lehmanni*. When the section of the latter is compared with *E. occidentalis*, there is undoubtedly a certain resemblance, but not directly, with *E. cornuta*.

Again, it is found from extended observation and increased material, that *E. occidentalis* runs more or less into at least six named species (not reckoning two varieties of *E. cornuta*), viz.:—

E. spathulata, Hook.
E. macrandra, F. v. M.
E. cornuta, Labillardière.
E. obcordata, Turcz.
E. redunca, Schauer.
E. pachypoda, F. v. M.

And the inference is that *E. occidentalis* is capable of and subject to a vast amount of variability.

Nay, further, in the concluding sentence of the notice of this form, it is stated "*E. occidentalis*, in its scope as here considered, seems so variable as to change much of former ideas as regards the precincts of Eucalyptus-species, a similar playfulness of forms having been observed by me in *E. stricta* and *E. incrassata*, the characters of shrubby Eucalypts proving generally less constant than those of the tall timber-trees of this genus" (Dec. 6).

In such a sentence as that there is contained the essence of a volume on the "Origin of Species." And when we consider that at least three species—*E. glauca*, *E. pulverulenta*, and *E. perfoliata*—have been based upon the young state of *E. globulus* (Dec. 6), it is not to be wondered at, but rather to be expected, that in such a variable genus of plants there would be striking resemblance in internal structure, as well as a certain amount of diversity.

IX.—Concluding Remarks.

If transverse sections of the petioles can be used as an important aid in the determination of species, then it is evident that this test may be applied where there is doubt as to specific identity.

Thus there is a remarkable resemblance, for instance, between the sections of the petioles of *E. calophylla* and *E. ficifolia*, and the question arises—Are they to be regarded as distinct species or not?

The principal differences between *E. ficifolia* and *E. calophylla*, as given by Baron von Mueller in his "Eucalyptographia" (Dec. 7), are as follows:—

E. ficifolia.

Tree.—Of less height.

Bark.—Somewhat more deeply furrowed.

Leaves.—Proportionately not quite so broad, but longer.

Flowers.—Mostly larger.

Calyces.—Assume a reddish hue.

Fruits.—Less turgid.

Seeds.—Much paler in colour, have a smaller kernel, and are provided with conspicuous appendicular membranes.

If the leading *specific* differences of the same authority be compared, it will be found that the *crimson filament* and the *pale seeds*, with a long membrane, of *E. ficifolia* are the principal offsets against the pale-yellowish, rarely pink filaments, and dark membraneless seeds of *E. calophylla.*

Here the differences are comparatively small, but the characters, such as they are, being permanent, are considered sufficient to fix this as a distinct species.

If we turn to the characters revealed by the petiole, the same remark applies.

The broad differences separating *ficifolia* from *calophylla* are:—

Slightly thicker epidermis, with a strong development of hypoderm, although there are indications of something similar to the latter in *calophylla.*

Cortical Cavities.—Much fewer and smaller.

Central Canals.—Smaller.

Vessels.—About the same size, slightly larger, but weaker development of wood.

Such permanent differences probably entitle *E. ficifolia* to specific rank, but it will be observed that the differences are just such as might arise from the same kind of tree, from any cause, becoming dwarfed and stunted in growth.

Both belong to the furrowed bark series (Schizophloiæ), have anthers opening by parallel slits (Parallelantheræ), and pollen-grains of the same size. The fruits in both are urn-shaped, and their habitat is confined to Western Australia.

To take just another striking example. *E. citriodora* is regarded on general grounds as a variety of *E. maculata*, and from the transverse sections of the petioles of both the same conclusion might be drawn. It is a suggestive fact that the resemblances and differences are mainly of a parallel kind with those of *E. ficifolia* and *E. calophylla*. But the differences are evidently less in degree, or rather the resemblances are closer, for they generally agree in thickness of epidermis, size, and number of cortical cavities, and size of central canals. But the vessels are about twice the size of those of *maculata*, while the wood itself is relatively much more feebly developed.

On the whole the study of the transverse sections of petioles of well-developed and fully-formed leaves of Eucalypts has led us to the following conclusions :—

1. Fresh species may be identified by means of such sections, combined with external characters of the leaf. The aggregate characters of the section are employed but chiefly those derived from the following parts:—Epidermis, hard bast, wood with its vessels, cortical cavities, and central canals.

2. Herbarium material, by appropriate treatment, may likewise be used.

3. The size and shape of the transverse section is often characteristic.

4. The relative thinness or thickness of the epidermis is a more or less constant feature, and it is often indicative of the habitat of a plant, say of a desert species.

5. The number, size, and arrangement of cortical cavities are very variable, but their relatively large *size* in some species is such a striking feature that it may be used for purposes of discrimination.

6. The central canals are so decided and distinct, and occur in such a limited number (at least of thirty-two species and varieties examined), that they might conveniently be used as a diagnostic character for a *section* of the Eucalypts.

7. Crystals are always present, more or less, but they form too precarious a feature to be relied upon.

8. The hard bast, whether dense or scanty, seems to be generally characteristic.

9. The wood-curve is likewise a characteristic feature, with the relative number, size, and arrangement of vessels ; but in some few instances it is too variable to be much relied on.

10. The broken nature of the wood-curve, as found in some species, cannot be used as a distinctive character, like the invariably unbroken curve in others, because on fuller investigation unbroken curves are found in all.

11. The closeness of resemblance in the sections of two allied reputed species may lead to their being recognised merely as varieties; or, on the other hand, the differences between reputed varieties may be sufficiently great to suggest their distinction as species.

12. Lastly, the general agreement among the various sections, and the absence of those clear distinctions which would mark off each species if quite independent, tend to the conclusion that the varied species of Eucalypts may have arisen through a process of evolution. After allowing for the changes which may have taken place through possible hybridisation, as hinted at in the "Eucalyptographia" (Dec. 9), "extreme forms," "aberrant forms," and "transition forms," so frequently referred to in that work, are not thereby accounted for. While the mere existence of transition forms does not prove that the transit has been accomplished through descent with modification, still permanent varieties or species, with such forms flanking them on every side as would be regarded as distinct species if isolated, would seem to have arisen thus. Hence the proper study of the Eucalypts, like that of the Platypus and Ceratodus, may add another page to Australia's contribution to the evolution theory. But perhaps it is hardly necessary to formally state this conclusion in the face of the recent utterance at the Newcastle meeting of the British Association, 1889, by the distinguished President (Prof. Flower):—"I think I may safely premise that few, if any, original workers at any branch of biology appear now to entertain serious doubt about the general truth of the doctrine that all existing forms of life have been derived from other forms, by a natural process of descent with modification."

Since this investigation is *strictly comparative*, we have endeavoured to preserve as much uniformity as possible, both in the sections made and the language used.

Besides, we felt that an important principle was being tested here, and one which might receive a wider application, viz., that in many families of plants the intimate structure of the leaf-stalk might be made a means or an aid in the identification of species. Therefore it was necessary to select a sufficiently varied number of examples, as well as a fair proportion of the entire number of known species on which to base our conclusions. It will be conceded, we think, that the Eucalyptus formed a sufficiently critical genus to test, and that the number of species (30), forming nearly one-fourth of the whole, was fairly extensive. According to the latest "Census" by Baron von Mueller, the number of Australian species of Eucalypts is 134. Whatever conclusions may be drawn, the photographed sections, and the accurate outlines, particularly of the wood, ought to be a decided addition to our knowledge of this characteristic and peculiar form of Australian vegetation.

EXPLANATION OF PLATES.

REFERENCE LETTERS TO ALL THE FIGURES.

b. bast.
c. cuticle.
cc. central canals.
ce. cavity of epidermal cell.
cp. cortical parenchyma.
cr. crystals.
ct. cortex.
ctc. cortical cavity.
cw. cuticularised cell-wall.
e. epidermis.
h. hypoderma.
hb. hard bast.
k. kinoid substance.
p. pith.
sb. soft bast.
sp. sieve plates.
st. sieve tubes.
vw. vessels of wood.
w. wood.
wc. wood curve.

PLATE 1.

Fig. 1. Epidermal cells of *E. globulus*, shortly after treatment with Schulze's solution, showing also hypoderma (h) (x 114).
Fig. 1a. Single epidermal cell of same, with underlying cells (x 600).
Fig. 2. Cortex of *E. globulus*, showing a cortical cavity (x 114).
Fig. 2a. Cortical cells adjoining hard bast (x 114).
Fig. 3. Crystal in cortical cells of *E. ficifolia* (x 140).
Fig. 4. Cortical parenchyma bordering on hard bast, in vertical section (x 600)
Fig. 5. Hard bast and adjoining tissue in vertical section (x 600).
Fig. 6. Cambiform cells of soft bast, in vertical section—comparatively elongated and thin-walled (x 600).
Fig. 6a. Cambiform cells, from round to brick-shaped—the commonest form (x 600).
Fig. 7. Soft bast in vertical section, showing sieve-plates (sp) on radial side-walls (x 600).
Fig. 8. Transverse section of base of midrib of young sessile leaf, to show not only structure of midrib, as far as the wood-curve is concerned, but mainly for comparison with section of petiole of mature leaf.
Fig. 8a. Natural size of section.
Fig. 9. Transverse section of quadrangular stem of young *E. globulus* for comparison with that of petiole.
Fig. 9a. Natural size of section represented in Fig. 9.
Fig. 10. Transverse section of stem of young *E. calophylla* for comparison with that of *E. globulus*.
Fig. 10a. Natural size of section represented in Fig. 10.

Note.—All the preceding drawings belong to *E. globulus*, except Figs. 3 and 10.

In Plates 6, 6a inclusive, the natural size of the section of each petiole is shown beside the enlarged section, and thus the amount of enlargement throughout is seen at a glance.

PLATE 2.

Fig. 11. *E. occidentalis*—Transverse section of petiole.
(Glycerine jelly).

Fig. 12. *E. cornuta*— do. do.
(Balsam).

Fig. 13. *E. cornuta*, var. *lehmanni*—Transverse section of petiole.
(Glycerine jelly).

Fig. 14. *E. obcordata*— do. do.
(Glycerine jelly).

Fig. 15. *E. marginata*— do. do.
(Glycerine jelly).

Fig. 16. *E. diversicolor*— do. do.
(Glycerine jelly).

PLATE 3.

Fig. 17. *E. gomphocephala*—Transverse section of petiole.
(Glycerine jelly).

Fig. 18. *E. megacarpa*— do. do.
(Glycerine jelly).

Fig. 19. *E. tetraptera*— do. do.
(Balsam).

Fig. 20. *E. rudis*— do. do.
(Glycerine jelly).

Fig. 21. *E. grossa*— do. do.
(Glycerine jelly).

Fig. 22. *E. calophylla*— do. do.
(Glycerine jelly and iron stain).

PLATE 4.

Fig. 22a. *E. calophylla*—Transverse section of petiole.
(Balsam).

Fig. 23. *E. ficifolia*— do. do.
(Glycerine jelly, nitric acid, and iron stain).

Fig. 23a. *E. ficifolia*—Transverse section of petiole.

Fig. 24. *E. alpina*— do. do.
(Glycerine jelly).

Fig. 25. *E. punctata*— do. do.
(Glycerine jelly).

Fig. 26. *E. maculata*, var. *citriodora*—Transverse section of the petiole.
(Glycerine jelly and iron stain).

PLATE 5.

Fig. 26. *E. maculata*, var. *citriodora*—Transverse section of another petiole, showing abnormal number of Central Canals
(Glycerine jelly).

Fig. 27. *E. corynocalyx*—Transverse section of petiole.
(Glycerine jelly).

Fig. 28. *E. melliodora*— do. do.
(Glycerine jelly).

Fig. 29. *E. tereticornis*— do. do
(Glycerine jelly).

Fig. 30. *E. saligna*— do. do
(Glycerine jelly).

Fig. 31. *E. maculata*— do. do.
(Glycerine jelly

PLATE 6.

Fig. 32. *E. macrorrhyncha*—Transverse section of petiole.
(Balsam).

Fig. 33. *E. globulus*— do. do.
(Glycerine jelly and iron stain).

Fig. 33a. *E. globulus*—Transverse section of petiole.
(Glycerine jelly).

Fig. 34. *E. obliqua*— do. do.
(Balsam).

Fig. 35. *E. amygdalina*— do. do.
(Glycerine jelly).

Fig. 36. *E. viminalis*— do. do.
(Glycerine jelly).

PLATE 6a.

Fig. 36a. *E. viminalis*—Transverse section of petiole.
(Glycerine jelly).

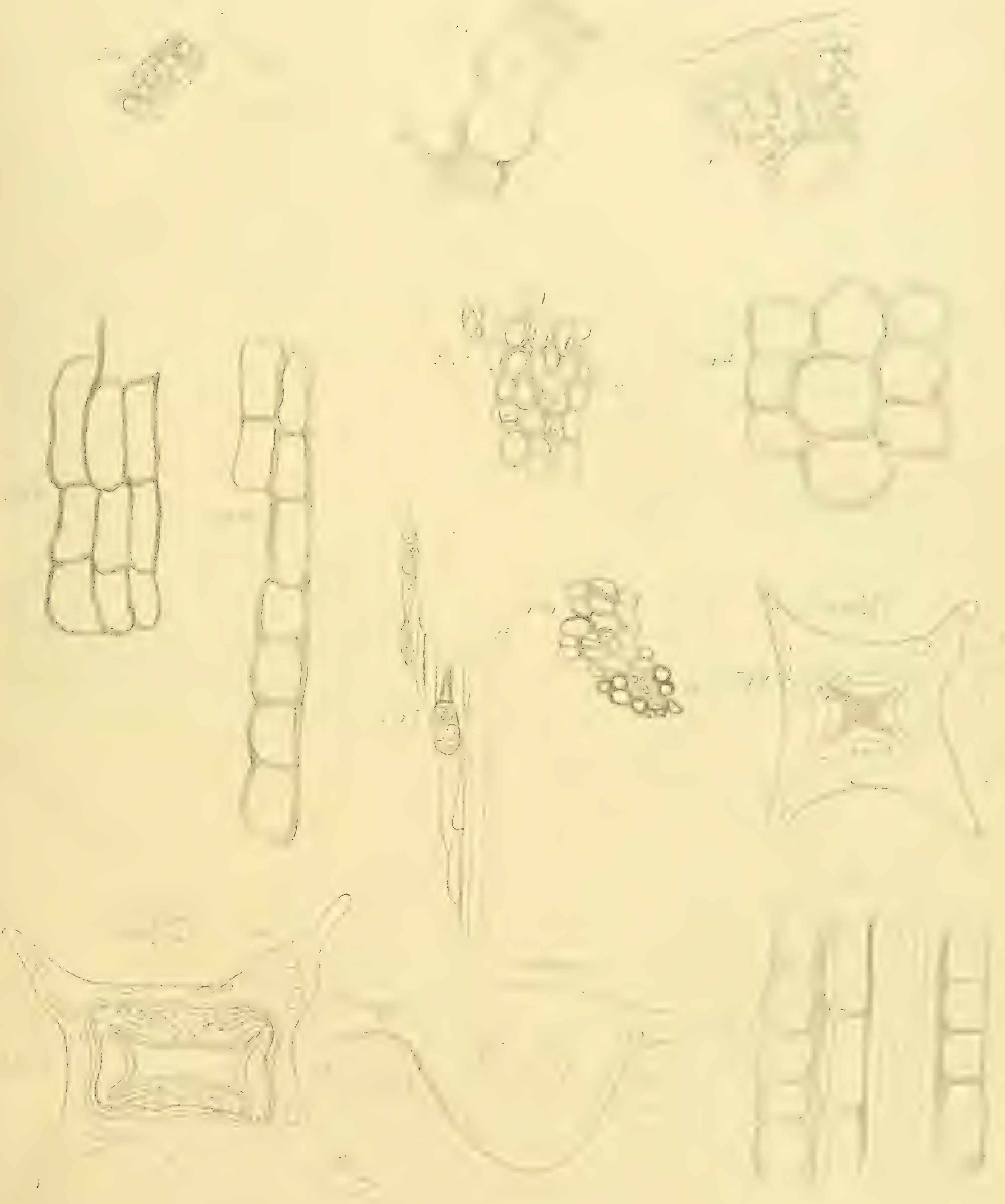
Fig. 37. *E. gunnii*— do. do.
(Balsam).

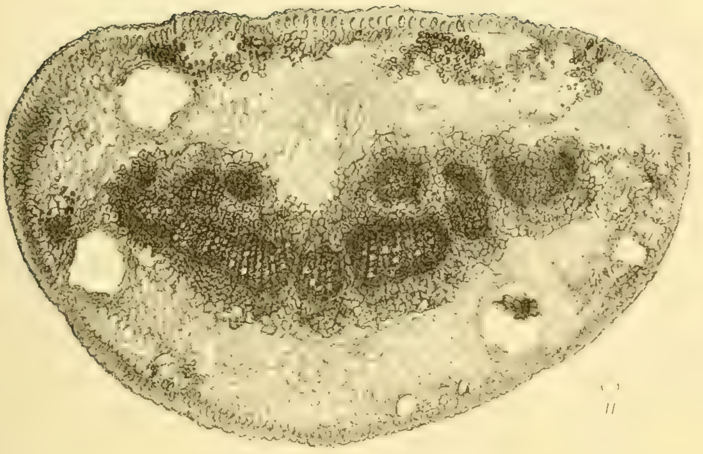
Fig. 38. *E. stuartiana*— do. do.
(Glycerine jelly).

Fig. 39. *E. leucoxylon*— do. do.
(Glycerine jelly).

Fig. 39a, b, c. *E. leucoxylon*—Outlines of three sections from different petioles, invariably showing broken wood-curve.

Fig. 40. *E. rostrata*—Transverse section of petiole.
(Glycerine jelly).





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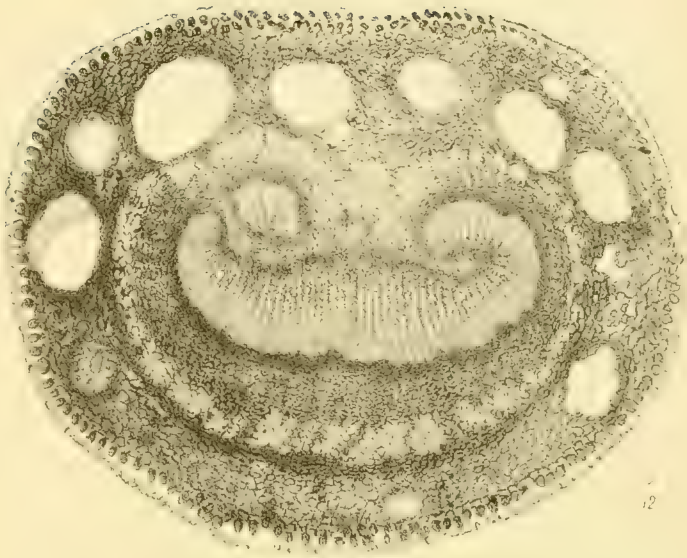

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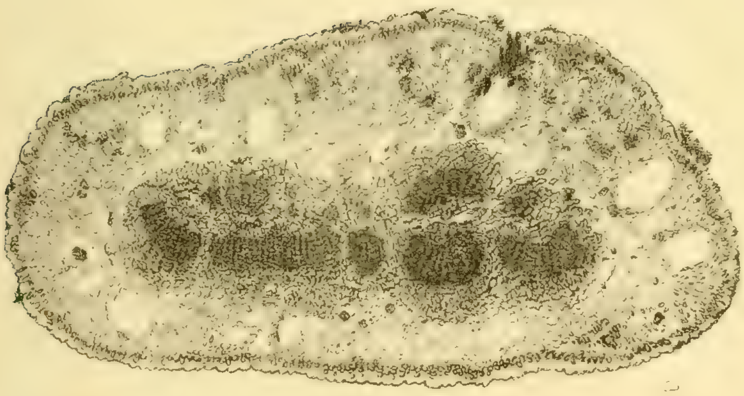

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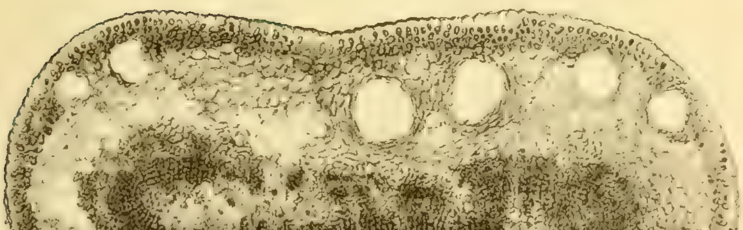

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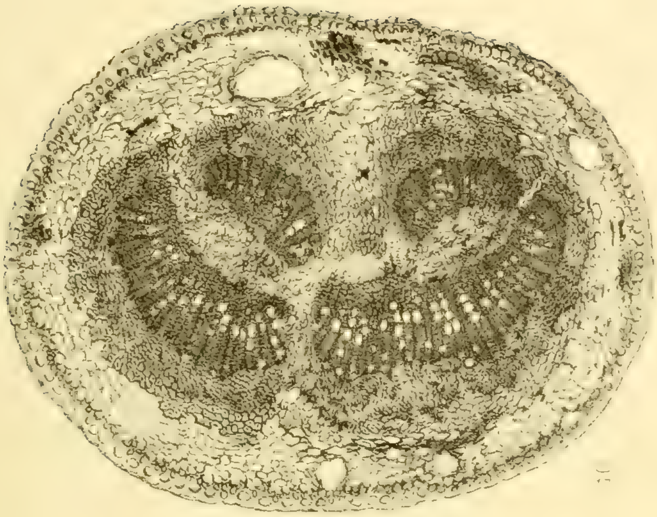

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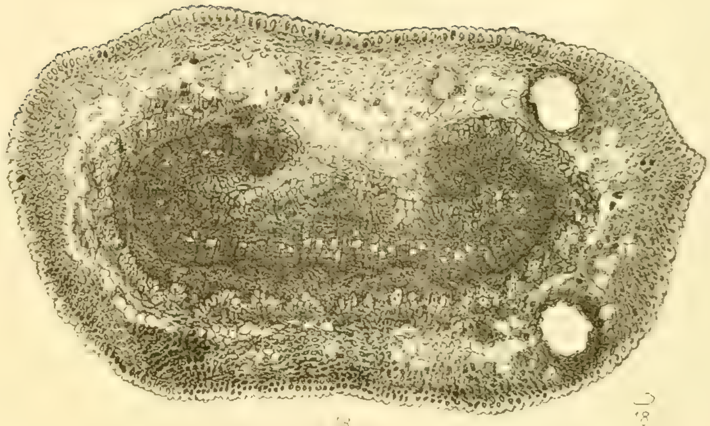

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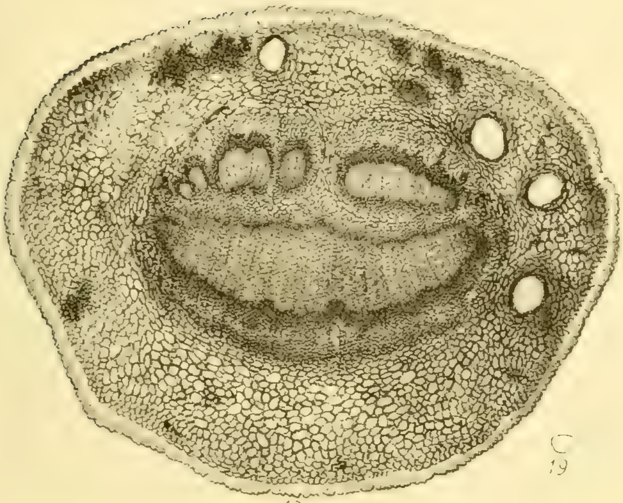

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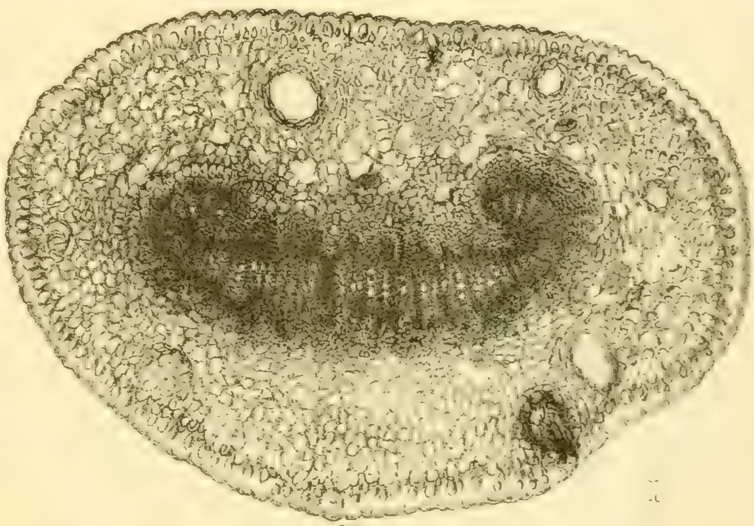

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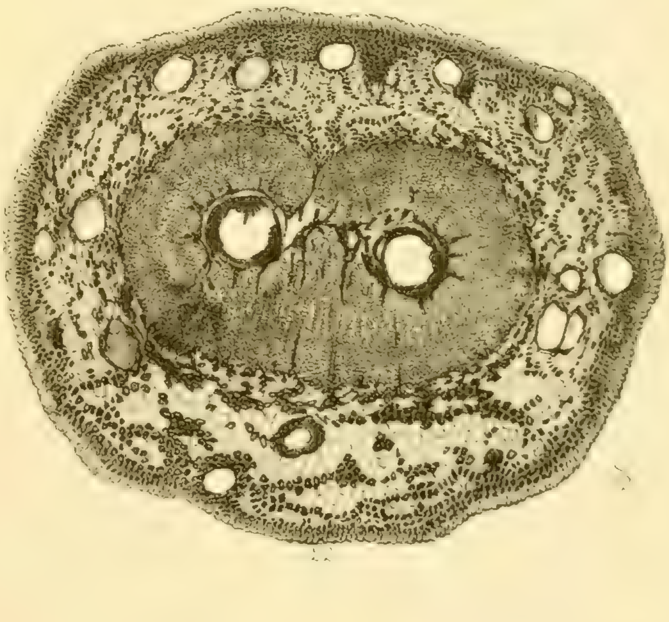

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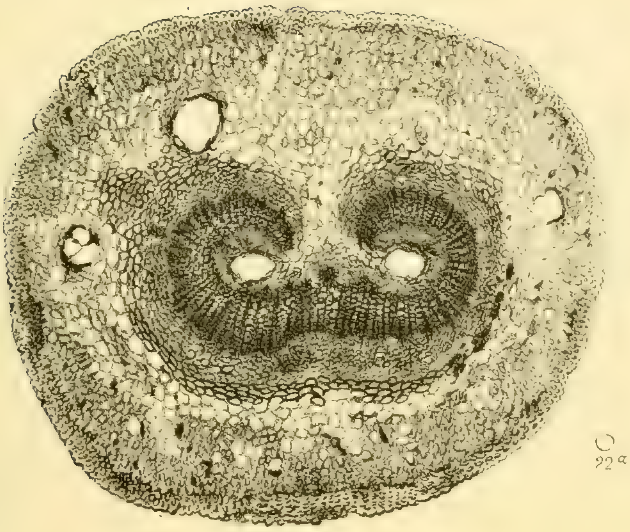

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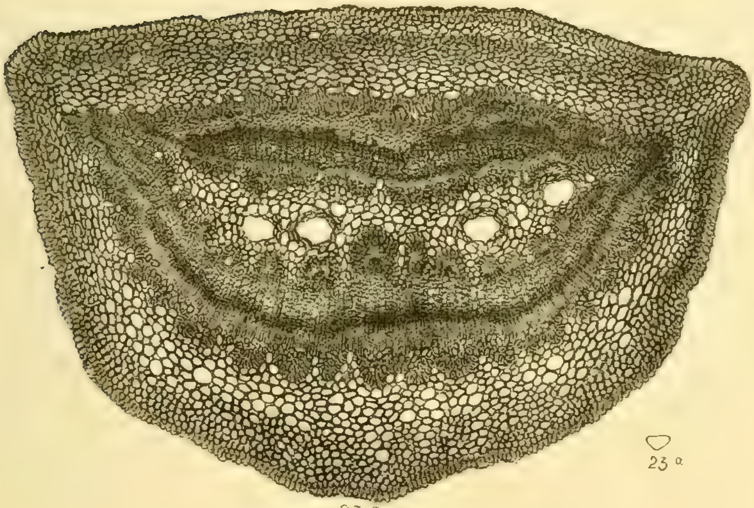

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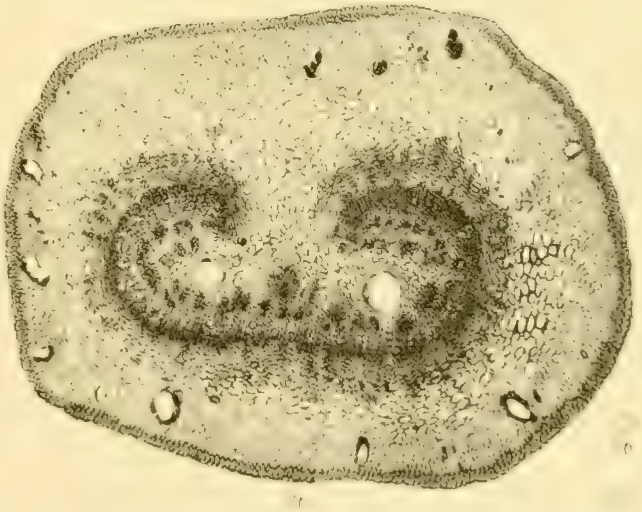

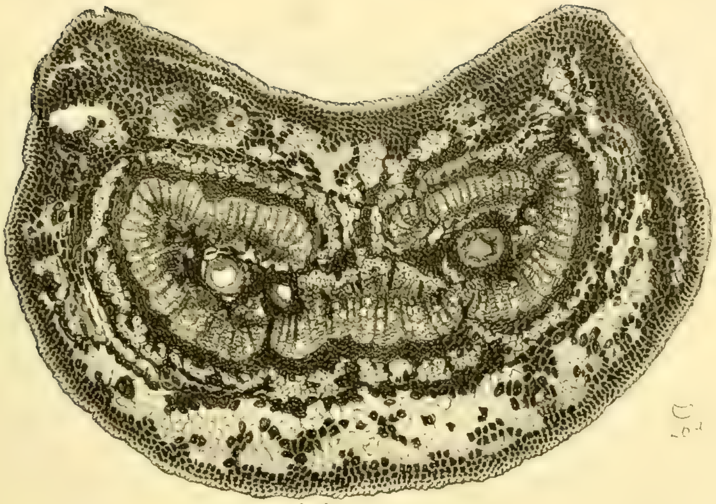

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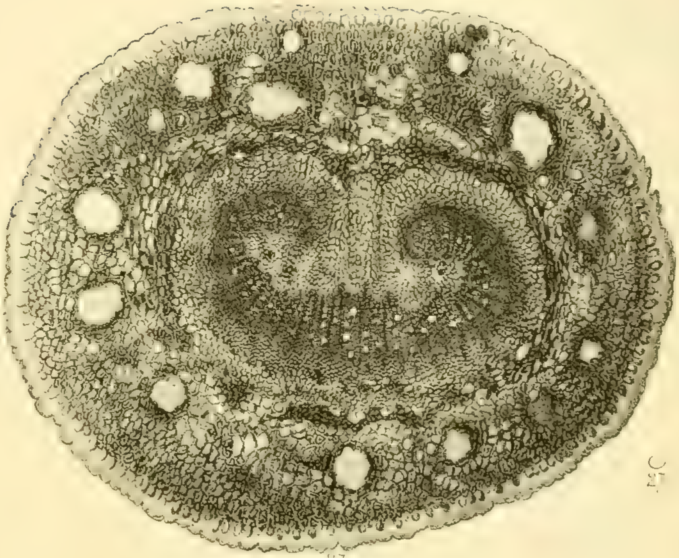

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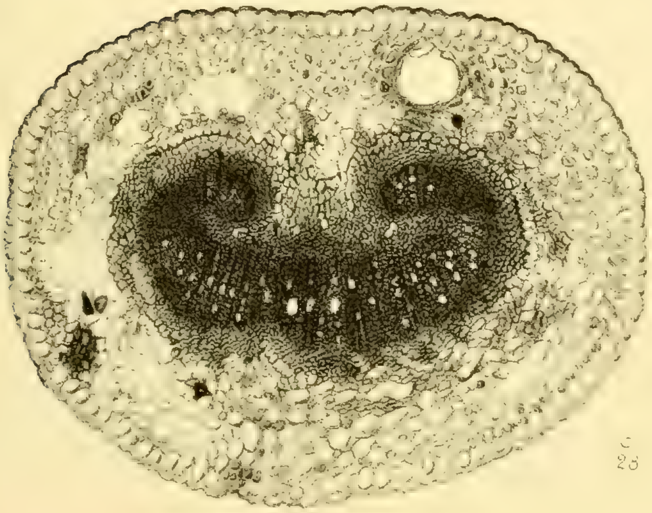

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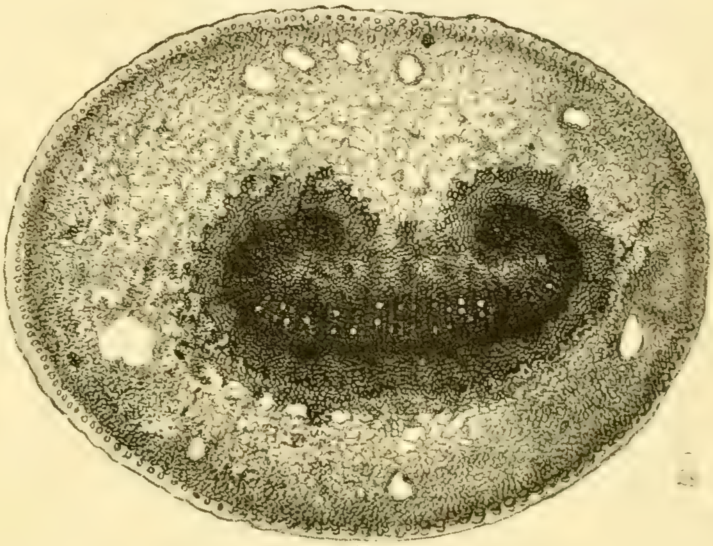

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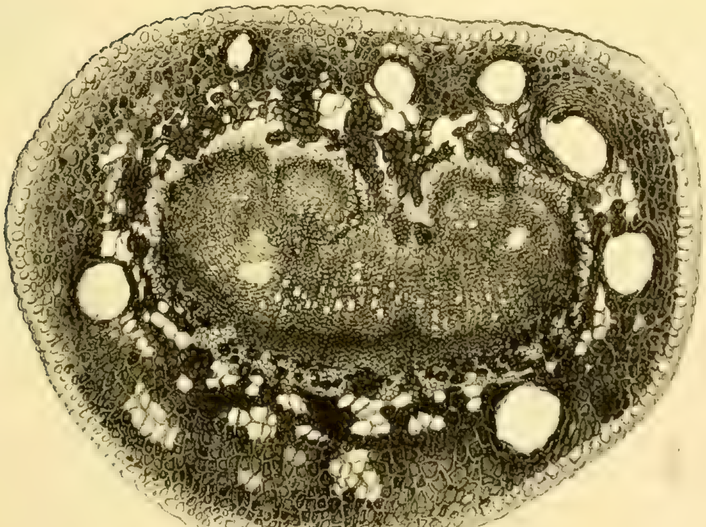

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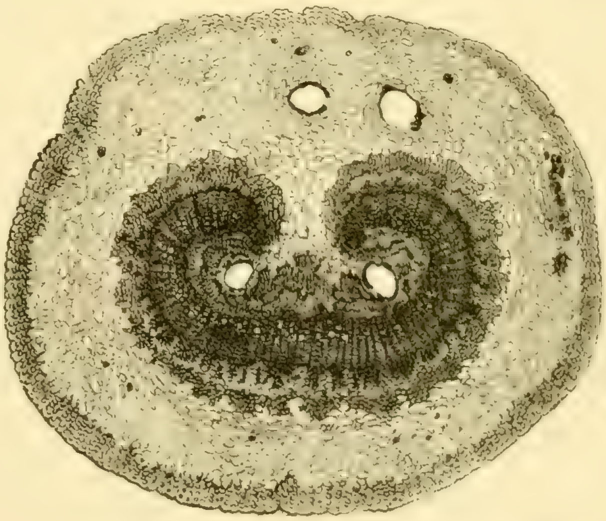

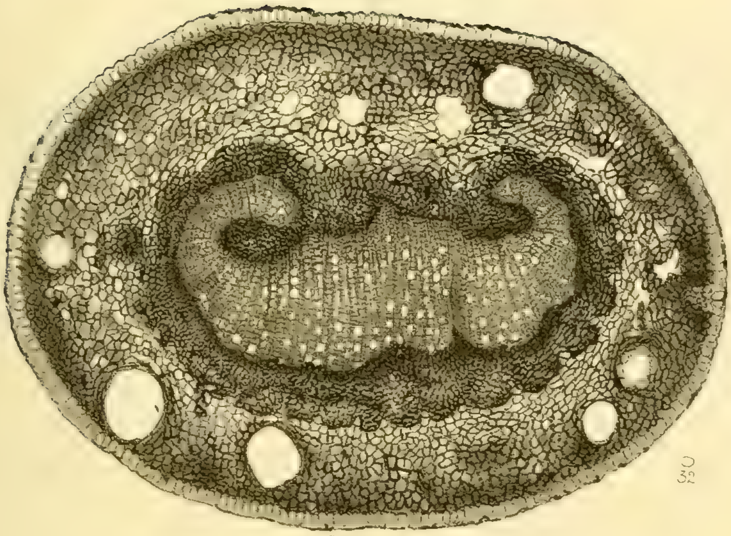

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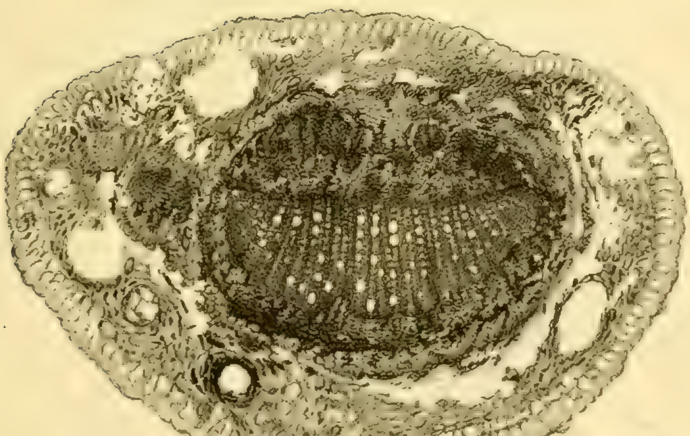

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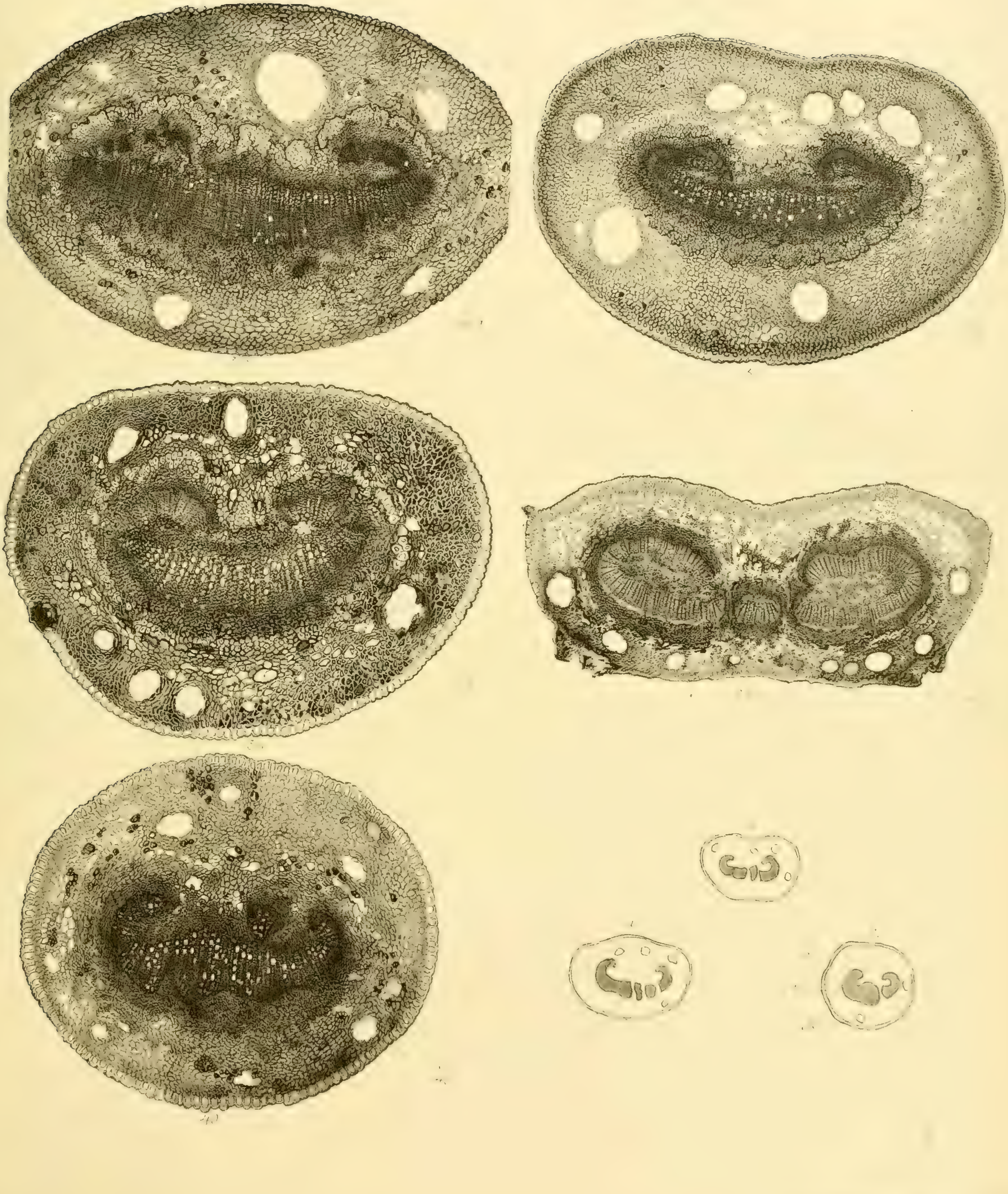

Lith. Melb

On the Victorian Land Planarians, by Arthur Dendy, M.Sc., F.L.S., Demonstrator and Assistant Lecturer in Biology and Fellow of Queen's College in the University of Melbourne.

(With Plate 7.)

(Read May 8th, 1890.)

Introduction.

The present paper may be regarded as a sequel to my memoir on the Anatomy of an Australian Land Planarian, already published in the Transactions of this Society.* Having fully described, in the memoir referred to, the anatomy of one species, which may be taken as a type of the whole group, it remains to name, briefly describe, and where possible figure the other Victorian species.

There are, as I have pointed out in my previous memoir, two genera of Australian land Planarians, *Geoplana*, with many small eyes, and *Rhynchodemus*, with only two larger ones. Both of these genera are found in Victoria and it would doubtless have been desirable to have described in detail the anatomy of a type from each; as, however, I have only seen a single specimen of *Rhynchodemus*, and that only recently, I have been unable as yet to do this. The gap thus caused is, however, to a great extent filled by the researches principally of Moseley and von Kennel, to which frequent reference is made in my earlier paper.

In their "Notes on Australian Land Planarians, with Descriptions of Some New Species" (Part I.),† Messrs. Fletcher and Hamilton enumerate eighteen Australian and Tasmanian species. Of these, seventeen were found in New South Wales, one in New South Wales and Queensland, one in New South Wales and Victoria, and one in Tasmania only. In the present paper I propose to describe fifteen Victorian species, viz.:

1. *Geoplana cærulea*, Moseley sp.
2. *G. quinquelineata*, Fletcher and Hamilton.
3. *G. munda*, Fletcher and Hamilton.
4. *G. spenceri*, Dendy.
5. *G. adæ*, n. sp.
6. *G. lucasi*, n. sp.

* Transactions of the Royal Society of Victoria, 1889.

† Proceedings of the Linnean Society of New South Wales, Vol. II. (Series 2), p. 349.

7. *G. m'mahoni*, n. sp.
8. *G. alba*, n. sp.
9. *G. hoggii*, n. sp.
10. *G. sugdeni*, n. sp.
11. *G. mediolineata*, n. sp.
12. *G. quadrangulata*, n. sp.
13. *G. walhallæ*, n. sp.
14. *G. fletcheri*, n. sp.
15. *Rhynchodemus victoriæ*, n. sp.

Of these fifteen species the first three occur also in New South Wales and have been already described by Moseley and Fletcher and Hamilton. The twelve remaining species are, so far as is yet known, exclusively Victorian, but it is more than probable that some of them will sooner or later be discovered in one or other of the adjacent colonies. Still it is evident, when we consider that out of twenty-nine known Australian species, nearly equally divided between the colonies of Victoria and New South Wales, only three have been found in both colonies, that the land Planarians, however widely they may be distributed as a class, do not enjoy wide specific areas of distribution; or, in other words, that in different districts of the same country we may expect to find different species of Planarians. In spite of the occurrence of one or two comparatively widely ranging species, such as *Geoplana alba*, which I have had from M'Mahon's Creek, Warragul, Macedon, and Croajingolong, this expectation is justified by my own observations.

With regard to the question of specific distinctions I have come to the conclusion that we may safely rely on a combination of the following characters (1) the colour and pattern, (2) the position of the external apertures, (3) the general shape of the body. Although I have examined considerable numbers of the same species, as, for example, in the case of *Geoplana spenceri* and *G. hoggii*, I have not found any important variations in these respects. Perhaps the most variable species are the common yellow Planarians which I have named *Geoplana sugdeni* and *G. mediolineata*. These two species agree fairly well in the general shape of the body and in the position of the external apertures, but the former has none of the stripes present in the latter. The two species are, however, connected by an intermediate variety with imperfect stripes. Under these circumstances I have assigned all specimens with any stripes at all to *G. mediolineata* and all those without any to *G. sugdeni*. It must, however, be remembered that although in *G. mediolineata* the number of stripes may vary yet the arrangement is always identical, and this is the important point. In the most perfectly striped examples which I have seen we find a single, fine, dark median stripe, a lighter stripe at some distance on each side of it, and outside this again on each side an indication of a stripe at the anterior extremity of the body only (Figs. 3, 3*a*). All these stripes may be more or less suppressed, the first to disappear being those on the outside and the last the one in the middle; or we may with equal justice assume that the parent form had no stripes and that the first to appear was the median one and the last the outside ones. The observations of Fletcher and Hamilton on the markings of very young specimens of *Geoplana quinquelineata*, which will be found quoted in the description of that species, seem to indicate that the latter assumption is the correct one. So it is in most of the species; the markings, if there are any, may be more or less strongly emphasised in different individual specimens, but fundamentally the pattern is the same in all. I have pointed out* the same fact in the case of *Peripatus leuckartii.*

We now know a good deal about the general habits of land Planarians. They are what I have elsewhere† termed "Cryptozoic" animals, living for the most part under logs and stones, or the dead bark of trees. They prefer moderately damp situations and appear to be much more abundant in the autumn, after rains, than in the drought of summer. When at rest in their hiding places they commonly lie coiled up with the anterior extremity in the centre of the coil (Fig. 12). As a rule they seem to venture abroad in search of food at night only, or in very damp weather, but I have more than once found *Geoplana sugdeni* crawling about in broad daylight, once on a stone near the top of Mount Macedon, in a decidedly dry situation. *Geoplana lucasi*, again, was obtained by Professor Spencer at a height of 4000 feet on the top of the coast ranges in the Croajingolong district.

Still there can be no doubt that land Planarians require a very considerable amount of moisture for their existence. Thus I once found a considerable number of specimens which had escaped from the collecting box dried up on the floor of a room, having apparently exhausted all their supply of moisture in the production of their slimy track.

In this connection I may mention that when a living land Planarian is placed in loose dry earth, it forms a cyst for itself by cementing together the particles of earth with its slimy secretion. Within this cyst the Planarian lies completely hidden, but if the cyst be torn it will crawl out perfectly clean and free from earth. This habit of forming cysts of earth may be a protection against drying up and may perhaps account for the disappearance of land Planarians in the heat of summer.

Land Planarians crawl with an even, gliding motion, which I believe to be largely due to the action of the numerous strong cilia on the ventral surface, for I have seen a minute fragment of the worm, snipped off with a pair of scissors, gliding away over a smooth surface by itself, much as in the case of detached parts

* Proceedings of the Royal Society of Victoria; 1889, p. 50, *et seq.*

† Victorian Naturalist; December, 1889.

of the common mussel described by McAlpine.* Cilia are probably present on the dorsal surface also, but very small and much obscured by slime. In crawling the horseshoe-shaped anterior extremity of the body, on which the eyes are mostly situate and which has usually more or less of a reddish tinge, is uplifted to gain a more extended view, and the path of the animal is marked, like that of a snail, by a slimy track.

They live upon the juices of insects and other small animals, which they extract by suction, the sucker-like pharynx being inserted in some soft part of the victim and the latter held fast by the intensely sticky slime secreted around it by its captor. Mr. C. Frost informs me that on one occasion when out collecting he placed a living land Planarian in a box with a live Cicada and that when he opened the box again to show the Cicada to a friend he found the insect quite flat and empty, all the inside having been sucked out by the Planarian. Hence the land Planarians are certainly carnivorous and they must be able to find an abundant supply of food amongst the innumerable cockroaches, beetles and other small animals which make up so large a proportion of the cryptozoic fauna.

Land Planarians are found breeding in the autumn and winter months and I have been able to observe the method of copulation in *Geoplana mediolineata*, at Upper Macedon on April 7th of the present year. The two individuals were precisely similar in colour and markings and of about the same size.

They were lying beneath a log in such a manner that the posterior portions of their ventral surfaces were applied together, the tail of the one pointing in the opposite direction to that of the other. The genital atrium in each case was expanded to form a sucker and the two suckers being applied together held the worms in position. The orifices of both male and female copulatory organs were in each case somewhat protruded and it follows from the position of the animals that the male opening of the one must come into close contact with the female opening of the other and *vice versâ*. The most important factor in bringing this about is the use of the common genital atrium as a sucker, in the hollow of which lie the male and female openings. Thus the method of action of the copulatory organs, whose minute anatomy I have described in the case of *Geoplana spenceri*, is made clear.

The eggs are laid in cocoons, several in each. I was fortunate enough to obtain recently a specimen of *Geoplana hoggii* with a cocoon in the uterus, which proves clearly that the cocoon is an internal structure and not, as in the case of the earthworm, an external structure formed by the skin. In the case observed the body of

* Transactions and Proceedings of the Royal Society of Victoria, Vol. XXIV., Part 2, p. 139.

the worm was seen to be greatly distended just behind the genital opening, and sections showed the presence of a fully formed cocoon occupying the whole of the greatly dilated uterus, and squeezing the other internal organs to one side. The cocoon itself was crowded with closely packed yolk-cells, whose nuclei and outlines were still visible. In older cocoons the yolk disappears as the embryos increase in size until at last the young worms come to occupy the whole of the cavity. Finally the young escape through simple rupture of the wall of the cocoon or through a definite circular opening. After having been laid for some time the cocoon appears as an oval or nearly spherical body of a shining black appearance. In the specimen which contained the cocoon *in utero* the yolk glands were, as might have been expected, very largely developed, and there was some evidence in support of the suggestion which I made in my previous memoir to the effect that the shell of the cocoon is secreted by certain glands opening into the small chamber which receives the contents of the united oviducts before they enter the uterus. To this chamber I therefore propose to apply the name "shell-gland chamber."

The brilliancy of colour and markings in the land Planarians are so well known that I need scarcely do more than allude to them. Blue, green, yellow, brown, black and red may be found in various combinations and generally arranged in longitudinal bands or stripes symmetrically disposed on the two sides of the body. It is difficult to account for these varied and brilliant markings, which seem, as I have already pointed out, to be tolerably constant for each species. Wallace proposes* to divide the colours of animals into four groups which he terms *Protective*, *Warning*, *Sexual* and *Typical*. I would suggest that the brilliant colours of land Planarians may be "warning" colours. There are many butterflies which have been shown by Wallace to be brilliantly coloured and at the same time inedible by birds and there is good reason for believing that the brilliant colours serve to warn the birds of the objectionable character of the butterflies and thus protect the latter from being pecked to death. In the same way I think it possible, though not as yet by any means proved, that the colours of Planarians may serve to protect them from being eaten by birds by rendering them readily recognisable.

But it requires to be shown first that land Planarians are inedible by or distasteful to birds. I have made two experiments which seem to indicate that this is the case ; (1) I tasted two species myself and found that the mere application of the tongue to the slimy surface of the animal was sufficient to produce an exceedingly unpleasant sensation, something like that caused by putting a piece of velvet or a lump of alum in the mouth. (2) I threw a living specimen of *Geoplana spenceri* to a number of hens. The hens, not being native birds, would, of course, not recognise the worm, and they at once attacked it, broke it up and took it in their mouths.

* "Tropical Nature, and other Essays," p. 172.

Instead, however, of swallowing the pieces they dropped them again. This experiment, though but a solitary one and of course in need of confirmation, tends to show that land Planarians are unpalatable to birds as well as to human beings.

In my paper on the anatomy of *Geoplana spenceri* I have already suggested that the unpalatable character of these worms may be due to the presence of the rod-like bodies in the slime with which they are always covered.

In concluding my introductory remarks I have much pleasure in expressing my indebtedness to my wife for her valuable assistance in collecting specimens; to Professor W. Baldwin Spencer for numerous Planarians from various localities and especially for an exceptionally interesting collection from Croajingolong, including a species of *Rhynchodemus*, which genus is now for the first time recorded from Victoria; to Mr. H. R. Hogg, for many specimens of Planarians from Macedon and for his kind hospitality and assistance whilst I was collecting in that district; to Mr. J. Bracebridge Wilson, for Planarians from the Otway Forest, and to Mr. Henry Dendy, of Walhalla, for assistance in collecting in that locality.

Description of Victorian Species.

Genus *Geoplana*.

This genus, as I have already had occasion to point out, is distinguished from the only other known genus of Australian land Planarians by the presence of very numerous minute, unicellular eyes, which occur principally on the lateral margins of the anterior end of the body and are usually, if not always, continued round the edge of the horseshoe-shaped anterior extremity. Frequently, also, the eyes occur more sparsely scattered along the sides of the body to the extreme posterior end.

1. *Geoplana cœrulea*, Moseley sp.

1877. *Cœnoplana cœrulea*, Moseley, Quarterly Journal of Microscopical Science, Vol. XVII., N.S., p. 285.

1887. *Geoplana cœrulea*, Fletcher and Hamilton, Proceedings of the Linnean Society of New South Wales. Series II., Vol. 2, p. 361, Pl. V., Fig. 1.

"Entire body of a dark Prussian blue colour, somewhat lighter on the under surface of the body and with a single, narrow, mesial, dorsal, longitudinal stripe of white. Length 5 cm., extreme breadth 4 mm., mouth central; generative aperture 8 mm., posterior to the mouth. Parramatta, near Sydney. Under the bark of a species of Eucalyptus." (Moseley, *loc. cit.*)

A number of specimens brought in spirits by Professor Spencer from Croajingolong appear to belong to this species. According to Professor Spencer the colour of the living worms was cobalt on the ventral and dark olive green on the dorsal surface, exactly as in *G. spenceri* but with a median, dorsal, yellow line. The spirit specimens still show very plainly the narrow median dorsal line, and they also show indications of a narrow, median, ventral light line in the posterior part of the body, apparently not observed in the living animals. They also still exhibit traces of a reddish anterior tip.

According to Messrs. Fletcher and Hamilton (*loc. cit.*) there appears to be a certain amount of variation in the colouration of this species. Thus these authors have found specimens without any red tip and with the dorsal median stripe varying from a dirty white to a distinct yellow, changing to white in spirit. These observations make it probable that the Croajingolong specimens are correctly identified as *G. cœrulea*, though the opening into the peripharyngeal chamber appears to be a little further back than Moseley places it. In shape this Planarian closely resembles *Geoplana spenceri*.

Localities.—Sydney, Parramatta, Ryde, Springwood, Mount Wilson, Hunter River (New South Wales); Cairns (N. Queensland); Croajingolong (Victoria).

2. *Geoplana quinquelineata*, Fletcher and Hamilton.

1887. *Geoplana quinquelineata*, Fletcher and Hamilton, Proceedings of the Linnean Society of New South Wales. Series II., Vol. 2, p. 366, Pl. V., Figs. 4, 5, 15, 16.

"Under surface whitish. Ground colour above presents considerable variations, pale yellow or nearly orange, dull olive-green, ochreous-brown, reddish-brown, sometimes almost brick-red. The dorsal surface divided into six longitudinal bands by five longitudinal lines, also varying in colour, sometimes a darker and more intense tint of the ground-colour, from dark brown almost black to warm brown or red, their margins irregular when viewed with a lens, arranged as follows: usually a very fine dark line occupies the median line, external to which on each side is a narrow band of ground colour; outside of which again on either side is a line of brown or red usually slightly broader and better defined than the mesial line; each of these again is bordered by a band of ground colour one and a-half times or twice as wide as the inner stripe on each side; beyond each of which is the outermost brown or red line of the same width as the first on each side but sometimes narrower, and each of these is followed by a narrow band of ground colour extending outwards to the lateral margin of the body. At the anterior extremity the lines blend in the red tip. The ground colour, and the reddish tint of the anterior extremity usually disappear more or less completely in spirit, while the bands become brown or sometimes black.

Largest living specimen 10 cm. long. In two contracted spirit specimens 42 and 23 mm. long respectively, the apertures of the mouth are 20 and 12 mm. respectively behind the anterior extremity; in a third specimen 26 mm. long the genital orifice is 4 mm. anterior to the hinder extremity. In none of our specimens are both apertures visible.

Young specimens on emerging from the cocoon are 2.5 to 4 mm. long. In these and sometimes in larger ones the colour of the anterior portion of the body is more intense. In very young specimens also the lines are brighter, but the outermost one on each side is only faintly indicated, or absent." (Fletcher and Hamilton, *loc. cit.*)

Messrs. Fletcher and Hamilton state that this is one of the commonest species in New South Wales, and they also record it from Sandhurst, Victoria. I myself collected four specimens near Sandhurst, all of which were found under stones on an old gold-field near the Back Creek Cemetery. The ground colour of the dorsal surface was, in the living worms, brownish yellow. The five dark lines were placed nearly equidistant from one another, running all down the body. All five were rather thin, the middle one black and the others chestnut brown. The ventral surface was greyish cream coloured.

I have also received two specimens from the Otway Forest, sent to me in spirit by Mr. J. Bracebridge Wilson. The latter are very large, the largest measuring 60 mm. in length and 5 mm. in breadth even in spirit.

Localities.—Near Parramatta, near Springwood, near Capertee, Guntawang, Beaudesert Hills, Biraganbil Hills (New South Wales); Sandhurst, Otway Forest (Victoria).

3. *Geoplana munda*, Fletcher and Hamilton.

1887. *Geoplana munda*, Fletcher and Hamilton, Proceedings of the Linnean Society of New South Wales. Series II., Vol. 2, p. 369, Pl. V., Fig. 8.

"Undersurface greyish in centre, yellowish towards the margins. Above there is a narrow median dorsal line of pale olive brown, bounded on either side by a very fine dark line, external to which is a broader band of a slightly darker brown, and this is bordered externally by a very dark brown line which gradually merges into a rather broad band of very dark brown which fades gradually towards its outer margin.

"This pretty little Planarian retains its colours in spirit very well but the undersurface becomes quite white. The single specimen obtained measured when alive and crawling, 2·5 cm. long, and 3 mm. broad. In spirit it measures 15 mm. long, 4 mm. broad, the mouth 6 mm. behind the anterior extremity, and the generative aperture 2 mm. behind the mouth." (Fletcher and Hamilton, *loc. cit.*)

As I have not seen this species in the living condition I quote the above description of Fletcher and Hamilton. Mr. J. Bracebridge Wilson sent me sixteen specimens in spirits, from the Otway Forest, which agree excellently with the above account, but I could not find the genital aperture. The species was described by Fletcher and Hamilton from a single specimen.

Localities.—Hartley Vale (New South Wales); Otway Forest (Victoria).

4. *Geoplana spenceri*, Dendy.

1889. *Geoplana spenceri*, Dendy, Transactions of the Royal Society of Victoria. Vol. I., Part 2, p. 50, Pls. 7, 8, 9, 10.

For the description and figures of this species I must refer the reader to my former paper.

Localities.—M'Mahon's Creek, Warburton, Walhalla (Victoria).

5. *Geoplana adæ*, n. sp. (Fig. 7).

The body is nearly oval in section, flattened ventrally, tapering rather more gradually in front than behind. The opening into the peripharyngeal chamber is situate in about the middle or a little behind the middle of the ventral surface. The ground colour of the dorsal surface is pale yellowish brown. There is one very fine, median, dark brown stripe, and a very broad lateral dark brown stripe on each side of it and separated from it by a fairly wide interval of ground colour. The lateral stripes are rather ill-defined at their outer edges, where they touch a band of the ground colour splotched with darker brown. The ventral surface is pale yellowish brown, slightly mottled, or white. The largest of the three specimens which I have seen was about 40 mm. in length and 3 mm. in greatest breadth when crawling.

I have called this beautiful Planarian after my wife, who has greatly assisted me in my search for cryptozoic animals.

Localities.—Macedon, Warburton (Victoria).

6. *Geoplana lucasi*, n. sp.

The body (in spirit) is very broad and much flattened, especially on the ventral surface; very blunt behind and tapering more gradually in front. The opening into the peripharyngeal chamber is rather behind the middle of the ventral surface and the genital aperture about halfway between it and the posterior end of the body. The dorsal surface, in the living animal, was of a creamy white colour, with a narrow dark brown median stripe and on each side of the stripe numerous close-set, narrow, discontinuous, wavy longitudinal streaks of brown over all the remainder of the dorsal surface. There is no record of any markings on the ventral surface of the living animal.

I received three specimens of this worm in spirit from Professor Spencer, from Croajingolong. The largest measures (in spirit) about 40 mm. in length and 8 mm. in greatest breadth, and came from a height of 4000 feet on the top of the coast ranges. I have named the species after Mr. A. H. S. Lucas, M.A., B.Sc.

Locality.—Croajingolong (Victoria).

7. *Geoplana m'mahoni*, n. sp.

Body (in spirit) strongly convex on the dorsal surface, flattened on the ventral, tapering gradually towards the anterior end and much more suddenly towards the posterior. Opening into the peripharyngeal chamber situate at about the junction of the middle and posterior thirds of the body. Genital aperture nearer to the posterior end than to the opening of the peripharyngeal chamber. The ground colour of the dorsal surface is yellow (pale or bright) and there are two strong brown stripes, one on each side of the middle line, separated by a considerable interval and meeting at the anterior and posterior ends. The ventral surface is cream-coloured. A specimen in spirit measured 23 mm. in length and 4·5 mm. in greatest breadth.

Locality.—M'Mahon's Creek, on the Upper Yarra (Victoria).

8. *Geoplana alba*, n. sp. (Figs. 10, 11).

Body broad and much flattened, strap-shaped; when at rest often crenated at the edges, the crenations disappearing when the animal is fully extended; sub-triangular in transverse section, the apex of the triangle with a very wide angle; tapering very gradually in front and unusually suddenly behind, so that the hinder end of the body is blunt, especially when the animal is at rest or in spirit. The opening of the peripharyngeal chamber is near the junction of the middle and posterior thirds of the body and the genital opening nearer to it than to the hinder end of the body. There are no stripes and except for the pinkish anterior tip the entire body is of a very pale and nearly uniform tint. I have noted specimens from M'Mahon's Creek as "cream-coloured or white" and specimens from Macedon as "peach-coloured or yellow flesh" and "brownish flesh-coloured all over, dorsally and ventrally, with beautiful peach-coloured tip." Specimens from Macedon measured when crawling about 65 mm. in length and 4 mm. in greatest breadth, but I have larger specimens from M'Mahon's Creek and from Warragul.

Localities.—M'Mahon's Creek, Warragul, Macedon, Croajingolong (Victoria).

9. *Geoplana hoggii*, n. sp. (Figs. 4, 5.)

Body almost elliptical in section but flattened beneath, long and narrow, tapering gradually towards the anterior extremity and more suddenly towards the posterior. Opening into the peripharyngeal chamber nearly in the middle of the ventral surface and genital aperture about one-third of the distance between it and the posterior end of the body. The ground colour of the dorsal surface is rather pale, translucent yellow, or greenish yellow. There are four stripes, two on each side of the middle line and extending throughout the entire length of the body. The two stripes nearest the middle line are separated from one another by only a very narrow band of ground colour and are usually of a green colour with a tinge of indigo; they may, however, be grey or greenish grey. The two remaining stripes, one on each side, are separated by wider intervals from those nearest to the middle line and are of a very dark brown, almost black colour. The relative breadth of the stripes appears to vary a good deal. The anterior extremity of the body is of the usual brownish pink colour, into which the stripes merge. The ventral surface is of a uniform yellow colour, a little paler than the ground colour of the dorsal surface. The largest specimen which I have seen alive was about 125 mm. long and 5 mm. in greatest breadth when crawling (Fig. 5). Usually, however, specimens are only about 70 or 80 mm. long when crawling.

I have seen great numbers of this species under logs and stones at Macedon and I have great pleasure in calling it after Mr. H. R. Hogg, on whose property it is particularly abundant and who first brought it to me in a living condition.

Locality.—Macedon (Victoria).

10. *Geoplana sugdeni*, n. sp. (Figs. 12, 13, 14).

Body very narrow and much elongated; approximately oval in section but somewhat flattened ventrally, more nearly cylindrical than in any other species of the genus with which I am acquainted; tapering gradually to each extremity. Opening into the peripharyngeal chamber a little in front of the middle of the ventral surface. Genital opening only a little behind the middle, separated from the opening into the peripharyngeal chamber by an interval of about 10 mm. (in spirit) and from the posterior end of the body by an interval of about 18 mm. The colour of the dorsal surface is bright canary yellow all over except the reddish brown anterior tip; the ventral surface is of a paler yellow colour. There are no stripes at all. Length when crawling about 70 mm., greatest breadth only about 2 mm.

This species is rather remarkable for its habit of wandering about in broad daylight, to which I have already referred in my introductory remarks. I have much pleasure in naming it after the Rev. E. H. Sugden, B.A., B.Sc., the Master of Queen's College in the University of Melbourne.

Locality.—Macedon (Victoria).

11. *Geoplana mediolineata*, n. sp. (Figs. 1, 2, 3, 3*a*).

Body long and narrow, oval in section but not very much flattened; tapering very gradually towards the anterior and more suddenly towards the posterior end.

Opening into the peripharyngeal chamber somewhat in front of the middle of the ventral surface. Genital opening at about the junction of the middle and posterior thirds of the body. The ground colour of the dorsal surface is bright canary yellow. The stripes vary considerably in the extent to which they are developed. The most typical condition appears to be that represented in Figs. 1 and 2. Here there is a single, narrow, very dark brown or almost black, median dorsal stripe. At the anterior end the brownish-pink tip is continued into two short, dusky brown stripes on each side of the middle line; the one nearest the middle line being the longest. At the posterior end also an ill-defined dusky stripe seems to be always present on each side of the middle line. Specimens with stripes answering to the above description are very abundant at Macedon. In a slight variety from Warburton and Walhalla, of which I obtained six or seven specimens, the stripes are less developed, even the median one being present only at the anterior end of the body, though longer than the others. In a third variety, on the other hand, from Macedon, there are three continuous stripes (Figs. 3, 3*a*), the innermost of the two lateral stripes on each side extending all the way down the body and becoming continuous at the posterior end with the rudimentary lateral stripes mentioned as existing there in the typical form. The ventral surface is pale, nearly white. When crawling, examples of this species are about 90 mm. in length and hardly 3 mm. in greatest breadth.

Localities.—Macedon, Warburton, Walhalla (Victoria).

12. *Geoplana quadrangulata*, n. sp. (Figs. 6, 6*a*).

Body almost quadrangular in section but rounded off at the angles. Dorsal surface a good deal broader than the ventral and connected therewith by inwardly sloping lateral surfaces. Both the dorsal and ventral surfaces are flattened. The opening into the peripharyngeal chamber is situate a little behind the middle of the ventral surface, and the genital opening is about half way between it and the posterior end. The dorsal surface is of a dark reddish brown colour, slightly mottled, with a narrow median stripe of very dark brown, and a dark brown anterior tip. At the junction of the dorsal with the lateral surfaces there is, in two out of three of my specimens, a single row of small, pale spots, very distinct in spirit specimens. The lateral surfaces are also reddish brown, but much paler than the dorsal surface. The ventral surface is white, but owing to the slope of the sides of the body the latter appear as a brown stripe on each side of a median white band (Fig. 6*a*). Length when crawling about 27 mm., greatest breadth about 1.5 mm.

Locality.—Macedon (Victoria).

13. *Geoplana walhallæ*, n. sp.

This species agrees with *Geoplana spenceri* in shape, and in the uniform dark olive green colour of the dorsal surface. The ventral surface, however, instead of being blue, is of a light, speckled brown colour. The anterior tip is dark brown. The opening of the peripharyngeal chamber is situate near the middle of the body, but slightly in front, and the genital opening is about half way between it and the posterior end, if anything a little nearer to the posterior end. Length of two specimens when crawling about 37 and 50 mm. respectively.

I found two specimens of this Planarian at Walhalla, Gippsland, Victoria, one crawling on the top of a stone (in the day-time), and one under a log.

Locality.—Walhalla (Victoria).

14. *Geoplana fletcheri*, n. sp. (Figs. 8, 9).

Body much flattened ventrally, convex dorsally; a good deal broader behind than in front; tapering gradually to the anterior, and much more suddenly to the posterior extremity. Opening into the peripharyngeal chamber a little behind the junction of the middle and posterior thirds of the body. Genital opening somewhat nearer to the posterior extremity of the body than to the opening into the peripharyngeal chamber, and hence very near the posterior end. The ground colour of the dorsal surface is canary yellow, not quite so bright as in *G. sugdeni*, with a tendency towards the formation of two brown lateral stripes, continued backwards for some distance from the brownish pink anterior tip. In one specimen (Fig. 9), the ground colour was slightly mottled with brown, and, in addition to the two partial stripes already mentioned at the anterior end, there was a faint, narrow, median, brownish stripe running along the posterior half of the dorsal surface. The ventral surface is pale yellow. Length when crawling about 60 mm., greatest breadth about 3 mm.

This species at first sight resembles *G. sugdeni*, but may be readily distinguished by the general shape of the body, and the position of the apertures. I have named the species after Mr. J. J. Fletcher, B.A., as a slight recognition of his valuable work on the Australian land Planarians.

Locality.—Macedon (Victoria).

Genus *Rhynchodemus.*

This genus is distinguished from the preceding principally by the possession of only two, multicellular eyes, situate near the anterior extremity, and on the dorsal surface. Although apparently not uncommon in New South Wales, five species being described by Messrs. Fletcher and Hamilton *(loc. cit.)*, only a single specimen has as yet been found in Victoria, and that in the Croajingolong district, not very far from the New South Wales border. The species is, however, a new one.

15. *Rhynchodemus victoriæ*, n. sp. (Figs. 15, 15*a*).

Body (in spirit) much flattened, especially on the ventral aspect, not tapering evenly to the anterior extremity but with a slightly developed neck, which seems, indeed, to be characteristic of the genus (*vide* Figs. 15, 15*a*). The opening into the peripharyngeal chamber is very distinctly margined and situate a little behind the middle of the ventral surface ; the genital opening is about half way between it and the posterior end of the body. The eyes are very near the anterior extremity (Fig. 15, *e*). Professor Spencer informs me that the principal colour of the dorsal surface in the living animal was French grey or "elephant's breath." At the anterior end, on the dorsal surface, the following stripes are visible :—A narrow dark median stripe, dying out about half way down the body and edged on each side by a creamy white stripe of about the same width and dying out a little before the dark one. Just above each lateral margin of the body is another narrow creamy white stripe, soon dying out. The two white stripes of each side unite near the anterior extremity and at their point of union the eye of that side is situated (Fig 15, *e*). The ventral surface in the living animal was lighter grey, with a single, median, creamy white stripe dying out just behind the genital aperture, and a similar stripe very near the margin on each side also dying out towards the posterior end. Length in spirit about 26 mm., greatest breadth about 3 mm.

I received a single spirit specimen of this interesting Planarian from Professor Spencer, who collected it at Croajingolong. Professor Spencer supplied me with the description of the colours of the living animal, but the arrangement of the stripes I was obliged to make out in the preserved specimen.

Locality.—Croajingolong (Victoria).

Description of Plate VII.

Figures 1, 2.—*Geoplana mediolineata*, n. sp. Dorsal aspect. Fully extended. Typical form. Painted from life ; natural size. Macedon.

Figure 3.—*Geoplana mediolineata*, n. sp. Dorsal aspect. Fully extended. Variety with three complete stripes. Painted from life; slightly enlarged. Macedon.

Figure 3*a*.—*Geoplana mediolineata*, n. sp. Dorsal aspect. Anterior extremity of the same specimen as that from which Figure 3 is taken ; enlarged to show the arrangement of the stripes. Painted from life.

Figures 4, 5.—*Geoplana hoggii*, n. sp. Dorsal aspect. Fully extended. Painted from life ; natural size. Macedon.

Figure 6.—*Geoplana quadrangulata*, n. sp. Dorsal aspect. Fully extended. Painted from life ; twice the natural size. Macedon.

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Figure 8.—*Geoplana fletcheri*, n. sp. Dorsal aspect. Pretty fully extended. Painted from life ; slightly enlarged. Macedon.

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Figure 15.—*Rhynchodemus victoriæ*, n. sp. Dorsal aspect ; *e*, eye. Drawn from a spirit specimen, twice the natural size. Croajingolong.

Figure 15*a*.—*Rhynchodemus victoriæ*, n. sp. Ventral aspect of the same specimen as represented in Figure 15. *O*, opening into the peripharyngeal chamber ; *g.a.*, genital aperture.


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Fig. 3
Fig. 3a.
Fig. 4
Fig 5
Fig. 6
Fig. 6a
o
ga
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Fig 15 a
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Fig. 12
Fig. 8
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Fig. 14

ARTICLE III.—The Eucalypts of Gippsland, by A. W. Howitt, F.G.S., F.L.S. (With Plates 8, 9, 10, 11, 12, 13, 14, 15, 16).

(Read Thursday, July 10th, 1890).

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TABLE OF BOTANICAL, ABORIGINAL* AND LOCAL NAMES OF THE GIPPSLAND EUCALYPTS.

E. pauciflora ..	Bundagra	Mountain White Gum.
E. stellulata ..	Yimbit	Black Sally, Muzzlewood.
E. amygdalina ..	Chunchuka	Peppermint Gum.
,, (d) ..	Katakatak or Yertchuk ..	
,, (e) ..	Wang-ngara† ..	
E. piperita ..	Yangura	White Stringy-bark.
E. obliqua ..	Kátakatak	Messmate.
E. capitellata ..	Dumung	Mountain or Red Stringy-bark.
E. muelleriana ..	Yangura	Yellow Stringy-bark.
E. macrorhyncha ..	Katakatak or Yuroka‡	Mountain Stringy-bark.
E. sieberiana ..	Yauut	Mountain Ash, Gum Top, White Iron-bark, Wooly Butt.
E. leucoxylon ..	Yirik or Bwurawi ..	Iron-bark.
E. melliodora ..	Dargan	Yellow Box.
E. polyanthema ..	Den or Dern	Red Box.
E. odorata.. ..	Dargan	Yellow or Grey Box.
E. hemiphloia ..	Den or Dern	Grey Box.
E. pulverulenta ..	Bindirk	Silver Leaf Stringy-bark.
E. stuartiana ..	But-But	Apple Tree or Apple Box.
E. viminalis (a) ..	Binak	White Gum.
,, (b) ..		Cabbage Gum.
E. tereticornis ..	Yuro	Red Gum.
E. gunnii	Gura-Binak	Swamp Gum.
E. botryoides ..	Binak	Snowy R. Mahogany.
E. goniocalyx ..	Baluk	Spotted or Bastard Gum.
E. globulus ..	Baluk or Wang-ngara† ..	Blue Gum.
E. eugenioides ..	Yangura	White Stringy-bark.

* The majority of these native names are taken from the Muk-thang dialect. Muk-thang, or "excellent speech," was spoken by the Brabolung Kurnai, who lived on the Mitchell, Nicholson, and Tambo Rivers.

† Wang-ngara, in the Nulit dialect, spoken by the Brataua and Tatung, who dwelt between the Lakes and the sea, and in South Gippsland; wang means "bark," and ngara "a string" or "tough," hence ngarang "a sinew." The application of such a term seems more appropriate to E. amygdalina than to E. globulus, for the bark of the former is extremely tough, and can be detached from the bole in long strips. The bark of E. globulus is not so tough, but at times hangs from the tree in long strings, in reference to which, perhaps, the name is given.

‡ Yuroka was the name given by the Krauatun Kurnai, who lived at the Snowy River and spoke Thang quai, or "broad speech," to the mountain stringy bark, E. macrorhyncha.

The Eucalypts of Gippsland, by A. W. Howitt, F.G.S., F.L.S.

Introduction.

So much has already been done by Baron von Mueller towards bringing into order the numerous varieties of the recorded Eucalypts, that it only remains to work out their local distributions, as well as the effects produced by soil and climate. This attempt I have now made as regards the Gippsland Eucalypts.

The difficulties which have met me in this enquiry have been greater than I at first anticipated, as it has necessitated a series of investigations, spread over a number of years, and covering the greater part of Gippsland. Even now, after examining the whole of the district more or less carefully, I find that in order to complete my work with even a fair degree of accuracy, it would be necessary to again visit certain localities, my earlier observations of which are wanting in that minute examination which later investigations have shown to be absolutely necessary. I am unable to revisit the localities referred to, and have therefore confined my remarks more especially to Central and West Gippsland, touching the North-eastern part very lightly, and scarcely referring to East Gippsland at all.

I regret that this should have been unavoidable, for it is in the country between the Snowy River and Cape Howe, and south of the coast range, that one would most probably find that the New South Wales species meet and mingle with those most general in Gippsland.

It is my pleasing duty to thank Baron von Mueller most heartily for the unending kindness with which he has, throughout the course of my enquiries, responded to my constant requests for information, for the readiness with which he has examined and named the collections which I forwarded to him, and thus resolved difficulties which I met with, and for most kindly making available to me the specimens in his museum. I am much indebted for the kindness with which Mr. Luehmann has given me his valuable aid in comparing my samples with those of the departmental herbarium, with which he is so fully acquainted.

To Dr. Wools I am under great obligations for valuable information as to New South Wales species, and for samples of the same.

Also to Mr. J. E. Brown, F.L.S., of Adelaide, to whom I addressed myself for information as to South Australian species.

Mr. John O'Rourke, of Woolgulmerang, Mr. David O'Rourke, of Buchan, and Mr. S. C. Holme, of Eagle Vale, have all most kindly made collections of the Eucalypts growing in their respective neighbourhoods.

Types of Eucalypts growing in Gippsland.

Renantheræ.—In the following notes on the Types of Eucalypts in Gippsland, I have endeavoured to avoid repetition of the descriptions which have been given by Baron von Mueller with such admirable clearness and precision in the "Eucalyptographia," and desire only to add such particulars as have presented themselves to me, or have special reference to the local occurrence of these Eucalypts in Gippsland.

E. pauciflora.—This Eucalypt is extremely constant in character, whether found in small isolated colonies in the littoral tracts, as at Providence Ponds and Morwell, or forming forests over large areas in the Gippsland Alps up to an elevation of 5000ft., as on the Wonnongatta Plains, at Omeo, Woolgulmerang, and Delegate.

It appears to be essentially an Alpine species, yet able to maintain itself, to some extent, in localities but little elevated above sea level.

E. stellulata.—This is also an Alpine species, ascending almost if not quite to the same elevation as E. pauciflora, but does not descend, according to my observations, lower than 700ft. at Dargo and Ensay. No varieties occur, as far as my observations go.

E. amygdalina.—This is one of the most variable, and at the same time, naturally most widely spread of the Gippsland Eucalypts.

I have observed the following well-marked and constant varieties :—

(*a*). The ordinary narrow-leaved variety.—This is the type described and figured in the "Eucalyptographia;" it generally grows throughout this district on all formations, from the sea level up to about 4500ft.

(*b*). The broad-leaved variety. In the mountains, and more especially in some of the Plutonic and Metamorphic areas, as at Dargo and the Wentworth and Omeo, there occurs a form of Amygdalina which is to some extent distinct from the typical form referred to. I have not observed it at a lower elevation than 700ft. at Dargo, and it grows upon Mount Livingstone at about 3000ft., which is, probably, near its upper limit. According to my observation it does not exceed 100ft. in height, and is more frequently under 50ft. Its bark is wrinkled, approaching to fibrous, and persists up to the smaller branches.

The seedlings and young saplings have opposed sessile lanceolar leaves, which are, however, much broader than the ordinary form, approaching at times pointed ovate.

The leaves when scattered are broadly foliate and unequal-sided. The umbels, buds, and flowers are those of the typical form, but the fruit is much larger, and almost always ovate top-shaped, with a flat or slightly convex margin, and a brown or brownish-red tint. The valves, as in the ordinary form, are small.

However much this tree resembles the ordinary form of this Eucalypt, it is clearly to be distinguished from it, because the two varieties very commonly grow together, each maintaining its own character.

In other places they may be found forming independent colonies. While the common variety grows especially in the damp gullies and on the shady sides of the ranges from the sea level up to about 4000ft., this form of Amygdalina (*b*) grows preferably upon the sunny slopes from 700ft. to 4000ft. (See Pl. 8.)

(*c*.) This variety is restricted to barren sand ridges of the littoral tracts, for instance, in South Gippsland, between Merriman's Creek and Warrigal Creek, together with Banksia serrata, Acacia oxycedrus, and other sand-hill vegetation. It does not exceed 30ft. in height, and has a marked drooping habit in its branches and foliage, while the bark is wrinkled and persistent up to the small branchlets. The form of the leaves distinguishes it from variety (*a*), for they are long and narrow lanceolar or falcate, the venation is so little spreading as to resemble in some respects that of E. pauciflora or E. stellulata; the flowers and fruit are typical of E. amygdalina, to which I have assigned the tree. (See Pl. 10, Figs. 6 to 12.)

(*d*.) This is the most widely-spread variety of E. amygdalina, and at the same time that which departs most from the typical form. It grows most freely upon the rather poor sandy and clay lands of the littoral tracts, but I have also observed it in the mountains, for instance, where poor sandy tracts occur, as well as on the quartz grits and conglomerates at Wild-horse Creek, Wentworth River, on the Upper Silurian sediments, between Toongabbie and Walhalla, the Silurian sediment in the Tambo Valley Road, the Upper Devonian formations of the Insolvent Track, the Devonian porphyries at Gelantipy, and the Silurian formations at Delegate River.

It rarely grows more than 100ft. in height, but is generally a rather small tree, often stunted. The bark classes it with the stringy barks, for it is fibrous and persistent up to the smaller branches, somewhat resembling that of E. obliqua, but thinner, more fissile, and lighter in colour. For roofing purposes the bark is worthless, and the timber of no value for splitting or sawing, having the soft, veiny character of some types of Amygdalina.

The seedlings have opposed, narrow, lanceolar leaves, with, occasionally, tufts of hairs and frequently wavy margins.

The opposed character of the leaves is not maintained beyond the first two or three pairs, and the leaves then become ovate lanceolar, resembling in their pointed and unequal-sided form those of E. obliqua, though rarely as large. They are thick in consistence, of a dull green, and not shiny; in the latter trait resembling those of E. sieberiana.

The umbels have numerous buds, with the typical form of E. amygdalina, to which also the shape of the calyx tube, the short style, and depressed lid belong. The fruit is ovate top-shaped, with a flat and slightly convex margin and small deltoid valves.

The tree is found at a height of 100ft. above sea level at Merriman's Creek and the Bairnsdale to Buchan-road, to 2500ft. at the Upper Wentworth River. I have not observed it on the mountain plateaux, even where they descend to the latter height, and conclude that it is a littoral species which ascends the coast ranges. (See Pl. 9.)

(e.) This is the Wang-ngara* of the Gippsland blacks. It is found in the eastern part of Gippsland, but, according to my observations, not so commonly as the other varieties of this type. It grows along the rivers and streams, and in moist valleys, where it takes the place of E. viminalis *(a)*. It has a smooth, tall, but comparatively slender bole, with a scanty, often rather spreading, head, in which there is frequently a marked absence of foliage. The bark is persistent, and wrinkled only on the lower part of the bole, above which it becomes smooth and almost white. It is of extreme toughness, whence the aboriginal name.

The seedlings and young saplings have sessile, rather long, lanceolar, opposed leaves, resembling those of the normal Amygdalina, but which in the older trees become narrow lanceolar-falcate, attenuated at the stalk and pointed. The venation is rather indistinct, the marginal vein considerably removed, and the lateral veins very longitudinal.

The umbels are on stalks as long or longer than the bud and stalklet, the stalklet slender and longer than the bud, the lid small and depressed, with a slight point.

* This native name has a reference to the extreme toughness of the bark of this tree. Wang—a band; ngara is connected with ngarang—a sinew.

Buds numerous, 3 to 20. Flowers normal. Fruit, ovate truncate, with slightly contracted orifice, compressed rather narrow rim, and small weak valves.

Compared with samples, for which I am indebted to Dr. Wools, of Sydney, this appears to be the White River gum of New South Wales, Eucalyptus radiata (amygdalina). This seems to be one of those eastern forms of vegetation which are not found any further to the westward than the Mitchell River, though this tree individually does not extend beyond the Tambo River.

I have observed it at an elevation of 50ft. at Jimmie's Point backwater, 200ft. at the Tambo crossing, 300ft. at the Murrendel River, and at Wangrabell on the Genoa in East Gippsland, at an elevation, judging from memory, of not more than 500ft. (See Pl. 10, Figs. 1 to 5.)

(f) (or *E. regnans*).—This Eucalypt, though possessing a specific title, belongs to E. amygdalina, and is less removed from the typical form than the varieties which I have designated *(d)* and *(e)*. Under its common name of black-butt it is found in the western part of Gippsland on the Mesozoic carbonaceous formations, where it especially flourishes. It reaches 300ft. in height, and according to the statements of some observers* to 400ft. and above that height.

The young seedlings of this Eucalypt are at first like those of the typical Amygdalina, but with somewhat broader, lanceolar, opposed leaves. These are soon replaced by broadly lanceolar, scattered, unequal-sided, pointed leaves, very like those of E. obliqua. The saplings so much resemble those of this Eucalypt in other respects that at first sight they might be confused. The leaves of saplings of E. regnans, however, are thinner in texture, rather lighter in tint, not so pointed nor quite so unequal-sided as in E. obliqua.

The flowers and fruit connect this tree with E. amygdalina, and do not differ from the typical form more than do those of the varieties (*d*) and (*e*).

It occurs over a wide area in South and Western Gippsland, chiefly on the carbonaceous formations, together with E. obliqua, and E. globulus, from the sea level up to about 1200ft. It is also found in the mountains, as at Walhalla, 1200ft., and at Tucker Creek, Wentworth River, 2500ft.

E. piperita and E. eugenioides.—In accordance with the list of typical Eucalypts, given at p. 81, I should now describe E. piperita and eugenioides in sequence, but it will be more convenient to speak of these together, since their near alliance renders it necessary to point out the distinctions which may be drawn between them.

Eucalypts referable to these types grow more or less plentifully throughout the whole of Gippsland, ascending from the sea level to 3000ft. above it.

* Amongst others Mr. J. Rollo, formerly a sawmiller at Yarragon.

In the "Eucalyptographia" Baron vonMueller says, in speaking of E. eugenioides, that the distinctions between E. piperita and E. eugenioides are not yet clearly made out, and that, perhaps, Bentham's view, that both should be regarded as forms of one species, may have to be adopted.* And, in referring to E. Piperita he describes its fruit as truncate or globular ovate, contracted at the narrow-edged orifice, with valves perfectly enclosed.

This description accurately fits the sample from New South Wales, which, by the courtesy of Baron von Mueller, I was enabled to examine in the collection of the Department of Botany of Victoria. But it does not apply so aptly to the fruit of E. piperita as I have found it in Gippsland. Occasionally I have met with examples of this Eucalypt with truncate-ovate narrow-rimmed fruit, as, for instance, at the Tambo River; but the general form of the fruit, especially in the western part of the district, is extremely variable, as will be seen from the following particulars.

In order to study the possible differences which might exist between E. piperita and E. eugenioides, I collected 26 samples from various parts of Gippsland, and compared the fruit as one of the readiest means of reaching some definite conclusion; for I had already found that a diagnosis, based upon the general characteristics of the aged trees, saplings, seedlings of the umbels, buds and flowers, led to no definite result, except to raise very strong doubts as to the distinctions between the so-called separate species being maintainable. Of the 26 samples, 3 had truncate-ovate fruit, 16 truncate-globular, and 7 truncate-spheroidal.

In 10 examples the rim was sharp, and in 16 blunt, but the bluntness of the rim was not always associated with a much-truncated form of fruit and a wide orifice; and in several cases I noticed on the same tree two forms of fruit, one truncate-ovate, with a comparatively narrow sharp rim, and another which was much truncated and more globular, and with a wide orifice.

The samples which I thus examined were, six from the country east of Bairnsdale, seven from the neighbourhood of Toongabbie, and the remainder from isolated places throughout the district, from the coast line to an elevation of 3000ft., at the sources of the Wentworth River.

If any conclusion is justified from these comparisons, I should say it is that the greater number of samples having a truncate globular fruit, with a contracted aperture, and a narrow sharp rim, are to be found in Eastern Gippsland, while those few, which, in their much truncated fruit, with wider, blunt rims, and wider apertures, may be assigned to Eugenioides, occur in the western parts, as, for instance, at Drouin and the Agnes River.

* Eucalyptographia Tenth Decade.

It is in Western Gippsland, namely, near Drouin and at the Agnes River, that I found those samples which were most near to the typical forms of E. eugenioides, and in which the valves were distinct, but yet only slightly exserted.

The conclusion to which I am led is that the suggestion thrown out by Bentham, and noted by Baron von Mueller, is correct so far as concerns Gippsland, namely, that E. piperita and E. eugenioides are near varieties of the same type. But when comparing the extreme forms found in South-western Gippsland with the typical E. piperita from New South Wales, to which the examples from near the Tambo River must be assigned, the conclusion is arrived at that the differences are such as to have justified Dr. Wools in regarding E. piperita and E. eugenioides, as they occur in New South Wales, as distinct.

An examination also of numerous individual trees in different localities where these Eucalypts flourish as one of the principal forest trees, for instance, at Merriman's Creek, Toongabbie, the Macalister River, Budgee Budgee, the Wentworth, and the Tambo, has shown me that in all these localities trees can be found growing side by side, having fruit which is either truncate ovate-globular with a narrow aperture, or compressed globular, much truncated, and with a wider aperture. The seedlings and saplings growing in such localities, with the aged trees bearing such fruits as above referred to, are indistinguishable from each other, and I have come to the conclusion that, so far as concerns Gippsland, possibly excepting perhaps its extreme eastern part, there are no strong features to separate these Eucalypts into Piperita and Eugenioides. If, however, samples are compared of the New South Wales Piperita with the Gippsland samples, which agree with the definition of Eugenioides, then it will be found that there are good and distinctive characteristics.

I have felt some difficulty in deciding to which type the Gippsland form should be assigned, but on consideration I think that, in the majority of cases, the form of the fruit and the seedings with ovate-crimped leaves, point to E. piperita rather than E. eugenioides (*). I have, therefore, assigned them to that species, though there are a few localities such as the Agnes River and at Drouin, where Eucalypts occur, which can rightly be referred to E. eugenioides.

E. muelleriana.—This Eucalypt has an extensive range in the western half of Gippsland. It is a littoral species, and is principally found between the Hoddle Ranges and the sea coast. There it forms the bulk of the forest, growing upon sands and sandy clays, from Monkey Creek, 20 miles from Sale, to Shady Creek, west of Alberton, in an east and west direction, and from Carrajung southwards to the coast. The area thus covered by this tree is about 300 square miles. It also occurs in lesser

* The seedlings of the New South Wales variety, for which I have to thank the courtesy of Dr. Wools, bear out this view.

colonies on the ridges extending from the Tertiary tracts up to the high ranges forming the spurs of the mountains. I have not observed it west of Toongabbie, where it ascends the hills of Upper Silurian sediment for about 6 miles northwards to 1000ft. in elevation. I have also seen it growing extensively on the hills across which the road, known as the Insolvent Track, runs from the Stockyard to Cobannah Creek. The formations here are Upper Devonian, resting upon sediments which may be either Devonian or Upper Silurian. Its range north and south in this locality is at least 25 miles, and its highest elevation probably over 1200ft. I have noted a third locality where this tree occurs under precisely similar conditions, extending northwards on the spurs of the mountains, skirted by the Tambo Valley-road. There it grows for several miles on the Silurian sediments, northwards from the edge of the tertiary marine beds, and reaches an elevation of at least 1000ft. I have little doubt that it will be found in the intervening localities, and perhaps further to the eastward ; but of this I have no direct evidence.

It appears to grow to the largest size on the sands and sandy clays of South Gippsland, where it forms most valuable forests. Its maximum height is 170ft. or thereabouts, but more frequently 100ft. to 150ft. The bole is straight and rather massive, with moderately spreading branches, and a fibrous and dark-grey bark, which is more deeply and coarsely fissured than that of E. piperita, in fact, resembling the bark of E. capitellata, where that species grows to a good size in favourable localities. The bark is persistent up to the small boughs, which are more or less smooth. The leaves of the aged trees are lanceolar, falcate, and more or less inequal-sided, rather dark green in colour, equally shining on both sides, and usually three to five times as long as broad, with a sharp apex.

The seedlings have narrow lanceolar opposed leaves of a dark green, shining but paler on the under side. In the earlier stages they are frequently more or less beset with small tufts of hairs. I have noticed that the leaves are still opposed in young plants 2ft. to 3ft. in height. In young saplings, and those some feet in height, the leaves are rather broad lanceolar, or ovate lanceolar in shape, less shiny on the lower page, much dotted with transparent pores, and rather thin in substance. A marked feature in the saplings of this Eucalypt, and one by which it can be distinguished almost at a glance from those of other stringybarks, is that the broadly lanceolar and pointed leaves have a tendency to assume a horizontal position, rather than a vertical one, and this gives the saplings a shining appearance. The stems of these saplings and young trees are somewhat smoother than those of E. piperita, E. capitellata, or E. macrorhyncha.

The umbels are usually solitary, and there is a marked tendency in this Eucalypt for them to become strongly panniculated. The buds are from 3 to 12 in most of the umbels. The stalk is frequently slightly flattened, and not much longer than the buds, and the stalket nearly as long as the calyx tube, the lid semi-ovate to hemispheric, smooth and occasionally slightly pointed, the stamens (rather sparse) are large and reniform like those of E. capitellata. Fruit almost hemispherical to approaching semi-ovate, the rim flat or even slightly inverted, not wide, valves deltoid, small, and inserted, or more rarely slightly prominent; four-valved, less frequently three to five valved.

The timber of this tree is usually rather darker in tint than that of E. piperita. It is fissile, free from gum veins or shakes, clear in the grain, and enjoying a great reputation for durability. It is used for fencing and sawing, and, according to Mr. Macalpine, of Tarraville, who has lived for 40 years in South Gippsland, fences are still standing at Woranga with posts split from this Eucalypt, which have been from 30 to 40 years in the ground. I have myself observed posts of this timber standing in fences at Woodside since 1859. The local name of this tree is "yellow stringy-bark."

This Eucalypt, therefore, is to be placed between E. eugenioides and E. capitellata. It resembles both, but the dissimilarities are more marked than the resemblances. The characteristic distinctions are quite as constant as those which distinguish those two species, and the occurrence of these species over so large an area, as well as in independent lesser colonies, negatives the probability of its being a mere hybrid. The distinctions which I have now noted as separating this Eucalypt from its nearest congeners are such as to have led me early in my enquiry to regard it as a species distinct from either. I hesitated, however, to definitely state this until I had an opportunity of comparing my samples with those in the collection of the Government Botanist. Having been enabled to do this through the courtesy of Baron von Mueller, and having been most kindly aided in the comparison by Mr. Luehmann, I feel that, being fortified by the opinion of our greatest authority, the venerable author of "Eucalyptographia," I may establish this Eucalypt as an independent species under the designation of Eucalyptus muelleriana.

E. capitellata.—This tree occurs in small colonies, scattered over a great part of Gippsland. It cannot, strictly speaking, be called one of the littoral species, for I have not seen it growing at a lower elevation than 500ft., as at Drouin West, 750ft. at Darlimurla, and above that elevation between Bruthen and Buchan. Thence it ascends the mountains to 1200ft., near Walhalla, and 2000ft. on Mount Elizabeth, near Noyang. It varies but little in character, yet in places the fruit approaches that of E. macrorhyncha in the somewhat protruded vertex and to E. muelleriana when the margin is but slightly convex. I have referred to the peculiarity of its seedlings in comparing those of the stringy barks generally, after speaking of those of E. obliqua.

E. macrorhyncha.—This is essentially a mountain species in Gippsland, and the lowest elevation at which I have found it growing is at Glen Maggie, 200ft. above sea level, upon Upper Silurian sediment. In the valley of the Macalister it grows extensively, ascending the mountains near Mount Wellington to 3000ft. On the Insolvent Track it appears at 1000ft., and thence extends through the mountains to the sources of the Wentworth River, reaching an elevation of 3000ft. Similarly on the Tambo River it commences at 800ft., near Noyang, and extends to 3000ft. at Omeo. Further to the East at Turnback 1000ft., Jingalala 2500ft., and Bonang 3000ft.; it is also found extensively on the Buchan, Snowy, and Deddick Rivers, extending towards the high mountains in New South Wales. It grows especially upon dry ranges, on Plutonic, Metamorphic, and Sedimentary formations of Silurian and Devonian age. I have not observed it anywhere in the Tertiary tracts.

E. obliqua.—This Eucalypt is principally found in the western and south-western portions of Gippsland, where it, in many places, forms the whole of the forests, or is in others mixed with E. goniocalyx, E. viminalis, E. gunnii, and E. globulus. It appears to be essentially a littoral form, but ascends the mountains to considerable elevations in the cool, shady, moist gullies on the southern slopes. For instance, in the great Dividing Range, where the Nicholson River rises, E. obliqua follows up the damp gullies on the south side, and forms part of the forest on the summit, together with E. sieberiana (*b*), E. viminalis (*a*), and E. amygdalina (*b*). It occurs also in Eastern Gippsland, as, for instance, at Buchan, Gelantipy, Bonang, and Bendoc. It varies but little in character, although the form of the fruit is in some cases, as, for instance, near Port Albert, in the sandy coast country, not quite so truncate-ovate as in the typical forms, yet in all cases the peculiar unequal-sided ovate lanceolar or even-cordate lanceolar and pointed form of the leaves always marks the saplings and large seedlings from those of any other species.

Having now referred to the various types of the stringy-bark groups, it is convenient to mention the distinctions between their seedlings and saplings.

The seedlings of E. piperita, E. eugenioides, and E. capitellata are beset on stems and leaf-stalks with numerous tufts of hairs, which also line the edges of the leaves.

The leaves themselves are more or less hairy, except in that form of E. capitellata growing in the mountains, as at Osler's Creek, where they are smooth. Those of E. piperita and E. eugenioides are, at this stage, universally hairy. The seedling leaves of both E. piperita, E. eugenioides, and E. capitellata are at first ovate and opposed, but in the former I have often observed them to be ovate-pointed, or even lanceolar and smaller than those of E. capitellata, which are always ovate. In neither species are the leaves shiny.

In E. macrorhyncha the seedlings are also more or less beset with tufts of hairs, giving the stems a rough appearance, but in a less degree than the last-named species. The leaves, at first opposed, are lanceolar in form, and slightly shiny. The seedlings of E. muelleriana are as characteristic as those of any other species known to me. The stem and stalklets are slightly tufted with hairs, or are even smooth, the leaves rather long, lanceolar, pointed, and opposed throughout, even in seedlings of a foot or more in height, while their extremely shiny upper surface distinguishes this form from all the other species of this group, being more marked even than in E. obliqua, from which the persistent opposition of the leaves readily distinguishes it.

The seedlings of E. obliqua are usually free from hairs, but are very commonly warty, and the leaves are lanceolar, shining on one side, and thinner in texture than those of E. macrorhyncha. They become scattered somewhat sooner than those of E. macrorhyncha, and very much sooner than those of E. muelleriana, and soon show the marked unequal-sidedness which is so characteristic of this tree.

The saplings of these Eucalypts may also readily be distinguished from each other.

Those of E. piperita remain rough up to 10ft. in height, the leaves then become unequal-sided, ovate-lanceolar, or ovate-pointed, having the upper surface slightly darker green, and more shining than the lower.

E. capitellata soon produces unequal-sided cordate leaves, fully twice the size of those of E. piperita, and of a lighter shade of green, moreover, they hang more vertically, and are consequently more equally tinted on both sides. In size, and the inequality of the sides, they resemble the sapling leaves of E. obliqua, but are readily distinguished by not being attenuated as those of Obliqua are.

The saplings of E. muelleriana are distinguishable from all the others by having opposed leaves, even up to two or three feet in height. The leaves are lanceolar and unequal-sided, but in a less degree than others of the group. The upper page is very shining, and the lower much duller and paler in hue. The apex is more or less acute, and the lateral veins are more numerous and less spreading than in E. capitellata. Even in saplings from 8ft. to 10ft. high, the leaves have a general tendency to assume a horizontal position, thus producing a peculiar shining appearance of their upper pages, which is characteristic of this tree when young.

The saplings of E. obliqua have somewhat large, very unequal-sided leaves, broadly lanceolar, or even cordate, and always attenuated, thus being, as I have pointed out, distinguished from E. capitellata, whose sapling leaves are not attenuated.

E. stricta.—The only locality in Gippsland in which this Eucalypt is found is, as far as I am aware, on St. Pancras Peak, a rocky mountain between the Buchan and Snowy Rivers, probably 4000ft. in height.

Baron von Mueller refers to it in the "Eucalyptographia, Tenth Decade," on the authority of Dr. Wools and Rev. R. Collie, as growing on the elevated parts of the Blue Mountains, particularly at some of the summits. In Gippsland it is locally called "Mallee," from some fancied resemblance to the growth of that species, growing in a number of slender saplings, from one thickened stump-like butt.

This variety agrees in almost all respects with that figured by Baron von Mueller, and described by Sieber as E. rigida, except that the fruit, in my example, has no prominent rim, and is rather hemispheric than truncate-ovate.

E. sieberiana.—There are two well-marked varieties of this Eucalypt which I distinguish as (*a*) and (*b*). E. sieberiana (*a*) occurs extensively on almost all formations, in parts of Gippsland, up to an elevation of 3000ft., near Grant and the sources of the Wentworth River, and at 4500ft. on Mount Wellington. It is characterised by a very rough deeply-fissured bark, which is persistent on the stem and larger limbs only, hence its local names of "gum top," or "silver top;" its name, "white ironbark," only refers to the colour of the wood. It grows especially on the dry tops of the mountain ridges, and upon their sunny slopes.

E. sieberiana (*b*) occurs only in the mountains above the limit of E. sieberiana (*a*), sometimes as low as 2500ft., but in other places, as on the summit of the Great Dividing Range at the sources of the Livingstone Creek, where E. sieberiana (*a*) ceases at 3000ft., and E. sieberiana (*b*) commences at 3500ft. It extends on the summits of the higher mountains, *e.g.*, the Bowen Mountains, near Omeo, and the Dargo High Plains to about 4500ft.

I estimate the height to which the tree attains as not exceeding 200ft. The bark is fibrous, and rather like that of E. obliqua, but perhaps more flaky; it is persistent upon the bole, the upper part of which and the branches are smooth, but with much detached bark, pendant from the forks and from the termination of the persistent bark.

The seedlings of these two trees have much the same features, but that of the (*a*) variety is much darker, and the stems more purple or reddish in tint. The fruit also is usually smaller and darker, but otherwise no marked difference can be observed between the seedlings of these varieties.

The timber of the (*b*) variety is of a light colour, long in grain, and remarkably fissile, yet elastic. It is not a heavy wood, and it seems to me should be valuable for many purposes. About 20 years ago, at Omeo, I made a set of swingle-bars for a four-horse team from this timber, which stood work remarkably well, and one of which is still in existence after much hard usage. I have also seen palings split from this tree over 6ft. in length, which were so clean, that after being planed up, were used successfully as weatherboards. Locally the tree is called "Woolly-butt," from the character of the bark, and also "Mountain Ash."

E. odorata.—This tree has in many respects a superficial resemblance to E. melliodora, with which it was for a long time locally confounded in Gippsland.

Of late it has received the local name of "Grey-box" from the splitters and sawmillers.

It grows principally on the Miocene limestones in the littoral tracts of North Gippsland.

The difference between E. odorata and E. melliodora was long apparent to me, from a careful comparison of the trees growing in the Mitchell River district, and especially from distinctions which have been apparent to the timber men there. The wood of this Eucalypt is much browner in colour than that of E. melliodora, and while the timber of the latter can very rarely be split into posts or rails, that of the former, although it is difficult to split "on the quarter," is, when once the log is opened, "backed off" with great ease. The principal differences upon which a rapid diagnosis may be made lie in the greatly superior height of E. odorata, in its freer growth, the rhytiphloious bark, the smooth upper portion of the stem and limbs, and the somewhat larger fruit, with a narrow compressed rim, and more deeply sunk orifice. Finally, the outer stamens are all provided with fertile anthers, while those of E. melliodora are anantherous.

The timber of this tree is most durable, and is one of the most serviceable of the Eucalypts of Victoria, especially for work which is exposed to damp.

This tree grows to 200ft., or in exceptional cases to perhaps 250ft. in height.

I have observed a small colony of E. odorata growing in South Gippsland, near Four-mile Creek. The occurrence of this tree in the Miocene limestones of North Gippsland falls in with the statement made by Baron von Mueller that it occurs upon limestone areas at St. Vincent's Gulf.

E. leucoxylon.—This tree does not form forests in Gippsland, as in other parts of Victoria, but occurs scattered over a wide extent of country, from sea level up to 2000ft. It grows upon various formations, as, for instance, at Toongabbie, on recent Alluviums, Tertiary clays, and Upper Silurian. At Bairnsdale, upon Miocene and later Tertiary beds; at Glen Maggie, upon Upper Silurian sandstone; at Upper Freestone Creek, upon Upper Devonian conglomerates; at Noyang, upon Palæozoic Plutonic rocks; and near Buchan, on Tertiary sands and clays.

I have not observed it further to the westward than Toongabbie, and it varies but little, if at all, in character throughout Gippsland.

E. melliodora.—This is also of wide distribution, from about Traralgon, in South Gippsland, to Jingalala, in North-east Gippsland, and at all elevations up to 2000ft., and on all formations. Its characteristics are also constant.

E. polyanthema.—Of this type there are two varieties, which, however, are not sufficiently marked to justify me in separating them, as I have done in other cases. Where it occurs in the littoral districts, as, for instance, at the Lakes' Entrance, or river flats at Heyfield or Bruthen, it has full foliage of a rather dark green colour, and the leaves somewhat thin in texture. The tree grows to some size, but in many cases, as Baron von Mueller has already pointed out, become so hollow as to form a mere shell.

The second variety is found in the hill country, and ascends from about 100ft. above sea level, as at Heyfield, to an elevation of 2000ft., as at the Wellington River and at the Tambo River (Fainting Range). This mountain variety is a much smaller tree than the lowland form; the leaves are thicker in texture, frequently pruinous, or even mealy. At first sight the tree resembles somewhat E. hemiphloia (variety Albens) in its bark, and ash coloured, and sometimes rather lengthened ovate leaves. But it is readily distinguished by the form of the buds, by the outer filaments being anantherous, and by the fruit. The seedlings and young saplings of both have much in common.

E. hemiphloia.—This species is extensively represented in Gippsland as a mountain form. It occurs, for instance, in the valley of the Tambo River, north of Fainting Range, where it forms the principal part of the forest, from about 750ft. at Numlamungie to 2500ft. at Tongeo Gap. It is found at Turnback, at the Snowy River, at Deddick, and, more rarely, at Tubbut.

Its characteristics accord entirely with the diagnosis given in the "Eucalyptographia," with the exception that the umbels are formed by buds of comparatively large size. The fruit is proportionately large. The bark, also, extends frequently far up the branches, so that when the leaves are not markedly elongated, this tree resembles, as I have already said, at first sight, the mountain form of E. polyanthema. Yet, so far as I have observed, the two species are sharply marked off from each other.

This form of E. hemiphloia appears to me to be that variety called E. albens.

E. pulverulenta is found in many places in Gippsland, though it nowhere forms the bulk of the forests, or it is found scattered widely among other Eucalypts. In South Gippsland, and near Boolarra, it grows to a maximum height of under 50ft., but is of a smaller growth in other parts, as, for instance, at Osler's Creek, Providence Ponds, and Buchan. The peculiarity of this variety, as found in Gippsland, to which Baron von Mueller has drawn attention in his "Eucalyptographia," lies in the lanceolar or falcate form of the opposed leaves of the aged trees, the ovate or rounded leaves being confined to the saplings, or young trees.

This tree is worthless for timber, and I have never seen it used for any purpose except for fuel, in default of better. The local name, "silver-leaf stringy-bark," refers to the pulverulent or ashy character of the foliage, and to its fibrous bark.

It occurs from near sea level up to an elevation of 700ft. at Darlimurla, nearly the same at Buchan, and 1000ft. at Osler's Creek. (See Pl. 15, Figs. 1 to 4, 9, 10, 13, 32, 33, 34.)

A few other remarks remain to be made when I compare E. pulverulenta, E. stuartiana, and the mountain form of E. viminalis.

E. stuartiana.—This species is well marked, and is one of the most persistent in character of any of the Eucalypts of Gippsland. Wherever I have seen it I have found it to be a tree with somewhat large and spreading limbs, with a scaly, wrinkled bark, which is persistent up to the small branches.

The wood of this tree is valueless for splitting, sawing, and even for fuel. Its general appearance has caused it to be confused with E. hemiphloia, under the designation of "white box," under which name I have known it to be cut for sale, at least at one sawmill in Gippsland. It is found growing over almost the whole of the district, from a little above sea level up to a considerable elevation in the mountains, as, for instance, up to 2300ft. on the track from Dargo to Omeo. It is found on all formations, but I have observed it especially on the Tertiary clays of South Gippsland, and on the Metamorphic and Plutonic areas of Tubbut, Dargo, and Jingallala.

E. viminalis.—My observation has shown me that there are at least three Eucalypts, which may be assigned to the type of Eucalyptus viminalis.

(*a.*) The typical form of E. viminalis in Gippsland is the so-called "white gum," or "river gum," which grows along the immediate course of streams. It may, for instance, be seen along the Glengarry, Thompson, Mitchell, and other rivers.

It accords well with the description of the species given in the "Eucalyptographia," hence I need not refer to it further here, more especially as I shall have to draw attention to it in distinguishing the varieties.

The typical form grows from near sea level to at least 4000ft., as on some small streams rising in Mount Livingstone. It is especially found following the river courses, and ascends to its highest elevation without extending to the hills on either side. (See Pl. 15, Figs. 23 to 31; Pl. 14, Figs. 7, 8, 9.)

(*b.*) This Eucalypt is sub-alpine, and appears some 700ft. above sea level, as at Dargo and Noyang, but somewhat higher on the Wellington River, and at Gelantipy. It also grows about Morwell, where, together with E. pauciflora, it forms part of the forest, just as it does throughout the alpine and sub-alpine localities, which are its special habitat. In the highest tracts, as at Dargo High Plains, it grows to a height of over 100ft. It has a rather massive bole, wlth moderately spreading limbs, and fairly full foliage. The bark is smooth and very white, excepting near the ground, where it more or less persists; it has frequently, when about to dehiss, a decided "coppery" tint upon the bole and limbs. The wood is somewhat soft, not very fissile, and resembles that of the lowland form, except that it has a more reddish or pinkish tint. The leaves are lanceolar, slightly falcate, and more or less attenuated at the stalk, the marginal vein is usually but slightly removed, the lateral veins numerous, not very marked, and inclined at about an angle of 40deg. with the midrib. The umbels are axillary or solitary, and the stalklets about as long as the buds. The buds are ovate, most commonly three in number, and arranged in the cruciform manner so characteristic of E. viminalis. The lid is semi-ovate, smooth, and occasionally pointed, but is not mamillated, as is the case with E. stuartiana. Judging by the examples which I have examined, I think that the buds of this variety are more broadly ovate, have shorter stalks, and more rounded lids than those of the lowland form. The fruit is semi-ovate, with a somewhat wide and more or less convex margin, and with rather strong deltoid and protruding valves.

These characteristics are those of the typical E. viminalis, but the seedlings and young saplings have peculiarities which raise doubts whether indeed this Eucalypt should not rather be referred to E. stuartiana.

The seedlings have round or ovate opposed leaves, which are closely sessile, rarely they are ternary in verticels, the stems as well as the leaves are mealy, and thus resemble very strongly, as also in other respects, the young plants of E. pulverulenta as it grows in Gippsland, rather than those of E. stuartiana.

Even when as high as 8ft. or 10ft., the saplings still have pulverulent leaves of an ovate form and opposed position, and the grown trees themselves occasionally show a reversion to this structure at the ends of their pendant branches. In some localities, as for instance at Dargo, this tree grows together with E. stuartiana, the latter being in its typical form. When the seedlings and saplings of these trees are thus compared, those of E. stuartiana are found to be much less mealy, to be of thicker consistence, and more pointed than those of this variety of E. viminalis, in which the opposed condition of the leaves is continued much longer than in E. stuartiana. There can be no doubt that E. viminalis and E. stuartiana are nearly allied, and it becomes necessary now to enquire to which of these this Eucalypt stands nearest. E. viminalis differs from E. stuartiana, as I have observed them to be in Gippsland, by having much smaller limbs as compared to the bole. The leaves of the former are smaller, as a rule, more attenuated at the stalk, of thinner consistence and lighter colour. The marginal vein is less distant, the lateral veins more numerous, nearer together, and more obscure. The angle formed by the lateral veins, with the direction of the midrib, is greater in E. viminalis than in E. stuartiana.

The mean of a considerable number of measurements gave 10deg. more for the former than the latter. In the greater number of cases the umbels of E. viminalis are three in number, arranged in a cruciform manner, while those of E. stuartiana are more numerous and not so arranged. The buds of E. viminalis are more ovate, with a rounded, or at most, minutely pointed lid; those of E. stuartiana are distinctly pointed, or even mammelated. The stalklets of E. viminalis are, as a rule, shorter, particularly in the mountain form, although in some cases those of the lowland forms are as long, or longer, than those of E. stuartiana.

The fruit of E. viminalis is more ovate than that of E. stuartiana, with a rim, which is always more or less convex, or frequently strongly so.

Especially is this the case in the lowland form along the river courses, but is less so in the mountain form.

In the mountain form the fruit is usually more hemispherical than in the lowland variety, with a convex vertex, and the valves somewhat weaker, although protruding. It is in those examples which grow at the highest altitudes, as, for instance, the Dargo High Plains, 4500ft., that I have observed the form of the fruit to resemble that of E. stuartiana, and in these the fruit is semi-ovate, the rim not very wide, and the valves, although exserted on the whole, having their insertions placed a little below the level of the rim. Yet, on examining the fruit from a number of trees, I observed that there was a considerable variation in that of the same tree. While some agree with this description, others have the protruding convex rim and exserted valves of the typical E. viminalis. (See Pl. 15, Figs. 14 to 22; Pl. 14, Figs. 1 to 6, 10 to 18.)

In the variety which I am now considering, it must be noted that the habit of growth, and the character of the wood, is that of E. viminalis, and not of E. stuartiana. Although the cortical character is not of much value, the character of its bark places it among the Leiophloiæ.

This tree is the manna-producing Eucalypt of the mountain country. The manna is produced as plentifully, in the same manner and of the same kind, as that produced by the typical E. viminalis.*

* When travelling through the Morwell district, where this tree forms part of the forest, some school children, whom I requested to point out the "manna gum," indicated this tree, saying that in December the ground under the tree was white with manna.

I must note, in this connection, however, that I have found small quantities of manna indistinguishable from that of E. viminalis, either by appearance or taste, attached to slight injuries on the leaves of saplings of E. stuartiana at Toongabbie.

The differences between this Eucalypt and the typical form of E. viminalis lie almost entirely in the form of the leaves of seedlings and young plants, and in their pulverulent character. In general appearance these certainly resemble the young plants of Stuartiana, but even more those of E. pulverulenta, as found in Gippsland.

Having to choose between E. viminalis and E. stuartiana, I have, after weighing all these considerations, assigned it to the former, notwithstanding the strong presumption which arises to the contrary from the extreme departure of its seedlings from the typical form.

It seems not only to connect E. viminalis and E. stuartiana, and thus to strengthen the alliance which, as Baron von Mueller points out, exists between these Eucalypts, but also to connect these two with E. pulverulenta, in some variety of which I have observed the fruit to have a protruding margin and exserted valves.*

(c.) A somewhat peculiar form of E. viminalis grows between Toongabbie and Walhalla, from about 1000ft. to 2500ft. above sea level. It does not exceed 100ft. in height. The bark is somewhat rugged, and persists over the bole, but on the branches is smooth and of a reddish brown tint, the foliage is plentiful, and of a somewhat ashy-grey tint. The leaves are lanceolar to falcate, the veins rather indistinct, but agree with those of E. viminalis. The umbels, buds, blossoms, and fruit are also of this type, but with this difference, that the umbels have numerous buds, and only rarely three arranged in a cruciform manner.

The timber of this tree is of no use except as fuel. I have not observed it growing in any other locality.

E. tereticornis.—This tree, the well-known "Red-gum" of Gippsland, is essentially a littoral species.

It grows mainly on the recent alluviums, river flats, ancient lake basins, and on the lower terraces of the Tertiary formations, up to an elevation of 150ft. or more, rarely 200ft., above sea level. The western limit is about Traralgon, and it extends eastwards, almost to Buchan, and northwards to Glen Maggie, Glenalladale, and Bruthen.

* The difference in the young plants of the lowland and mountain forms of this Eucalypt are little, if any, greater than those which I observed exist in the young forms of the two varieties of E. leucoxylon, which grow in the neighbourhood of Heathcote.

The smooth-barked variety, locally known as spotted box has, in its young form ovate, opposed, somewhat mealy leaves. The rough-barked form—the Ironbark—has opposed leaves only in very young seedlings.

In only one instance have I found it growing in the mountains, viz., at Glen Falloch, where it occupies a basin of soft shale of Upper Devonian age, from 700ft. up to 1500ft. above sea level. The soil of this basin, which is derived from the soft shales, resembles that of the lower districts where E. tereticornis thrives best.

The slight distinctions which separate it from E. rostrata are constant throughout Gippsland, although the terete form of the lid varies ; some forms being much more attenuated than others. Yet in all the characteristic arrangement of the anthers is constant.

E. gunnii.—This type is very widely spread over Gippsland, not only in horizontal range, but also in elevation above the sea level. I have observed a lowland and a highland form, and each of them has a dwarf variety.

Lowland form (*a*).—This form has been fully dealt with by Baron von Mueller, and I have only to add that it occurs throughout the littoral country. In the damp climate of West and South-Western Gippsland it grows to a considerable height, say 150ft., with a straight clear bole, and was there cut by saw-millers, in one instance at any rate, as "blue-gum." In Central and Eastern Gippsland it does not grow to so great a height, but maintains its other characteristics.

(*b*).—This dwarf variety grows in poor, boggy country in the low-lying tracts, but also occurs in the drier hills at Foster. It usually does not grow higher than 4ft. to 5ft., but at Foster it is found from 18ft. to 20ft. in height. The bark is smooth in texture and ashy grey in colour, which becomes lighter in the upper branches. Generally, when in its dwarf form it has a large butt level with the ground of several feet in diameter, from which rise numerous shoots.

In the dwarf form the leaves (excepting in the upper shoots) are somewhat broadly ovate, and are opposed and sessile. The texture is thick and leathery, of a dull, rather dark green colour. In the taller examples the leaves become scattered, ovate lanceolar, somewhat attenuated at the stalk, and accuminate. They are equilateral, slightly shining, and of a rather brighter tint than the sessile leaves, and have the marginal vein distinctly removed, the lateral veins numerous and rather spreading. Very often the terminal leaves are opposed.

This Eucalypt flowers and fruits when in a completely dwarf state. The umbels are mostly axilliary, and of a bright yellow to orange colour, as are also the stalks and young shoots. The stalklet is angular and wrinkled, sometimes rounded, about twice as long as the sessile buds, which are 3 to 7, and much crowded together. The fruit sessile in clusters of 3 to 7, semi-ovate, margin slightly compressed, valves small, not exserted, stalk slightly flattened.

The Tall Mountain Form (*c*).—This much resembles some of the lowland varieties, which grow upon dry tracts of land; but the leaves are shorter, more ovate, smoother, thicker in consistence, and rarely have the wavy margin which is characteristic of the tall lowland form.

Its lower limit is probably about 600ft. above the sea level, but I think it possible that the tall lowland form intermingles with it at that elevation, or less.

Dwarf Highland Form (d).—I have observed this form of E. gunnii growing extensively in the swampy flats at the source of the main branch of the Livingstone Creek, at an elevation of about 3000ft.

The description given of the dwarf lowland form applies in many respects to this also. It does not exceed 20ft. in height; the bark is smooth, persistent at the butt, and smooth and greenish on the branches. The leaves are ovate, and at first opposed and sessile, or nearly so, finally scattered, of a dull green. The umbels are axillary, or solitary, of sessile crowded buds. Fruit, semi-ovate rim, rather broad and slightly convex, the valves barely exserted. The young twigs and umbels are all slightly mealy. This form, however, differs from the corresponding lowland one in the leaves being shorter and broader when they become scattered, in the darker green of the foliage, and the smaller size and mealy character of the buds. The fruit also is of a smaller size.

E. botryoides.—This, compared with the other species of Gippsland, is one of the eastern types of Eucalypts. It spreads along the coast line westward to the sandy tracts known as Bole Bole, between the Gippsland Lakes and the sea, where it becomes stunted and worthless as a timber tree, though on the northern shores of the lakes, at Lake Tyers, and at the Snowy River, it grows to a large size, and is a valuable timber. At the latter locality it is known as "mahogany."

On the northern shore of Lake King it is to be found growing to about 100ft. in height, and I have observed a small colony at the very extreme end of the long narrow delta through which the Mitchell River enters Lake King. This is probably the most westerly point at which this tree grows, and, with Rubus rosifolius, which is found in one gully at Mount Taylor, is marked the western limit of the east coast flora in Gippsland.

E. goniocalyx has a wide range in Gippsland, especially in the western parts. It grows well in the deep shady gullies of the southern slopes of the mountains, where it reaches some 200ft. to 250ft. in height, with a tall, massive bole. In its typical form it occurs in the valley of the Thompson River, on the Upper Wellington, near Grant, on the southern slope of Fainting Range, at Gelantipy, and elsewhere, up to 4000ft. above sea level in favourable localities.

It is very commonly termed "Blue-gum," and as such, has, to my knowledge been cut by sawmillers. At Walhalla it is used in preference to E. sieberiana or E. capitellata, as being the best procurable in the district for props in the mines, and, so far as my experience goes, may be placed after E. globulus as a useful timber tree for work that is not placed in or on the ground—as framing or planking.

The typical form of E. goniocalyx seems not to be able to cross from the cool southern slopes to the warmer and drier northern sides, but there is found in such places a peculiar divergent form.

On the south side of Fainting Range E. goniocalyx ascends to the summit at about 2000ft., while on the northern face of the mountain, and at about 2500ft. above sea level, there is a peculiar variety of this type. The seedlings and young plants have opposed, ovate, sessile leaves, of a rather light tint of green, not shining, and without the peculiar and characteristic rank odour of the leaves of the young plant of the common form.

The tree is usually under 50ft. in height, often with a short bole, and scanty limbs and top. The bark is distinctly wrinkled, and the branches only are smooth. The leaves are finally scattered, long lanceolar or falcate lanceolar, and more attenuate at the stalk than is usually the case in the typical form. The marginal veins are somewhat removed, and the lateral ones slightly spreading. The umbels, flowers, and fruit accord well with the general character of this Eucalypt.

E. globulus is much more widely distributed in Gippsland than might be expected. It varies but little, and the variation is, I think, principally in the more or less smoothness of the fruit. It grows especially well in the cool and moist districts of the Strezlecki and Hoddle Ranges, more particularly on the southern slopes, to the very shore of Corner Inlet. It is more rarely found on the northern side of these mountains, as also scantily on the foot-hills of the main ranges—as, for instance, about Toongabbie, Freestone Creek, and the Tambo River. It grows in the gullies on the north-side of Lake King, near Jimmie's Point, at Lake Tyers, and in other places towards the eastern boundary of the colony. In the Gippsland mountains, it is found here and there in isolated colonies, even ascending to 4000ft. on the north-eastern slopes of Mount Livingstone.

Distribution of the Eucalypts.

In deciding how the various types of Eucalypts are distributed throughout Gippsland, the first point which attracts notice is that the greater number fall into one or the other of two groups. One group essentially belonging to the mountains, and the other to the lowlands. Besides these, there are a few which are spread more or less over the whole district, whether littoral or alpine.

Certain types, peculiar to the littoral tracts, are found, which thence extend up the river valleys, and moist, cool gullies at their sources on the southern slopes of the mountains. They then cease, and are replaced on the warm, dry northern slopes, and on the more elevated, cool, sub-alpine tracts, either by other types, or by other varieties of the littoral forms.

A few instances will make my meaning more clear. I commence with the best-marked westerly example, that of the valley of the Macalister. In it E. viminalis, E. piperita, E. obliqua, and E. goniocalyx afford instances.

The lowland form of E. viminalis, which is the "river-gum" of Gippsland, follows up the Macalister River, growing only on the banks, or on the flooded flats, to an elevation of 3000ft. at Lake Karng, and at an elevation of 1000ft. at the Wellington River. The mountain form of E. viminalis *(b)* occurs on the open, grassy spurs flanking the river, and then is found here and there, until it becomes plentiful on the table-land, through which flows the Caledonia River.

E. piperita, which forms extensive forests along the foot of the hills, follows up the valley of the Macalister, growing on the flats above flood level, but gradually ceases on approaching Glen Falloch.

E. macrorhyncha commences at Glen Maggie, on the dry Silurian ridges, extends all along the stony ranges flanking the valley, and reaches an altitude of about 3000ft. on the track leading up from the Wellington to the Snowy Plains. In the mountain gullies, having a southerly aspect, which descend from the mountain at Lake Karng towards the Wellington River, E. piperita again appears, together with E. viminalis *(a)*, and E. goniocalyx, which all reach, in this spot, an altitude of 3500ft. above sea level.

The high mountain ranges to the westward of the Macalister, and the still higher alpine tracts to the west of the Mitchell, above the Dargo junction, and again those to the west of the Snowy River, above its junction with the Buchan, precipitate the westerly rains, and divert the rainfall from the valleys on the eastern side of the mountains.

Somewhat similar seems to be the effect produced by the coast ranges upon the sub-alpine plateau of Omeo and the Dargo basin.

At the sources of Cobbanah Creek, and at the Budgee Budgee Mount, similar observations can be made.

E. piperita and E. obliqua ascend the sources of Granite Creek to the saddle separating it from Bulgaback Creek at 500ft.

They then cease, and on the dry north side are replaced by E. macrorhyncha, which then extends as the sole stringy-bark to about 1200ft. in the mountains leading to Grant. On following these mountains, however, E. obliqua re-appears in the south gullies of Mount Ewing, at an elevation of 4000ft., which is its limit in these mountains.

In proceeding from Dargo to Omeo, by way of the Wentworth River sources, instructive observations can be made as to the distribution of the different types of Eucalypts.

In Dargo itself, which is essentially one of the mountain areas, E. viminalis (*b*) occurs at its lowest limit of 700ft., growing plentifully over the open grassy hills of Plutonic rocks. E. viminalis (*a*) occurs in the river courses, following them up from the littoral tracts. At the source of Teapot Creek, near Mount Steve, is to be found an outlying colony of E. amygdalina (*f*) the Black-butt, of South Gippsland, together with E. piperita and E. obliqua at an elevation of 2500ft. The summit of the ridge is crested by E. sieberiana (*a*), and in the creeks falling into the Wentworth River, the Eucalypts are essentially lowland forms, with the examples of E. amygdalinas (*a*) and (*b*) which occur locally at Pheasant Creek. These lowland forms, for instance, E. viminalis (*a*), E. amygdalina (*a*), E. piperita, E. obliqua, E. melliodora, E. polyanthema, E. stuartiana, follow up the sources of the Wentworth River towards the Great Dividing Range.

On the range along which runs the Wentworth track to Omeo, I observed that E. melliodora ceased at Wild Horse Creek at about 1500ft.; E. macrorhyncha at 2400ft., E. amygdalina (*b*), which here grows plentifully at one place, and at an unusual elevation of 2400ft. E. polyanthema gradually decreases in number, diminishes in size, until at 2300ft. it ceases with a few dwarfed trees. At the same place E. stuartiana also ceases abruptly on the south side of the ridge, and with a diminution of size.

At 3000ft. E. piperita disappears at the extreme source of Wild Horse Creek, without any change of size. At the same point E. viminalis (*a*) also ceases. It appears that the elevation above the sea level has less to do with the disappearance of these trees than the change of climate from the cool moist gullies on the southern slopes to the cold yet drier northern side of mountains.

On the great Divide itself E. sieberiana (*a*) ends abruptly at 3000ft., and E. sieberiana (*b*) commences at 3500ft., here also grows E. obliqua to great size, but ceases at 3100ft. at the descent into the Upper Livingtone Creek, where the mountain types of Eucalypts commence, viz., E. gunnii (*b*), E. stellulata, E. pauciflora, E. viminalis, and E. amygdalina.

In descending from the Omeo plateau towards Tongio, I observed that E. hemiphloia, variety albens, commences at 2500ft. This Eucalypt grows preferentially upon the Plutonic and Metamorphic formations of the dry valleys of Tongio and Ensay, the Upper Snowy (in Victoria), and of the Deddick and Tubbut Rivers. In the descent from Omeo one finds E. melliodora at 2000ft. In passing from the deep valleys of Ensay to the coast ranges, which may be regarded as commencing at Mount Elizabeth, I observed that E. hemiphloia ceased at 1000ft. at Ensay, but this elevation must probably be decreased considerably, as I believe this type grows on the Tambo at Numlamungie, approximately 700ft. above sea level. The same remarks apply to E. stellulata, on the summit of Fainting Range. I have noticed that E. polyanthema, E. goniocalyx, E. piperita, and E. obliqua re-appear at their upper limit in this locality, and it is about here that the littoral types touch and intermingle with the mountain forms. It is here to be noted, as at other places to which I have referred, that it is the lowland types which slightly cross the limit set them by the summit of the cool mountains, and descend to some little extent in the warmer slopes, rather than the mountain types, which descend the moist southern side.

At Noyang, on the Tambo Valley road, there occurs a tract of Plutonic and Metamorphic rocks, and here there is, to a certain extent, a re-appearance of the sub-alpine types intermingling with a greater number of the lowland Eucalypts.

Further down the road E. muelleriana appears, growing on the Silurian formations from the upper limit of the Tertiary marine beds at 700ft. to 1300ft. I observed only one or two scattered examples growing in the forest of E. piperita on the Tertiary sands near Monkey Creek.

I might instance other examples in the mountain country, in the sources of the Buchan River—at Murrendel, at Woolgulmerang, and at Bonang, but the above will suffice, and my observations in these localities, although made with sufficient care to satisfy me as to the general results, want the precision which I have endeavoured to give to the cases which I have noted. My notes on the eastward of the Snowy River, in Croajingolong, were made many years ago, and fall into line with those I have given, but as they were less precise even than those made between the Tambo and Snowy Rivers, I prefer not to rely upon them.

The observations which I have now recorded as to the distribution in the mountainous and littoral tracts of Gippsland, of the several types of Eucalypts, seem to me to show that elevation above sea level, rainfall, and aspect have had more to do in their distribution than have the geological formations, or than have the different soils produced therefrom.

The range of mountain and littoral types has, it seems, varied from time to time; that is to say, the mountain types have at times spread into or over the littoral tracts, while at others the littoral types have spread into the mountains.

The manner in which E. piperita, E. obliqua, E. goniocalyx, E. polyanthema, and others climb up the southern slopes, and there meet with the subalpine forms, and others whose habitat is in the dry valleys within the coast range, shows that the distribution of these forms is regulated by climate.

It would only require that the conditions which now prevail on the southern slopes should extend over the drier mountain pleateaux; in other words, that the rainfall should be greater there than it is now for those Eucalypts to extend still further northwards from the lowlands.

I have been led to suspect, from the study of the Gippsland Eucalypts, that varieties have arisen, not only through the impulse of the favouring conditions of climatic change, but also that to the same cause is due an emigration from the lowlands to the highlands, and *vice versa*.

The instance of E. goniocalyx is significant. It is at present almost entirely confined to the cool, moist littoral regions, where the soil is good, and the cool, humid gullies of the southern slopes; it does not, in its typical form, extend across the watersheds into the warmer and comparatively dry northern slopes. Its place is there taken by a dwarf variety having marked differences.

Were the climate to become so much altered that the same conditions obtained throughout the district as are now found, for instance, at Dargo, Ensay, or Glen Falloch, I conclude that the lowland form of E. goniocalyx would disappear, and the dwarfed mountain form might take its place. The species would no longer be represented by a tree reaching 200ft. to 250ft., with a smooth-barked massive bole, but by a straggling tree with, often, a short gnarled trunk, a wrinkled strongly persistent bark, scanty foliage, and a young form, in which the leaves, although opposed, are not pointed-ovate or broadly lanceolar, nor having the powerful odour which characterises the lowland form.

The existence of small colonies of mountain species in the lowlands, as, for instance, the before-mentioned E. pauciflora and E. viminalis (*b*) points, I think, to survivals from a time when the climate was much colder than it is now. The oscillations of level which have affected the coast line of the southern half of this continent may be as well studied in Gippsland as in any part that I have seen from Shoalhaven to beyond Adelaide. These must certainly have produced variations of climate, extending back beyond the Cainozoic period.

The Gippsland Alps have not been submerged below a contour line of some 800ft. to 1000ft. above sea level, not only during that period of time, but that land surface must have been continuous backwards to the time when the Mesozoic coal measures of Gippsland were formed.

The lauraceous and other plants which have been found in the Miocene drifts of Gippsland, indicate, as does also the fauna of the marine limestones of that district, a warmer climate than of the present day.

Lake Karng at Mount Wellington, if it be a moraine lake, points, on the other hand, to an alpine climate, descending to within at least 3000ft. of the sea level. Such changes of climate have evidently been attended by a corresponding change in the Tertiary flora, in which that element, which is now characteristic of Australia, has gradually predominated. Such changes of climate may, as it seems to me, also account in part for the great number of recorded types of Eucalypts and their varieties, and of which no less than 35 occur in Gippsland.

Geological formation, as producing variation of soil, has no doubt influenced the present distribution of the Eucalypts, but its effects cannot be made out so clearly as those produced by climate, but the broad features can be readily seen by anyone travelling through Gippsland. E. tereticornis grows almost entirely on lands which have been at one time lake or estuary beds, or in the alluvial flats of rivers.

The stringy-bark Eucalypts prefer the Tertiary sands and sandy clays. E. odorata grows mainly on the Miocene limestone, but this partiality to particular formations is not so apparent when all the Eucalypts are considered. Still, in looking over the whole of Gippsland, I observed some marked cases which it would be well to note. A good instance is afforded by E. amygdalina regnans (*b*), which, in Gippsland, grows almost wholly upon the Mesozoic coal measures. E. hemiphloia appears to be confined to the Plutonic and Metamorphic areas of the Tambo and Snowy Rivers. A final instance may be taken from the Gelantipy tableland, to the west of the Snowy River, which shows how certain Eucalypts grow preferentially upon certain formations. This tableland is formed by a great thickness of Devonian and Plutonic rocks, overlaid by more or less connected sheets of Tertiary basalt. I observed that on the former grow especially E. piperita, E. globulus, E. sieberiana, and E. amygdalina, and on the latter formation E. stuartiana, E. melliodora, E. polyanthema, and E. macrorhyncha.

The annexed table has been compiled from observations which I have made in almost all parts of Gippsland, and shows the distribution of the Eucalypts on the various formations.

Influence of Settlement on the Eucalyptus Forests.

The influence of settlement upon the Eucalyptus forests has not been confined to the settlements upon lands devoted now to agriculture or pasturage, or by the earlier occupation by a mining population.

It dates from the very day when the first hardy pioneers drove their flocks and herds down the mountains from New South Wales into the rich pastures of Gippsland.

Before this time the gramminivorous marsupials had been so few in comparative number, that they could not materially affect the annual crop of grass which covered the country, and which was more or less burnt off by the aborigines, either accidentally or intentionally, when travelling, or for the purpose of hunting game.

These annual bush fires tended to keep the forests open, and to prevent the open country from being overgrown, for they not only consumed much of the standing or fallen timber, but in a great measure destroyed the seedlings which had sprung up since former conflagrations.

The influence of these bush fires acted, however, in another direction, namely, as a check upon insect life, destroying, among others, those insects which prey upon the Eucalypts.

Granted these premises, it is easy to conclude that any cause which would lessen the force of the annual bush fires, would very materially alter the balance of nature, and thus produce new and unexpected results.

The increasing number of sheep and cattle in Gippsland, and the extended settlement of the district, lessened the annual crop of grass, and it was to the interest of the settlers to lessen and keep within bounds bush fires which might otherwise be very destructive to their improvements.

The results were twofold. Young seedlings had now a chance of life, and a severe check was removed from insect pests. The consequences of these and other co-operating causes may be traced throughout the district, and a few instances will illustrate my meaning.

The valley of the Snowy River, when the early settlers came down from Maneroo to occupy it, as for instance, from Willis downwards to Mountain Creek, was very open and free from forests. At Turnback and the Black Mountain, the mountains on the western side of the river were, in many parts, clothed with grass, and with but a few large scattered trees of E. hemiphloia.

The immediate valley was a series of grassy alluvial flats, through which the river meandered. After some years of occupation, whole tracts of country became covered with forests of young saplings of E. hemiphloia, pauciflora, viminalis, amygdalina, and stellulata, and at the present time these have so much increased, and grown so much, that it is difficult to ride over parts which one can see by the few scattered old giants were at one time open grassy country.

Within the last twenty-five years many parts of the Tambo valley, from Ensay up to Tongio, have likewise become overgrown by a young forest, principally of E. hemiphloia and macrorhyncha, which extend up the mountains on either side of the valley. This dates especially from the time when the country was fenced into large sheep paddocks, when it became very important that bush fires should be prevented as a source of danger to the fences, and even when fire occurred the shortness of the pasturage checked the spread.

Similar observations may be made in the Omeo district, namely, that young forests of various kinds of Eucalypts are growing where a quarter of a century ago the hills were open and park like. In the mountains, from Mount Wellington to Castle Hill, in which the sources of the Avon River take their rise, the increase of the Eucalyptus forests has been very marked. Since the settlement of the country, ranges, which were then only covered by an open forest, are now grown up with saplings of E. obliqua, E. sieberiana, and others, as well as dense growths of Acacia discolor, A. verniciflua, and other arborescent shrubs. These mountains were, as a whole, according to accounts given me by surviving aborigines, much more open than they are now.

In the upper valley of the Moroka River, which takes its rise at Mount Wellington, I have noticed that the forests are encroaching very greatly upon such open plains as occur in the valley. I observed one range, upon which stood scattered gigantic trees of E. sieberiana, now all dead, while a forest of young trees of the same species, all of the same approximate age, which may probably be twelve years, growing so densely that it would not be easy to force a passage through on horseback. Again, at the Caledonia River, as at the Moroka, the ranges are in many parts quite overgrown with forests not more than twenty years old. The valleys of the Wellington and Macalister Rivers also afford most instructive examples of the manner in which the Eucalyptus forests have increased in the mountains of Gippsland since the country was settled. The forest in these valleys, below 2000ft. above sea level, is principally composed of Eucalyptus polyanthema, E. macrorhyncha, with occasional examples of E. melliodora and E. stuartiana ; while E. viminalis occupies the river banks and moist flats. I noticed here that E. melliodora and E. macrorhyncha formed dense forests of young trees, apparently not more than twenty-five years old. In some places, moreover, one could see that the original forest had been composed, on the lower, undulating hills and higher flats of a few very large E. melliodora, with scattered trees of E. polyanthema and E. macrorhyncha. At the present time the two latter have taken possession, almost to the exclusion of E. melliodora. In other places E. polyanthema or E. macrorhyncha predominate; but, on the whole, I think the latter will ultimately triumph over its rivals, unless the hand of man again intervenes.

Such observations may also be made in Western and Southern Gippsland, but, of course, with reference to different species of Eucalypts.

In the great forest of South Gippsland many places can be seen where there are substantially only two existing generations of trees; one of a few very large old trees, the other of very numerous trees which are, probably, not older than 30 to 40 years, and, in most cases, certainly not half that period. The older trees of this second growth do not, I suspect, date further back than the memorable "Black Thursday," when tremendous fires raged over this tract of country. It may also be inferred, from the constant discoveries during the process of clearing of blackfellows' stone tomahawks, that much of this country, now covered by a dense scrub of gum saplings, Pomaderis apetala, Aster argophylla, and other arborescent shrubs, that the country was at that time mainly an open forest.

I might go on giving many more instances of this growth of the Eucalyptus forests within the last quarter of a century, but those I have given will serve to show how widespread this re-foresting of the country has been since the time when the white man appeared in Gippsland, and dispossessed the aboriginal occupiers, to whom we owe more than is generally surmised for having unintentionally prepared it, by their annual burnings, for our occupation.

The age of the new forests does not, however, depend merely on the general observation that they have sprung up since the settlement of the country in 1840.

I have been enabled to make some direct observations, which show the size of certain trees of known age, and which will serve as comparison for the general growth of the forests.

In 1864 the discovery of auriferous quartz reefs in the Crooked River district, caused a township, which is now called Grant, to be formed on the summit of the mountains, near the sources of Good Luck Creek. In part of the Government reserve, upon which the warden's quarters and police camp stood, and which was cleared of timber, a few young E. amygdalina trees grew, and were permitted to remain. One of these was lately kindly measured for me by Mr. W. H. Morgan, M.M.B., who found it to be 56ft. high and 10ft. in girth 3ft. above the ground. This tree is an example of very many others of the same species now growing on the surrounding ranges. At Omeo, in the Government reserve, a number of young E. viminalis are now 60ft. high, which in 1863 were only small saplings under 5ft. in height. On the road from Sale to Port Albert, which was formed somewhere about 1858-59, there are numerous places where E. viminalis and E. muelleriana and other species are now growing, upon the ditches formed at the sides of the road. Those, for instance, at Lillies Leaf are on an average about 30ft. high.

These instances show how the occupation of Gippsland by the white man has absolutely caused an increased growth of the Eucalyptus forests in places. I venture, indeed, to say with a feeling of certainty, produced by long observation, that, taking Gippsland as a whole, from the Great Dividing Range to the sea, and from the boundary of Westernport to that of New South Wales, that, in spite of the clearings which have been made by selectors and others, and in spite of the destruction of Eucalypts by other means (to which I am about to refer), the forests are now more widely extended and more dense than they were when Angus M'Millan first descended from the Omeo plateau into the low country.

I have spoken just now of the destruction of Eucalypts by other means than the hand of man, for clearing his holdings, and the following are the facts I have gathered concerning the subject:—

About the year 1863-4 I observed that a belt of Red-gums which extended across the plains between Sale, Maffra, and Stratford were beginning to die. Gradually all the trees of this forest, as well as in other localities, perished. At that time my attention was not drawn to the investigation of the cause. Later, however, probably about 1878, I observed the Red-gum forests of the Mitchell River Valley to be dying, just as those at Nuntin and elsewhere had died years before. I then investigated the subject, and found the trees were infested with myriads of the larvæ of some one of the nocturnal Lepidoptera. These devoured the upper and under epidermis of the leaves, thus asphyxiating the tree. Some 75 per cent. of that forest died that year, and subsequently almost all the surviving trees died also. Since then I have observed the same larvæ at work, some of which, when kept until they had passed through their several metamorphoses to the perfected insect, were pronounced by Professor M'Coy to be examples of Urubra lugens. Whether this insect has in all cases been the agent in destroying the red-gums I cannot affirm. Probably not wholly, but I am satisfied that the greater part of the Red-gum trees which have died in Gippsland from obscure causes have been killed by its agency.

The inference may be drawn from the above observations of forests having been killed by infesting insects, that each species of Eucalypt, or at any rate each group of allied species, will have attached to it some particular insect which preys upon it rather than upon any other Eucalypt.

If this is so, we ought to find some one tree selected for destruction out of a number of species, and it is the case with the Red-gum, for it falls a victim to Urubra lugens, whilst its neighbours the White-gum (E. viminalis), the Swamp-gum (E. gunnii), and the Yellow-box (E. melliodora) are untouched and in vigorous health.*

I feel little doubt that this will explain why it is that in many parts of the country, at all elevations above sea level, certain tracts of dead forest are to be found. Twenty-five years ago I noticed that during the course of three years all the White-gums (E. viminalis) in part of the Omeo district died, whilst E. pauciflora and E. stellulata remained alive.

I have said that in my opinion the increased growth of the Eucalyptus forests since the first settlement of Gippsland has been due to the checking of bush fires year by year, and to the increase thereby of the chance of survival of the seedling Eucalypts, and to the same cause we may assign the increase of the leaf-eating insects which seem in places to threaten the very existence of the Red-gum.

Bush fires, which swept the country more or less annually, kept down the enormous multiplication of insect life, destroying myriads of grasshoppers and caterpillars, which now devastate parts of the Gippsland district, spoiling the oat crops, and eating the grass down to the ground.

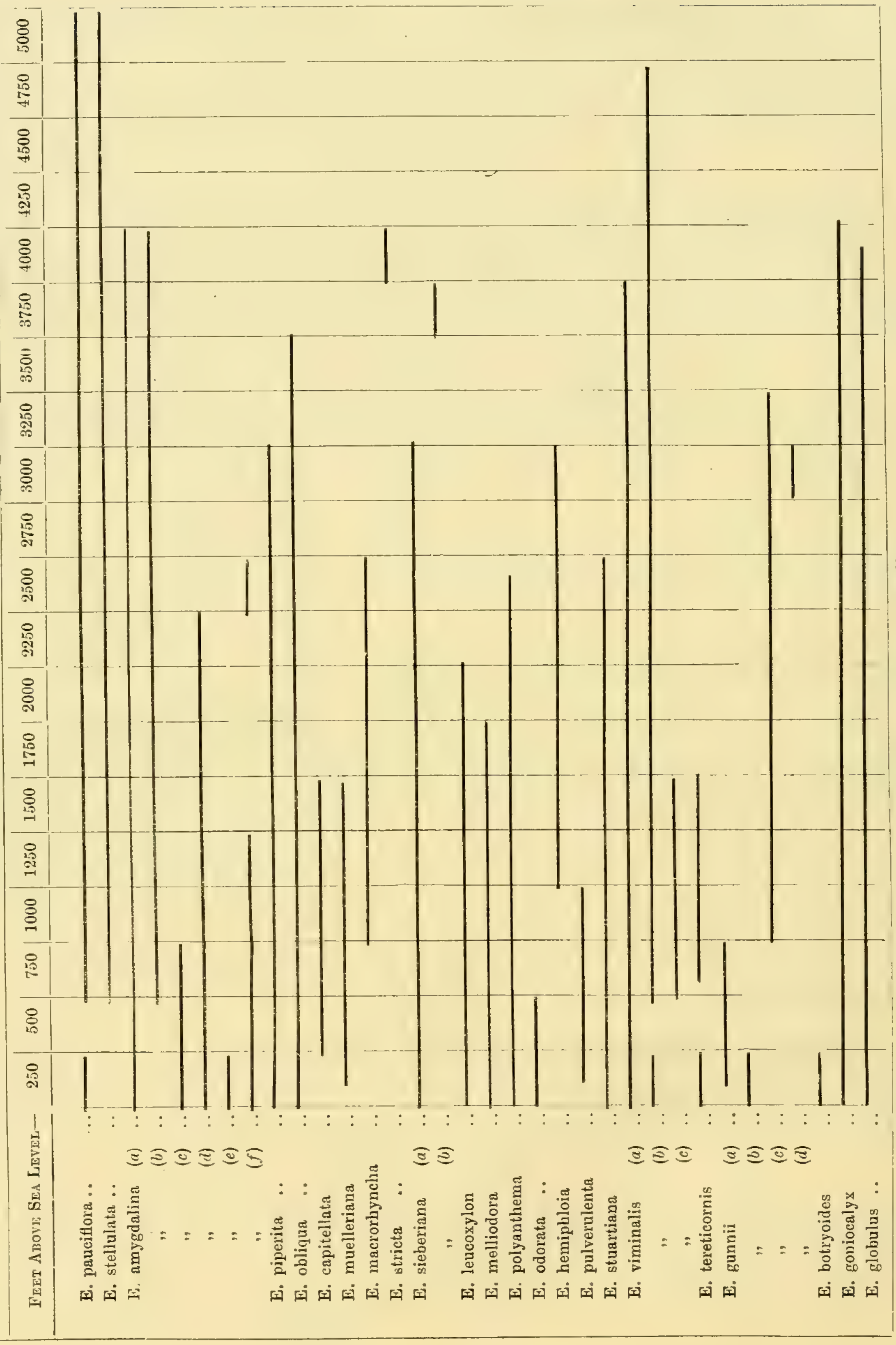
The ravages of the larvae of Lepidoptera are at present greatly aided by the sickly state in which many of the Red-gum forests in Gippsland now are. The long-continued use of the country for pasturage, and the trampling of the surface of the ground by stock, has greatly hardened the soil, so that rain which formerly, in what I may call the "normal state" as regards Eucalypts, soaked in, now runs off. In the course of successive droughty seasons the soil of such places becomes thoroughly dry and hard, so that the Red-gum is deprived of much moisture which it otherwise would have in reserve. The trees are wanting in vigour, and thus unable to withstand the attacks of insect pests.

The effects produced by man's interference with the balance of nature, by settling new countries, is not only of great scientific interest, but is also of importance in showing us how and why it is that the labours of the graziers and farmers are being carried on year by year under the increasing attacks of insect pests.

The subject is a tempting one, but to pursue it further would be foreign to the subject of these Notes, which is the "Eucalypts of Gippsland."

* I have observed, however, in some localities E. melliodora and E. piperita have been slightly attacked by Urubra lugens.

RANGE OF EUCALYPTS IN ALTITUDE.*



* From repeated aneroid readings.

GEOLOGICAL DISTRIBUTION OF EUCALYPTS IN GIPPSLAND.

Name.	Plutonic.	Metamorphic.	Silurian.	Devonian.	Mesozoic.	Miocene.	Pliocene and later.	Volcanic.
E. tereticornis			—	—		—	—	
E. piperita				—		—	—	
E. muelleriana			—	—			—	
E. capitellata			—		—		—	
E. regnans			—					
E. macrorhyncha		—						
E. obliqua	—	—			—			
E. sieberiana				—			—	
E. leucoxylon	—		—				—	
E. melliodora	—	—	—	—		—	—	
E. odorata						—	—	
E. polyanthema		—	—	—			—	
E. goniocalyx	—		—		—		—	—
E. globulus		—			—		—	—
E. gunnii	—	—	—	—	—			
E. viminalis (*a*)	—			—	—	—		
E. viminalis (*b*)								
E. pauciflora	—	—		—			—	
E. stellulata		—		—				—
E. stuartiana	—		—				—	
E. pulverulenta			—					
E. botryoides							—	
E. amygdalina						—	—	

EXPLANATION OF PLATES.

Plate 8.

Eucalyptus amygdalina (*b*).

1. Lower leaf of sapling, Mount Livingstone.
2. Lower leaf of sapling, Dargo.
3. Upper leaf of sapling, Wentworth River.
4. Leaf of aged tree, Wentworth River.
5. Seedling, Mount Livingstone.
6. Buds, natural size.
7. Section of fruit.

8, 9. Anthers x 24 linear.

10. Anthers x 6 linear.
11. Fruit, natural size, Mount Livingstone.

Plate 9.

E. amygdalina (*d*).

1. Lower leaf of sapling, Stradbroke.
2. Lower leaf of sapling, Wild Horse Creek.
3. Leaf of young tree, Dargo.
4. Leaf of aged tree, Tambo River.
5. Leaf of aged tree, Carrajung.
6. Seedling, Bruthen Creek.
7. Anthers x 24 linear.
8. Filaments and anthers x 6 linear, Stradbroke.
9. Cluster of buds, natural size, Stradbroke.
10. Fruit, natural size, Dargo.

Plate 10.

E. amygdalina (*e*).

1. Terminal shoot of young sapling.
2. Cluster of fruit.
3. Buds.
4. Seedling.

5. Leaf of aged tree, Tambo River.
6, 7. E. amygdalina (*c*), Leaves of aged tree.
8. Section of fruit.
9. Cluster of fruit.
10. Buds.
11. Anthers x 6 linear.
12. Anthers x 24 linear.

Plate 11.

E. muelleriana.

1. Seedling, Insolvent Track.
2. Seedling, Toongabbie.
3. Seedling, Shady Creek, South Gippsland.
4. Spray, with buds and flowers, Woodside.
5, 6. Anthers x 24 linear, Woodside.
7, 8. Anthers x 24 linear, Toongabbie.
9, 10. Anthers x 24 linear of E. eugenioides, Agnes River.
11, 12. Anthers x 24 linear, E. piperita, Toongabbie.
13, 14. Anthers x 24 linear, Wild Horse Creek.
15. Section of fruit of E. muelleriana, Woodside.
16. Cluster of fruit of E. muelleriana, Woodside.

Plate 12.

E. muelleriana.

1. Leaf of sapling (8ft.), Daraman.
2. Leaf of sapling, Insolvent Track.
3. Leaf of sapling, Woodside.
4. Leaf of aged tree, Four Mile Creek.
5. Leaf of aged tree, Woodside.
6. Leaf from top of sapling, Tambo River.
7. Leaf of aged tree, Toongabbie.

Plate 13.

1. Leaf of sapling of E. piperita, Toongabbie.
2. Leaf of sapling of E. capitellata, Ostler's Creek.
3. Leaf of sapling of E. obliqua, Walhalla.
4. Leaf of sapling of E. macrorhyncha, Dargo.
5. Leaf of sapling of E. eugenioides, Drouin West.

Fruit of E. piperita.

6. Bruthen.
7. Fainting Range.
8. Tambo River
9. Wild Horse Creek.
10. Stockyard.
11, 12. Monkey Creek.
13. Groggingee.
14. Bruthen.
15. Bulgaback.
16. Insolvent Track.
17. Bruthen.
18. Toongabbie.
19. Insolvent Track.

E. eugenioides.

20. Agnes River.
21. Drouin.

E. muelleriana.

22. Tambo River.
23. Insolvent Track.
24. Toongabbie.
25. Woodside.

E. capitellata.

26, 27. Lilies' Leaf.
28. Mirboo North.
29. Ostler's Creek.

E. macrorhyncha.

30. Drouin West.
31. Fanwick.
32. Dargo.

PLATE 14.

1. Seedling, E. piperita, Toongabbie.
2. Seedling, E. capitellata, Ostler's Creek.
3. Seedling, E. macrorhyncha, Bulgaback.
4. Seedling of E. eugenioides, Agnes River.
5. Seedling of E. obliqua, Agnes River.

PLATE 15.

1, 2, 3, 4. Anthers x 24 linear, E. pulverulenta, Boolarra.
5, 6, 7, 8. Anthers x 24 linear, E. stuartiana, Lilies' Leaf.
9. Pair of leaves of aged tree, E. pulverulenta, Monkey Creek.
10. Terminal leaf (alternate), E. pulverulenta, Monkey Creek.
11. Leaf of aged tree, E. stuartiana, Toongabbie.
12. Seedling, E. stuartiana, Toongabbie.
13. Seedling of E. pulverulenta, Monkey Creek.

Buds and Fruit of E. viminalis (b).
14. Squirrel Forest.
15. Omeo.
16. Morwell.
17. St. Pancras Peak, Woolgulmerang.
18. Eighteen Mile Creek, Dargo High Plains.
19. Fraser's Plain.
20. Dargo High Plain.
21. Grant.
22. Woolgulmerang.

E. viminalis (a).
23. Monkey Creek, Port Albert Road.
24. Alberton.
25. Coal Creek.
26. Wentworth River.
27. Tucker Creek.
28. Wild Horse Creek.
29. Sources of Tucker Creek.
30. Woolgulmerang.
31. Upper Wentworth River.

E. pulverulenta.
32. Monkey Creek, Port Albert Road.
33. Boolarra.
34. Ostler's Creek.

E. stuartiana.
35. Lilies' Leaf.
36. Stradbroke.
37. Cuidmundie, Dargo.
38. Insolvent Track.

All natural size.

Plate 16.

E. viminalis (*b*).

1. Lower leaf of sapling, Dargo.
2. Pair of upper leaves, sapling, Dargo.
3. Leaf of young tree, Dargo Plains.
4. Leaf of aged tree, Dargo Plains.
5. Leaf of aged tree, Omeo.
6. Young plant, Omeo.

7, 8, 9. Anthers x 24 linear of E. viminalis (*a*), Alberton.

10, 11, 12. Anthers of E. viminalis (*b*), Cuidmundie, Dargo.

13, 14, 15. Anthers x 24 linear, E. viminalis (*b*), Squirrel Forest.

16, 17, 18. Anthers x 24 linear, E. viminalis (*b*), Omeo.

Plate 8.

Annie Howitt del.

Plate 9.

Troedel & Co. Lith.

Plate 10.

Annie Howitt del.

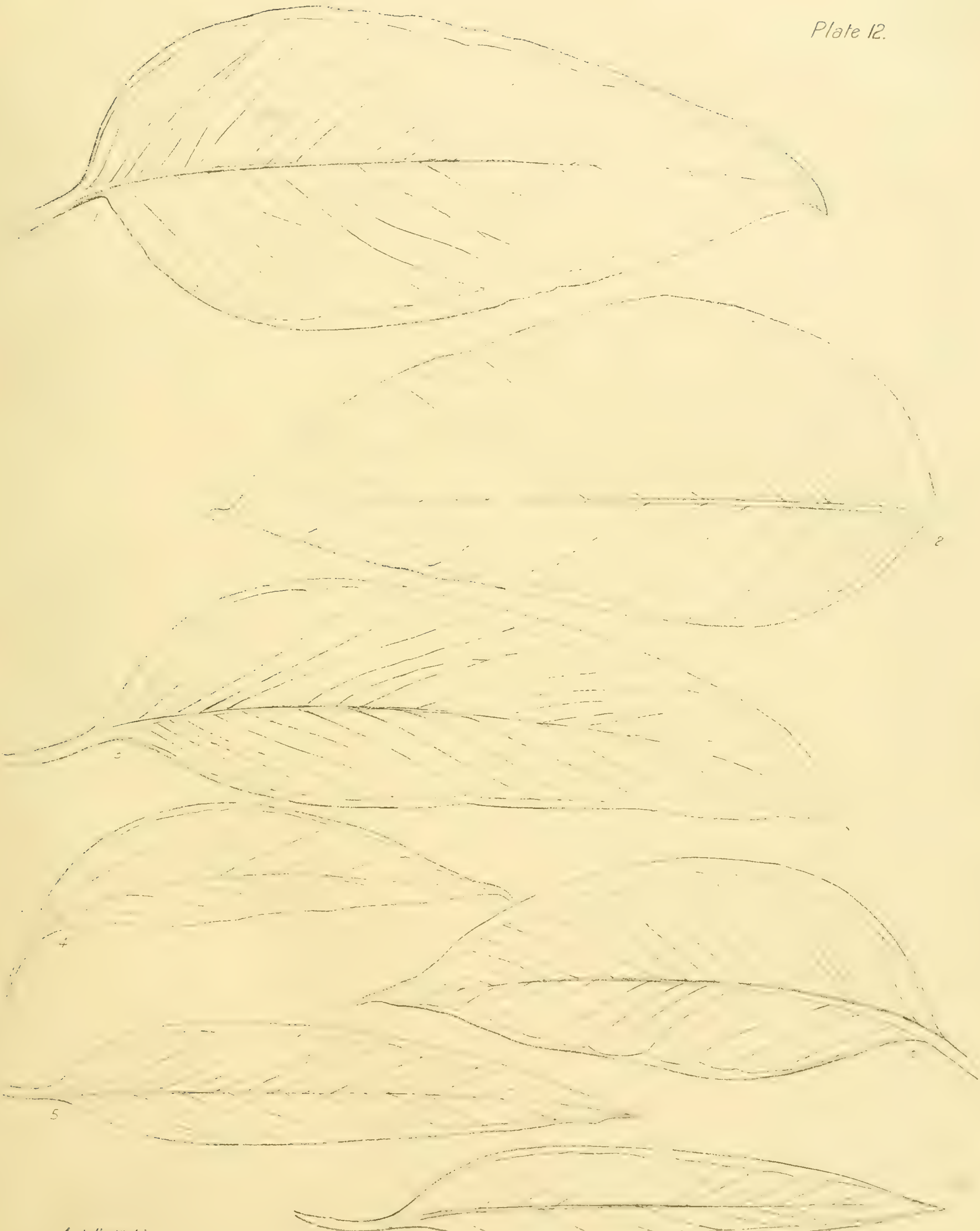
Troedel & Co Lith

Plate II.

Annie Howitt del.

Troedel & C° Lith

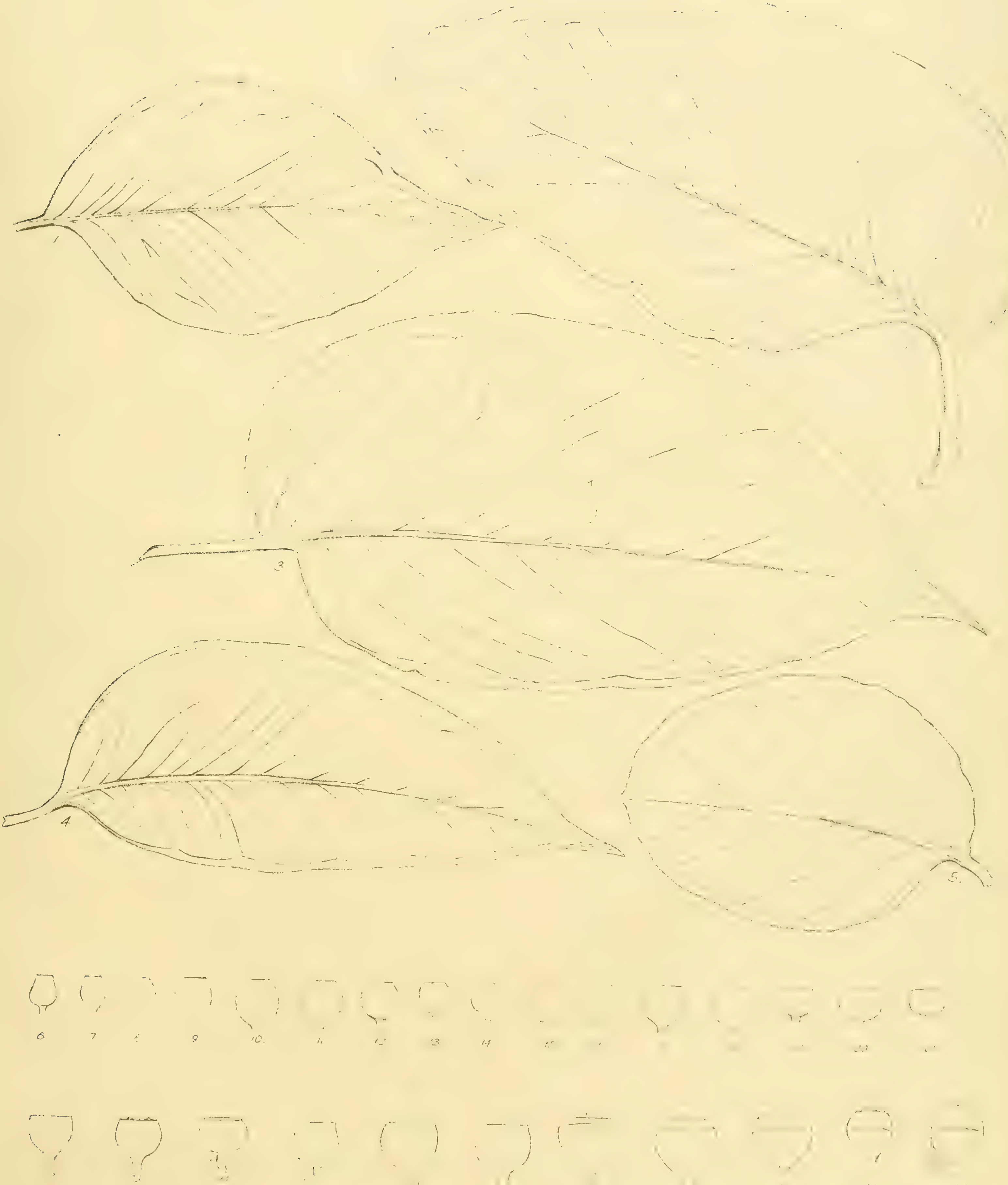
Plate 12.



Annie Howitt, del.

Troedel & C° Lith.

Plate 13.



Annie Howitt, del.

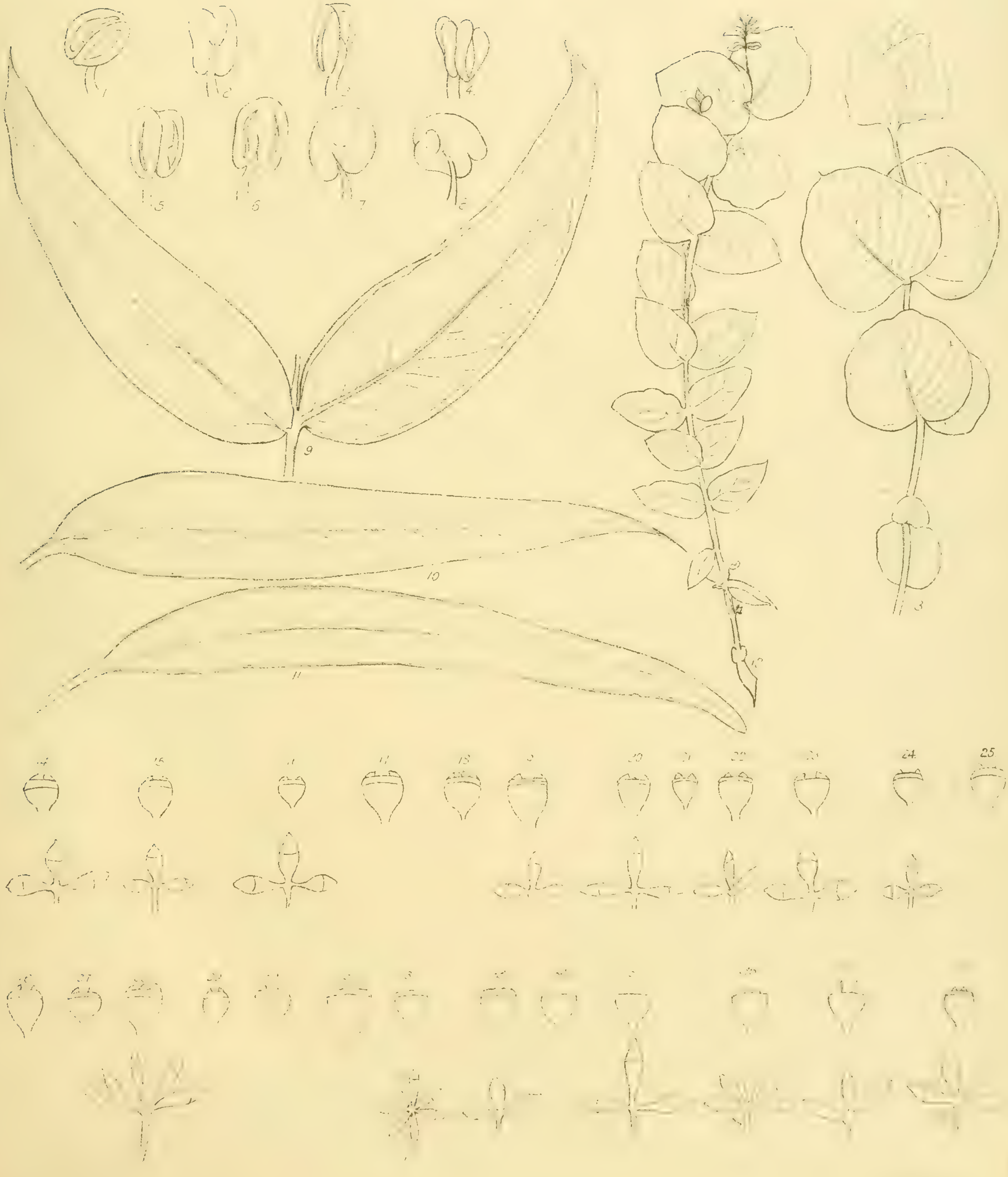
Troedel & Co. Lith.

Plate F

Annie Howitt, del.

Troedel & Co. Lith

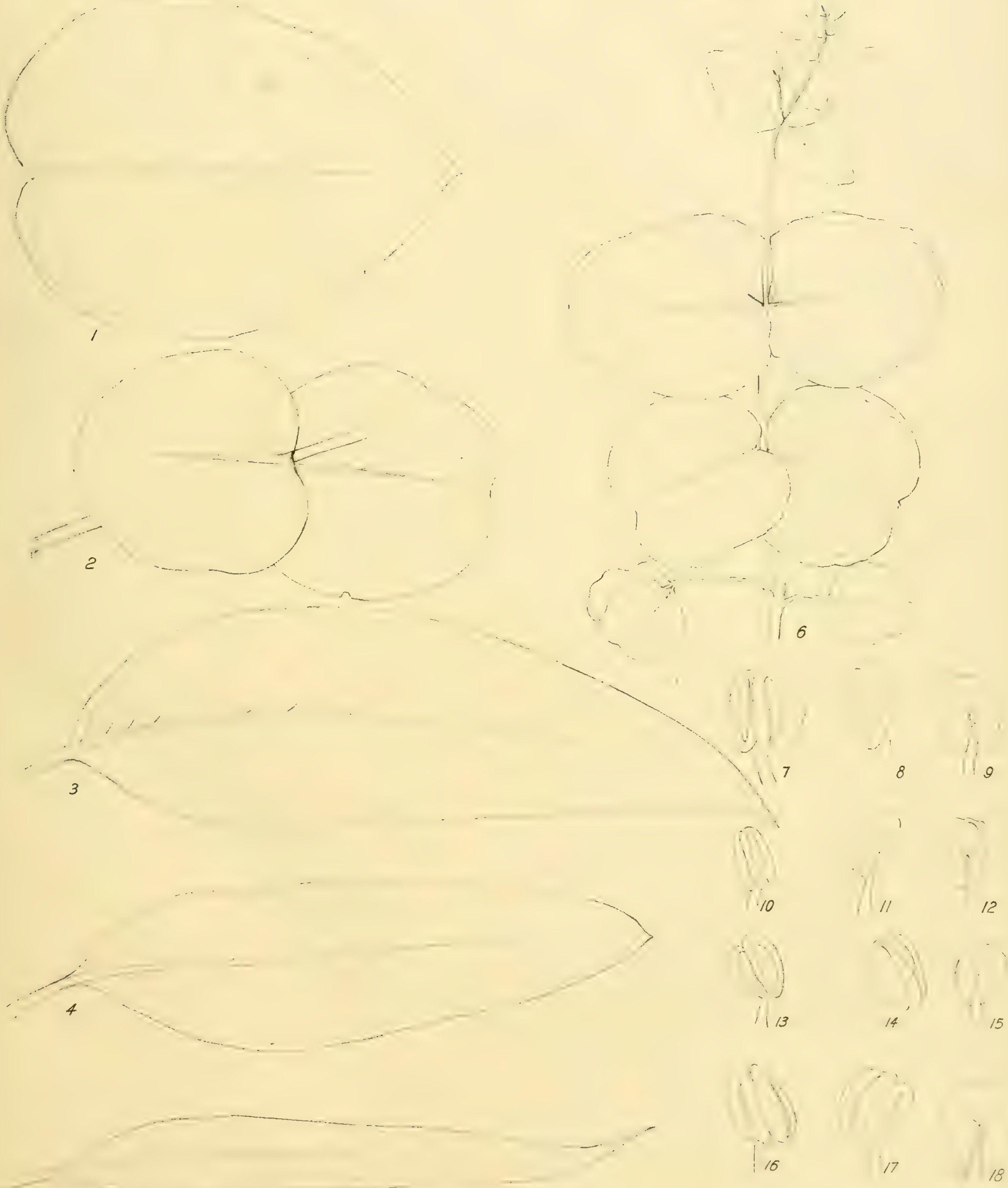
Plate 15.



Annie Howitt del.

Troedel & Co Lith.

Plate 16.



Annie Howitt del.

Troedel & Cº Lith

ARTICLE IV.—A New Family of Hydroidea, together with a Description of the Structure of a New Species of Plumularia, by W. Baldwin Spencer, M.A., Professor of Biology in the University of Melbourne.

(Read Nov. 12th, 1890.)

The following deals with two hydroid forms obtained by Mr. J. Bracebridge Wilson, M.A., from the neighbourhood of Port Phillip. One of these is so distinct from any hitherto described that it must be taken as the type of a new Family, to which the name of Hydroceratinidæ is given, the other is a new and somewhat curious species of the genus Plumularia. The paper is, therefore, divided into two parts—(1) On the Hydroceratinidæ, a new family of the order Hydroidea, and (2) On *Plumularia procumbens*, a new species of the genus Plumularia.

(1) On the Hydroceratinidæ, a New Family of the Order Hydroidea.

The form in question undoubtedly calls to mind, in the general appearance of the dried specimens, one of the two genera which were placed in a distinct family—the Ceratelladæ—by Dr. Gray,* and, when this paper was read before the Royal Society of Victoria, I provisionally referred it to this family.† Dr. Gray had doubtfully

† Note.—Up to the time of reading this paper I had only the necessarily somewhat imperfect descriptions (since taken from dried specimens only) of Dr. Gray and Mr. Carter to be guided by together with the figures of the former. Those of Dehitella bore a general resemblance to the specimen in question which was placed provisionally in that genus as a new species. Through the courtesy of Dr. E. P. Ramsay I have since been able to examine specimens of Ceratella and Dehitella from the Australian Museum, Sydney, and have received from there specimens obtained from the New South Wales coast, and from Lord Howe Islands by Mr. Whitelegge, to whom I am much indebted for kind assistance and information. The examination of these specimens has shown that the form with which this paper deals differs in such important points not only from the Hydractiniidæ but also from the Ceratelladæ that it must be placed in a separate family and I desire to here record my indebtedness to the authorities of the Australian Museum, Sydney, for the courteous assistance received from them.

* Proc. Zool. Soc., Nov., 1868.

placed the family in the group Porifera. Mr. Carter subsequently had the opportunity of examining both Dr. Gray's specimens and others of allied forms from New Zealand and the Cape, and rightly referred them all to the Hydroidea, placing them in the family Hydractiniidæ. This classification was adopted by Dr. v. Lendenfeld, and also, at first, by Mr. Bale in his valuable contribution to the literature of Australian zoology—the "Catalogue of Australian Hydroid Zoophytes."* Subsequently, Mr. Bale had the opportunity of examining spirit-preserved specimens with the hydranths and soft parts present, and, finding that these differed very considerably from those of the Hydractiniidæ in the presence of irregularly distributed capitate tentacles, &c., rightly separated them once more from the Hydractiniidæ, and adopted the name of Ceratelladæ for the family.† I was unaware of this short paper of Mr. Bale's until my attention was kindly drawn to it by Mr. Whitelegge, of the Australian Museum.

Whilst Dehitella in its general form (in the dried specimen) is somewhat like the specimen obtained by Mr. Wilson, there can be little doubt that the two are markedly distinct, even so far as the skeleton goes. Dehitella has most clearly what have well been called hydrophores‡, and agrees closely in this respect and in the general formation of its skeleton with Ceratella ; in their soft parts we may reasonably suppose that a corresponding agreement exists. Now the soft parts of the Ceratella are known,§ and they differ very strongly from those of the form with which this paper deals, so that we are probably correct in assuming that a similar difference exists between the latter and Dehitella. There is, on the other hand (as will be shown subsequently), quite as marked a distinction between the new form and any member of the family Hydractiniidæ as exists between the former and the Ceratelladæ, so that it is necessary to create a new family for its reception.

I have not so far, though numerous sections have been cut, been able to detect any reproductive elements, and therefore the description is incomplete, but will quite sufficiently serve to distinguish it from other forms.

Family Hydroceratinidæ.

Hydrophyton, consisting of a mass of entwined hydrorhiza, with a skeleton in the form of anastomosing chitinous tubes; the surface is studded with tubular hydrothecæ, into which the hydranths can be completely retracted. Hydranths sessile and connected with more than one hydrorhizal tube, claviform with a single verticil of filiform tentacles. Defensive zooids present with a solid endodermal axis and nematocysts borne at the distal end.

* Catalogue of Australian Hydroid Zoophytes. W. M. Bale, 1884.

† Bale, Proc. Linn. Soc., N.S.W., Vol. III., pt. 2, p. 748; also Brazier, Proc. Linn. Soc., N.S.W., new series, Vol. I. page 575; Whitelegge, *loc. cit.*, p. 578.

‡ Bale, Proc. Linn. Soc., N.S.W., 1888, p. 749.

§ Bale, *loc. cit.*

Clathrozoon wilsoni, n. gen. et. n. sp.

Hydrophyton irregularly sub-dichotomously branched, expanded in one plane fan-shaped. Main stem somewhat flattened and ridged, arising from an expanded base, dark brown in colour, with the surface showing a series of tortuous grooves. Smaller branches cylindrical. The whole composed of a number of branching and anastomosing tubes, with chitinous walls complete, except those of the most external ones. Hydrothecæ, which have the form of tubular spaces with chitinous walls, project slightly from the surface of all the branches, irregularly placed on the main stems, spirally on the branches. The whole, except the external openings of the hydrothecæ, completely enclosed in a thin transparent chitinous layer, from which arise very numerous cylindrical tubes enclosing the defensive zooids, and which forms also a funnel-shaped collar, projecting beyond the lips of the hydrothecæ.

Locality—Near Port Phillip Heads, Victoria. Mr. J. Bracebridge Wilson.

The description of the species is the same as that of the genus, and I have much pleasure in dedicating it to Mr. Wilson.

The specimens were obtained from two spots, each within a distance of five miles of Port Phillip Heads, that is, in Bass Straits, close to the Victorian shore. They were dredged in water of from twenty to twenty-two fathoms, and were placed directly into strong alcohol so that, like all received from Mr. Wilson, they are in excellent histological preservation. The polypes are, of course, in a state of retraction, and though very many sections from various parts of the hydrophyton have been cut, nowhere as yet have I been able to detect the presence of reproductive organs, or of individuals modified in connection with these, and though, therefore, unable to give any account of the reproductive organs, I have thought it advisable to describe and figure the animal carefully so far as can yet be done.*

The largest colony secured by Mr. Wilson measures 10in. in height, by 4in. in greatest width, and at first glance recalls to mind, to a certain extent, one of the dark coloured fan-shaped gorgonid forms. A cursory examination, however, at once shows that it does not belong to this group of animals.

If the whole colony be secured, it is found to be attached by a broad flattened-out base, attached to some solid structure; from this arises a single large stem, perhaps $\frac{3}{8}$in. in thickness, slightly flattened out in one plane, and distinctly ridged (Fig. 1). From the edge at either side of the plane lateral branches are given off, varying much in size;

* That the animal is not at all common is shown by the fact that, though during this summer (1890-91), Mr. Wilson has been kind enough to spend a considerable amount of time in dredging, with the special object of procuring more specimens, not a trace of this hydroid has been brought up in the dredge, though the same ground which previously yielded it has been visited.

from these other branches are given off on either side, which again divide in a roughly but not constantly dichotomous manner, the smaller branches being cylindrical in shape. All the branches in the living and spirit-preserved specimens usually lie in the one plane, but when dried they often become slightly twisted, and thus thrown out of the plane. There is thus a considerable resemblance in general appearance between the form Clathrozoon on the one hand, and Dehitella and Ceratella on the other, especially between the two first mentioned, owing to the rounded branches of Dehitella. If, however, we come to examine the structure of the two more minutely, we find that the differences are very marked; whilst both have the skeleton in the form of a horny network, that of Clathrozoon has more the appearance of being composed of a series of anastomosing tubes, and rather less of the appearance of an open meshwork than is the case in the Ceratelladæ; but, what is of much greater importance, it presents on its surface a large number of circular openings at the extremities of slightly projecting chitinous tubes, which form true hydrothecæ. These are very distinct from what Mr. Carter and Dr. Gray aptly described as scoop-like projections of the chitinous network of the Ceratelladæ, though they unfortunately gave to them the name of hydrothecæ, that of hydrophore being more correct and suggestive of their real function, as at most they can but afford a support for the proximal part of the hydranth.

Skeleton (Figs. 4, 5, 6, 7, 8, 9, 11, 12, 13, 16).

When the branches of spirit-preserved specimens, with the soft parts present, are viewed under the lens, the surface is seen to be covered with a great number of tortuous grooves, filled with light yellowish coloured material—the cœnosarcal tubes. The edges of the grooves are formed by the chitinous perisarc of a dark-brown colour (Fig. 6), and arranged in a spiral manner are circular projections, the external opening of chitinous cylinders forming the hydrothecæ and containing the retracted polypes. These hydrothecæ are encircled by the tortuous grooves, and supported by extensions of the ordinary perisarc. The whole surface is covered over by an extremely thin and delicate colourless layer of perisarc common to the whole branch. This layer is not usually recognised until sections are cut, but the whole surface is seen to be studded with small cylindrical tubes, which are really formed from this thin layer and the spaces in which are continuous with the tortuous grooves below the latter (Figs. 7, 8, 9).

Sections show also that this thin layer rises up somewhat from the general surface, and is attached to the lips of the hydrothecæ; beyond the margin of the latter it is continued on so as to form a very thin collar-like extension, acting as an operculum. The arrangement is represented in the figures, especially in Fig. 13, which is meant to be a diagram showing the relationship of a hydrotheca to the perisarc, as seen in a very thick section cut transversely to the length of a branch. This operculum-like structure is very thin and liable to be torn away, but is present in all well-preserved and cut specimens. Sometimes it projects as a stiff collar, sometimes (Figs. 4, 16) it is thrown into folds, and at others is withdrawn into the hydrotheca. With only specimens in which the polypes are completely retracted to examine, I cannot say how much of the body of the polype is covered by this thin collar when the animal is fully expanded.

When the soft parts are dissolved away by potash the whole branch appears to consist of a meshwork of tubes with chitinous walls (Fig. 11), which anastomose so freely that the skeleton appears, in surface view, to consist of an irregular chitinous network, which has a considerable superficial resemblance to the skeleton of a horny sponge, though this resemblance is even more strongly marked in the case of the Ceratelladæ. On cutting sections, however (Figs. 7, 8, 9), the tubular arrangement can be recognised. The structure is essentially identical in the branches and branchlets, whatever be the size, the only difference consisting in the greater number of tubes entering into the composition of the larger branches as compared with the smaller ones. The tubes (Fig. 7) run roughly parallel to the length of the branch, continually branching and anastomosing. The spaces which they contain vary much in calibre. Towards the exterior the chitinous walls are much stronger and thicker than in the interior, and the most external series are incomplete, forming grooves rather than tubes. The thin external layer of the branch, previously alluded to, touches the chitinous lips of these grooves (Figs. 8, 9), and thus a complete inclosure for the most external-lying cœnosarcal tubes is formed.

Sections also show that the larger circular openings, visible on the outside, lead down into tubular spaces, the walls of which are formed of chitinous material similar to that of the tube walls with which they are connected. These form the hydrothecæ, and the spaces within them are continuous with one or more of those within the tubes surrounding them (Figs. 4, 7, 12). The thin external chitinous (?) layer always passes up to be attached to the rim of the hydrothecæ. The cylindrical structures (P″) on this thin layer are very simple in form, open at both ends, and serve during life to contain the defensive polypes which are directly connected with the external layer of cœnosarcal tubes. (Fig. 5).

Measurements of the Skeleton.

Diameter of branch taken, ·7 mm.

Number of tubes, as seen in longitudinal section, entering into the composition of a branch of this size, 7—9; as seen in transverse section, 40—50.

Thickness of the tube, varying, but averaging about ·07 mm.

Thickness of wall of tube, ·0525 mm. at the exterior, some of those in the centre being not more than ·00525 mm.

Hydrotheca.—Transverse section, ·175 mm. — ·1225 mm.

Hydrotheca.—Longitudinal section, ·525 mm. (average).

Soft Parts. (Figs. 3, 4, 5, 10, 12, 14, 15).

The chitinous tubes are filled by the cœnosarcal tubes which branch and anastomose freely. No one of the latter tubes is more prominent than any other. The polypes are distributed over the whole surface, having apparently no definite arrangement on the larger stems or branches, but, in the smaller ones, a very distinct spiral arrangement (Figs. 6, 11). One corresponds to each of the hydrothecæ, seen in the skeleton, and is capable of complete retraction within the latter. When thus retracted the opening is protected by the thin collar-like projection formed of the outer layer of perisarc mentioned above.

Each polype has the typical hydroid form. It is somewhat tubular, with a conical hypostome, from the base of which arises a single circlet of solid tentacles, which vary in number from six to ten, and are provided with minute nematocysts, the threads of which are short, stiff, and unbarbed. When the tentacles are retracted they curl over towards the mouth, much in the same manner as do those of Pedicellina, amongst the Polyzoa.

The body of the polype is formed of the typical layers—an ectoderm of somewhat columnar cells, an endoderm of larger cells less defined in shape, and between the two a very strongly marked layer of mesoglœa (.00875 mm. in thickest part). From the bases of the ectoderm cells pass off long processes (Fig. 14), much more strongly marked than is usual in hydroid forms. In its greatest breadth one of these fibres measures ·0058 mm. They give rise to a circular band of what are evidently in function, " muscle fibres." In figure 14 these are represented as seen when an oblique longitudinal section of a polype is cut.* Possibly some of them may have lost their connection with the ectoderm cells from which they have been derived. Each has a very definite outline and contents, which, when stained, have a somewhat granular appearance. They all lie external to the mesoglœa, and form a very definite band round the body of the polype, the position of which is represented in the diagram (Fig. 12).

Sections, transverse and longitudinal, show that the basal ends of the polypes are continuous with more than one (sometimes as many as four or five) of the

* These bear a considerable resemblance to those described by Weismann as occurring in the cœnosarc of *Plumularia echinulata*. See Entstehung der Sexualzellen bei den Hydromedusen, Pl. VIII., Fig. 9*b*.

cœnosarcal tubes. In this they resemble the polypes in the group Hydrocorallinæ. The cavities of the polypes and of the meshwork of tubes are hence directly continuous. The tubes are formed of the two primary layers with, if present at all, an extremely thin layer of mesoglœa between them. The endoderm is always unilaminar and distinct; the ectoderm is composed of smaller cells, the nuclei, but not the outlines, of which are clearly marked. It appears to be frequently more than one cell in thickness, and to be irregular in outline, spirit specimens showing projections (Fig. 10) which come in contact with the chitinous walls. Probably during life there is very little space between the hard and soft parts. Within the cœnosarcal tube are frequently seen large globular structures containing darkly staining portions (Fig. 10. x.)

The whole of the external layer of cœnosarcal tubes is studded over with an enormous number of small defensive polypes of very simple structure (Figs. 3, 5, 15). One corresponds to each of the cylindrical structures which rise up from the outer thin perisarc layer, and consists of a stalk and a head. The former is directly continuous with the cœnosarc tube, and consists of an internal axis, the nature of which is difficult to determine. It is solid, and contains no prolongation of the tubular canal of the cœnosarc, but appears to be continuous with the endoderm, though I cannot as yet make out the cellular structure. It is very much shrunken in spirit specimens. The outer layer is thin and continuous with the ectoderm of the cœnosarc (Fig. 15). In spirit-preserved specimens it has the appearance of a thin layer of granular protoplasm with nuclei, the diameter of which is greater than the thickness of the protoplasmic layer, in which the outline of cells cannot be distinguished. No trace of muscle elements can be distinguished.

The head consists of a little mass of nematocysts, with the remnants of the cells, which have given rise to them, and the nuclei of which can be clearly seen. Each nematocyst is fusiform in shape, and the whole form a little group lying close to the open end of the cylindrical tube, through which the threads can doubtless be ejected. None of the nematocysts have the threads put out, and their exact form cannot be therefore described.

In relative size and structure these defensive polypes resemble more than anything else the machopolypes of the Plumulariidæ, and have no resemblance to the defensive polypes of Hydractinia or Podocoryne, whilst none have as yet been described in the Ceratelladæ.

In figure 3 is represented a diagrammatic restoration of a branch of the colony only the soft parts being drawn. The upper surface is supposed to have been cut away, and the network of cœnosarcal tubes is shown branching and anastomosing. The connection of the alimentary polypes with the tubes is drawn, and the small defensive polypes are shown arising from the outermost layer of cœnosárc. The hard skeleton parts represented in figure 11 occupy the spaces between the tubes in figure 3, the polypes corresponding in position to the large circular openings leading down into the hydrothecæ. The general relationship of the polypes to the skeleton and the cœnosarcal tubes is represented diagrammatically in figure 12.

Affinities of the Hydroceratinidæ.

Clathrozoon differs in important points from any hydroid hitherto described, and it is somewhat difficult to determine its affinities, more especially in the absence, as yet, of any knowledge of its reproductive elements.

At first glance it would appear to be related to the Ceratelladæ, but this is simply in consequence of the superficial resemblance in the skeleton of the two groups; each consists of a branching mass of entwined perisarcal tubes, and here the resemblance ends, for, whilst the branching network of tubes may be compared with that constituting the skeleton of the Hydractiniidæ and the Ceratelladæ, there are present two structures entirely wanting in the members of these two families, (1) the hydrothecæ, and (2) the external layer of thin perisarc, with its projecting cylindrical tubes. The first of these structures are quite unlike those of any other hydroid in their simple shape, the thickness of their walls, the relation of these to the surrounding perisarc tubes, and the number of openings leading through the wall into the enclosed space. At the same time, if the cavity in the scoop-like projection, formed of a small network of perisarcal tubes in the Ceratelladæ, were to become deeper and to penetrate the substance of the branch, and if the branches of the network bounding the cavities thus produced were to "run together" and thus give rise to a tubular structure, in which apertures were left, we should have produced a structure similar to the hydrothecæ of Clathrozoon. The second of these structures is, apparently, not present in any other hydroid, and the manner of its origin is difficult to conceive. There is no such external layer of cœnosarc investing the colony as is present in the Hydractiniidæ, and which might be supposed to secrete such a layer. On the contrary, the surface of the colony shows a series of much branching tortuous perisarc tubes, each incomplete externally, and the whole covered in by this thin continuous layer, which does not give the idea of having been formed as a separate outer covering for each most external tube, though it must apparently have been produced in this way. The little cylinders arising from it enclose each, it is important to notice, a defensive zooid, which arises directly from the cœnosarcal tube immediately below. In one or two of the sections cut transversely near to the end of a growing branch, the perisarc tubes appear to have a thin innermost lining distinguishable from the rest of the perisarc; possibly this may be comparable to this outer layer, but at all events the latter, as shown in sections, passes continuously from lip to lip of the outer grooves, and has nothing to do with any layer lining the latter internally. That it is connected in development with the soft structures in these there can be little doubt if only on account of its relationship to the protective zooids to which they give rise.

The extension of this layer beyond the mouth of the hydrothecæ so as to form, as it were, an operculum for these, is a curious feature, and one not met with, so far as I am aware, in any other hydroid. This particular part is very flexible, being capable of being thrown into folds (Fig. 16), or even of being pulled back within the outer rim of the hydrotheca by the retreating zooid. Taken altogether the skeleton, though in certain respects showing a resemblance to the Hydractiniidæ and Ceratelladæ, differs essentially from that of these forms in the two important points dealt with above.

In dealing with the soft structures we find a most curious combination of characters, each one characteristic of hydroid forms, belonging to groups perfectly distinct from one another.

The network of cœnosarcal tubes resembles, to a certain extent, that of the Hydractiniidæ, Ceratelladæ and Hydrocorallinæ, but even here we have to note the entire absence of an external continuous layer, characteristic certainly of the first and third, and, probably, also of the second group.

The alimentary polypes are sessile, and distinctly "claviform," that is, have tubular bodies with a conical hypostome and a single circlet of simple solid tentacles, in which points they resemble the genus Clava. Those of the Ceratelladæ*, on the other hand, have scattered capitate tentacles, and in the Hydractiniidæ they are provided with a strongly developed hydrocope.

The gastrozoids again resemble those of the Hydrocorallinæ, and differ from all others amongst the Hydrozoa in being connected with several of the cœnosarcal tubes.

The defensive zooids, or dactylozooids, resemble more than anything else, certain individuals characteristic of the Plumulariidæ, to which the name of "machopolype" has been applied. They consist of a solid stalk bearing a number of nematocysts at its free end, each zooid being enclosed in a distinct protective case or nematophore.

The structure of the gastrozooids thus calls to mind the genus Clava, that of the dactylozooids the family Plumulariidæ, and the relationship of the gastrozooids to the cœnosarcal tubes, the sub-order Hydrocorallinæ. This combination of characters, together with the nature of the skeleton, serves to render the Hydroceratinidæ distinct from any family of Hydroidea yet known.

* Bale, *loc. cit.*

2. A New Species of Plumularia.

This form was dredged by Mr. Wilson in Port Phillip, and differs, as far as I can ascertain, from any yet described. In (1) that the nematophores are perfectly independent of the hydrothecæ, (2) that no intrathecal ridge is present, (3) that the hydrothecæ are cup-shaped, with smooth untoothed margin, and are set at some distance apart from one another, the form in question shows the features characteristic of the group to which Allman gave the name of Eleutheroplea.

The arrangement of the hydrothecæ would prevent it from being placed in any of the three divisions—Isocola, Anisocola, and Monopyxis—into which Kirchenpauer proposed to divide the genus.

The species may be described as follows:—

Plumularia procumbens, n. sp.

Hydrocaulus upwards of 6in. in length. The whole colony procumbent with large polysiphonic branches running in a roughly horizontal direction. From one side of these principally arise smaller polysiphonic branches, all lying in one plane. From the sides of the branches arise numerous pinnæ (at largest ¼in. in length) irregularly arranged; in addition to these, hydrocladia (pinnules) may arise direct from the hydrocaulus. Two pinnules, alternate, arise from each joint of the primary pinnæ. Pinnules composed of alternate small and large joints, the latter only bearing hydrothecæ and nematophores. Nematophores bithalamic with simple terminal aperture, one beneath each hydrotheca, two at the level of the mouth of the hydrotheca, all independent of the latter. Two nematophores in the angle between the pinnule and main stem of the pinna; nematophores scattered irregularly in great numbers over the surface of the polysiphonic stem and branches.

Colour.—Light-brown stems.

Hab.—Port Phillip, Mr. J. Bracebridge Wilson.

The colony reaches a considerable size, and from the fact that the main branches run in one direction (Fig. 20) with the smaller ones arising principally from one side, it is inferred that in all probability it is procumbent in habit. The branches of the hydrocaulus are all polysiphonic and strong, the pinnæ and hydrocladia, which arise from them, being very small indeed in comparison. The two latter are given off all round the branches, and reach at most the length of ¼in., whilst the main branch may be 6in. in length.

Skeleton.

(a) Structure of large branches (Figs. 24, 25, 26, 27, 28).

Under the lens the tubes making up the branches can be clearly seen, the surface being marked by darkish brown lines, due to the edges of the perisarcal tubes seen in optical section (Fig. 25). The tubes on the exterior run parallel to one another along the length of the stem, branching very rarely. From the surface arise irregularly, and on all sides—(1) large pinnate shoots, the proximal parts of which are covered with one or more layers of dark-brown perisarc, within which only one tubular cavity is contained; (2) smaller branches (hydrocladia), corresponding to the pinnules in structure; (3) a great number of nematophores, or protective cases, for the minute defensive zooids which are characteristic of the group.

In transverse section (Figs. 27, 28) the branch is seen to be made up of a great number of tubes—as many as 40-50 in a branch of average size—the number varying with the size of the branch.

Each tube has a definite and thick perisarcal wall, which shows clear indications of arrangement in layers. In places the cavities within the tubes are seen to be (Figs. 24, 27, 28) in communication with one another. A striking feature of both transverse and longitudinal sections is the presence of a distinct central tube, always clearly recognisable, both on account of its size and the slightly yellow colour of its walls when compared with the surrounding ones (Fig. 24). This central tube, which, from its relations to the other parts, is probably to be regarded as homologous with the main stem of a monosiphonic form, passes along all the branches of the colony, and from it arise *every one* of the pinnæ and hydrocladia, though, as will be shown shortly, these may be also connected with the other tubes which go to form the polysiphonic stem. Professor Allman has figured* in *Aglaophenia coarctata* a connection existing between the various tubes of a polysiphonic stem, and this is most clearly seen in the species under consideration. The connection is, however, somewhat different from that obtaining in *A. coarctata*, which is thus described by Allman :—" Communication is effected by very short processes, which are given off from the component tubes, those of two juxtaposed tubes meeting one another and inosculating in such a way as to suggest the conjugation of a zygnema." In longitudinal section (Fig. 24) the various tubes are seen to be arranged so that they run parallel to the central one, and at intervals their walls are pierced by apertures. Where the pinnæ and hydrocladia pass through, the walls of the latter are connected with those of the stem-tubes, and apertures are formed opening into the cavities of the latter.

(b) Structure of the pinnæ, etc. (Figs. 21, 22, 23, 25, 26).

The origin of these from the stem is shown in figure 25, their structure in figures 21, 22, and 26.

* "Challenger" Reports, Hydroidea, Part I., Plumulariidæ.

The basal portion of each pinna is strengthened by the development of a very strong layer of dark brown coloured perisarc, continuous with that of the tube walls. This thick external layer ends abruptly just before reaching the distal end of either the first or second joint (Fig. 25). Each joint beyond the first one or two carries two pinnules. There appears to be a slight variation in the most proximal joints; sometimes the first, sometimes the first and second, differ from the rest, in bearing each only one pinnule.

The pinnules are alternate, and consist of a varying number of joints, which are alternately shorter and longer, the latter only bearing the hydrothecæ and nematophores (Figs. 21, 26). This arrangement is constant in all specimens which I have examined. In other Plumulariæ the pinnules of which are composed of alternately longer and shorter joints, such, for example, as *P. setaceoides, goldsteini, delicatula*,* the shorter ones always bear a nematophore. This is absent in *P. procumbens*. The hydrothecæ are cup-shaped, with a smooth margin, and are placed on the side facing the central stem of the pinna. The most distal pinnules carry one hydrotheca each, the proximal as many as six. The cavity is separated from that of the joint by a septum pierced by a circular opening, which lies near to the external wall. There is no trace of an intrathecal ridge.

The nematophores are three in number on each of the larger joints; one is placed below the hydrotheca, two at the level of its upper margin. Each is bithalamic with the terminal chamber cup-shaped, and the proximal one somewhat canaliculate. The walls are thin (Fig. 22), except where the division into the two parts is formed, at which spot they thicken considerably, and give rise to a circular ridge projecting upwards into the distal chamber. The opening is single and terminal, and each nematophore is only attached by its proximal end, where the walls are thin, and may be thrown into slight folds.

The walls of the pinnule joints show internal ridges, which are always more prominent on the side facing the central stem of the pinna, and thin away towards the opposite surface. They are always arranged thus—(1) In the larger joints there is a ridge close to each extremity, with a third one corresponding in position to the septum of the hydrotheca; this varies much in development, being sometimes scarcely noticeable. (2) In the smaller joints there are uniformly two ridges. (3) In the projection from the joint of the pinna bearing the pinnule there is always one ridge. Taken altogether the result is that each line of division in the pinnule has one ridge immediately on either side of it (Fig. 21).

In the axil of the pinnules there are present—(1) Two nematophores corresponding in structure exactly to those described above, (2) between these a curious

* Bale. Catalogue of Australian Hydroids, Pl. XI.

structure formed of the perisarc, having the shape of a cone with the apex cut off (Fig. 21). The space within the latter communicates by the narrow end with the exterior, and by the broader with the cavity of the pinna joint. Into it cells of the ectoderm may enter to a slight degree, but more usually it appears to be unoccupied (in spirit-preserved specimens), and I am quite unable to attach any meaning to it, though it is a perfectly constant structure. It has nothing to do with the reproductive structures. Possibly it may serve as a means of allowing of the ingress and egress of water to and from the perisarcal tubes. Any space between the ectoderm and the perisarc in the very numerous tubes which compose the colony must presumably be filled by liquid. The openings leading into the hydrothecæ and nematophores from the stem are small and narrow, and quite filled up by the soft parts. When sudden contraction takes place part of the soft portions must be withdrawn through these openings and occupy space within this perisarcal tube previously, presumably, occupied by fluid. If there be some means of expelling this fluid then the sudden contraction of the polypes and machopolypes is rendered more easy. It may be that these openings serve this purpose. The openings are guarded, as it were, by two machopolypes.

Soft Parts (Figs. 17, 18, 19, 24).

(*a*) Larger branches.

These are all polysiphonic. The cœnosarcal tubes of which each is composed may be divided into two divisions—(1) a central one, (2) others varying in number and surrounding this. The tubes very rarely branch in such a way that two running longitudinally arise from a common one, though (Figs. 24, 27, 28) they frequently are united with one another by short transverse branches passing through openings in the perisarcal walls. Each consists of ectoderm and endoderm containing a cavity. From the outermost series arise a great number of minute machopolypes or defensive zooids. *The central one gives origin to all the branches passing out into the pinnæ and hydrocladia,* with which the branches are irregularly studded. As they pass from the centre to the external surface they are connected with a varying number of the surrounding cœnosarcal tubes, a feature which is especially marked in the case of the pinnæ (Figs. 17, 24). This arrangement is clearly seen when sections are cut, and has not, so far as I am aware, been noted before. Bale,* in speaking of the structure of the stem and branches in the Plumulariidæ, says that in most polysiphonic species "the primary jointed stem is slender (the requisite strength being given by the compound stem, which is only developed as the zoophyte increases in size), and the branches spring, not from the jointed stem, but from the supplementary tubes which grow up in contact with it. For example, in

* Genera of the Plumulariidæ, with observations on various Australian Hydroids. Proc. R. S. Victoria, 1886.

Aglaophenia longicornis we find at the back of the original slender-jointed stem a stouter secondary tube, *and from this spring, at regular intervals, the alternate pinnately arranged branches.** . . . . Keeping in mind the hydrorhizal origin of the polysiphonic stem we see that in *Aglaophenia longicornis*, for example, every one of the main pinnæ is equivalent to a separate shoot of such species as *A. parvula*, a fact which is further illustrated by the presence, near the base of the stem in the latter species (and, indeed, in many others), of a long oblique joint similar to that which exists near the base of each pinna in *A. longicornis*. . . . . *I have not hitherto met with any species with branches springing both from the jointed stem and the added tubes*."*

It will be seen at once that an important difference exists in this respect between the species now described, and those examined by Mr. Bale, and, so far as I am aware, any other investigator. Not only is there a very distinct connection between the soft and hard parts of all the tubes of the polysiphonic stem, but the central one, though distinguishable from the rest, has the same fundamental structure as the latter so far as its walls are concerned, and shows no traces of joints.† The question naturally arises What elements are we to consider as entering into the structure of the polysiphonic stem in this form ?

We may regard it as composed of—

(1.) A central tube equivalent to the hydrocaulus of a monosiphonic form, which is surrounded by a series of added but modified hydrorhizal elements, or

(2.) A number of hydrorhizal elements forming branch-like structures, and giving off pinnæ, or

(3.) A number of hydrocauli in close apposition to one another.

The last is the most improbable, since, if it were the case, we might expect pinnæ to be given off from all or any of the tubes composing the stem, whilst they *all* arise primarily from the central one. The same objection applies to the second, and the distinction which undoubtedly obtains between the central and all the other tubes seems to point to the fact that the former is the fundamental portion, the latter being secondary structures. At the same time a hard and fast line of distinction between hydrocaulus and hydrorhiza cannot possibly be drawn. In some forms of Plumulariidæ we find the pinnæ arising directly from the hydrorhiza, in others they arise from the sides of a hydrocauline structure which grows upwards from the

* The italics are mine.

† At the free extremity of each branch it is continued directly on into a jointed stem forming the centre of a pinna, and may probably be regarded as having lost its jointed nature subsequent to its being completely enclosed by the surrounding tubes of the polysiphonic stem.

hydrorhiza. Sometimes the structure bearing the pinnæ, or the central stem of the pinnæ itself, may be strengthened by the addition of tubes clearly growing up from the hydrorhiza. These tubes, in some monosiphonic forms, may be feebly developed, whilst in typical polysiphonic ones apparently homologous structures may be constant and greatly developed. In the former case the distinction between hydrocaulus and hydrorhiza is clear enough, but then if the true polysiphonic form be investigated, we find that the supplementary structures grow around the primary jointed stem, and (1) finally (as in *Aglaophenia longicornis*) give rise to the pinnate branches, just as does the hydrocauline tube in such a form as *P. falcata*, the jointed stem bearing no branches; or (2) they form (as in *P. procumbens*) an enclosing mass for the original tube which alone gives off the pinnæ, though these may be connected with the hard and soft parts of the enclosing branches. Thus what must be regarded as homologous structures, may either (1) be feebly developed, and retain their original hydrorhizal nature; or (2) be strongly developed and *(a)* give rise to pinnæ, and, as it were, usurp the function of the original hydrocauline tube which they support, or *(b)* assume an intermediate form, the original tube which they inclose alone giving rise to pinnæ, with which, however, as well as with the former they are in organic connection.

(*b*) *Pinnæ, etc.*

There is little to say with regard to the structure of the soft parts contained in the pinnæ; the hydranths have the form typical of the genus Plumularia, with the body divided into two parts by a central constriction, the distal part bearing a single circlet of solid tentacles at the base of a broad hypostome, the proximal half being somewhat globular and presenting no special feature.

The machopolypes of the main branches and the pinnæ are of precisely similar structure, corresponding to those of other forms which Lendenfeld has distinguished as "guard animals with corticating capsules."* There is no trace of any with adhesive cells such as are found in the genus Aglaophenia.

Each machopolype consists of a proximal tubular part lying in the proximal half of the nematophore and a distal swollen part, which contains rounded nematocysts. I have been unable to study the living form, and have only seen spirit specimens, in which the soft parts are of course much contracted; in these, lines running from the head down the stalk probably indicate muscle fibres, the machopolype being capable of great extension.

In figure 17 is represented a restoration of the soft parts of a small portion of one of the polysiphonic stem, together with one of the hydrocladia and pinnæ which arise from it.

* Zeitsch. f. Wissen. Zool., Vol. XXXVIII., p. 335.

(c) Reproductive structures.

The only specimen bearing reproductive structures was a male colony. The gonothecæ (Figs. 18, 19, 23) are simple and pear-shaped, with a large terminal opening and short stalk springing from the axil of a pinnule. Each contains one gonophore (Fig. 18), which in longitudinal section is seen to arise from the blastostyle and to fill nearly the whole cavity. The blastostyle in the spirit-preserved specimen examined was much shrunken with a terminal swelling (D) below the opening of the gonotheca. The cell-layers could not be distinguished. The two prominent parts of the gonophore are the mass of sperm cells (sp), which stain deeply, and the spadix (Fig. 19, end.) Outside the sperm cells a very thin layer of ectoderm can be distinguished. I failed after long searching to recognise any trace of reproductive elements in the cœnosarcal tubes or blastostyle, or any appearance of the formation of more than one gonophore in each gonothecæ, though in *P. echinulata* Weismann states that very often a second gonophore may be found before the contents of the first have passed out.* In *P. halecioides* also it seems that two may be present at the same time.†

* Entstehung der Sexualzellen bei den Hydromedusen, p. 180.

† *Loc. cit.*, p. 184.

DESCRIPTION OF PLATES.

Plates 17, 18, 19, and 20 refer to *Clathrozoon wilsoni.*

Plate 17.

Figure 1.—The skeleton of a dried specimen of *Clathrozoon wilsoni*, life size, from a photograph.

Figure 2.—Skeleton of part of a colony of *Clathrozoon wilsoni*, drawn from a spirit specimen.

Plate 18.

Figure 3.—Restoration of the soft parts. The hard skeleton parts are entirely omitted. Only the end of one of the branches of a colony is represented, but this is typical of the structure of the whole. The upper surface of the branch is supposed to be cut away to show the connection of the gastrozooids with the cœnosarcal tubes. The outermost of the latter are studded with the defensive zooids. The whole is much magnified, the actual size of the branches being represented in figures 1 and 2.

Figure 4.—Represents a longitudinal section of a small portion of a branch to show the connection of a polype (retracted) with the cœnosarcal tubes. In the figure the polype is connected with three of these. (A) The perisarc walls are shown, and the thin external layer forming at the mouth of the hydrotheca an operculum P. Outline drawn with the camera under Zeiss A. oc. 2.

Figure 5.—Transverse section of a small portion of the outermost part of a branch to show a defensive polype, connected with one of the outer cœnosarcal tubes, which is connected again with a deeper lying one. The defensive polype is enclosed by the nematophore. E. is one of the most external tubes, the outer wall of which is formed of the thin layer (P.) of perisarc, on which lies an accumulation of foreign substances, spicules, &c. Outline drawn with camera under Zeiss A. oc 2.

Plate 19.

Figure 11.—A small branch much enlarged showing the skeleton only, the soft parts having been dissolved in potash. The hydrothecæ are shown arranged spirally and projecting with circular margins slightly from the surface. The network of chitinous tubes is seen to represent somewhat in appearance the clathrate horny skeleton of certain sponges. The somewhat prominent lines on the surface corres-

pond to the dark curving ones in figure 6. The thin external layer with the nematophores is only shown at the edges, in reality it covers the whole surface. Letters as before. x 50.

Figure 12.—A diagrammatic drawing to show the relationship of the hard and soft parts as seen at the external part of a longitudinal section of a branch. A gastrozooid is shown partially expanded. Hy. the walls of the hydrotheca. C. cœnosarcal tube. Ma. protective zooid arising from the outermost cœnosarcal tube. P. the thin external layer of perisarc. P′. the continuation of the latter to form a collar beyond the opening of the hydrotheca. P″. the nematophore. T. tentacle.

Figure 13.—A semi-diagrammatic drawing of a hydrotheca as seen in a thick transverse section of a branch very much enlarged. The walls of the hydrotheca are supported by numerous extensions of the perisarcal network, and the openings into the internal-lying end of the hydrotheca are shown. The perisarc tubes have branched and anastamosed to such an extent that their walls form a network, and the tubular structure is not so evident as it is in the more deeply lying parts. Letters as before.

Figure 14.—The basal part of a gastrozooid cut obliquely to show the strong band of muscular fibres derived from the ectoderm together with the thick layer of mesoglœa. *Ect.* ectoderm. *End.* large granular endoderm cells. *M.* thick mesoglœa layer. *Mus.* muscle fibres, some in connection with the ectoderm cells, from the basis of which they arise, others cut at a deeper level, at which their connection with ectoderm cells is not seen. Possibly some have lost their connection with ectoderm cells. Drawn under Zeiss F. oc. 2.

Figure 15.—A defensive zooid highly magnified. It consists of a stalk and head. The former is in connection with a cœnosarcal tube one wall of which, as seen in longitudinal section is shown. The centre of the stalk is solid and continuous with the endoderm, though no cellular structure can be determined. Outside this is a thin layer of ectoderm in which nuclei are scattered. The head consists of nematocysts at the bases of which remnants of the cells in which they have been formed can be seen with their nuclei. *Ect.* ectoderm. *End.* endoderm. *M.* mesoglœa. *N.* nematocyst. Drawn under Zeiss apo. 4.0 mm. apert. 0.95 oc. 12.

Figure 16.—The collar-like operculum surrounding the margin of a hydrotheca seen from above. The collar is thrown into folds. Drawn under Zeiss F. oc. 2.

Plate 20.

Figure 6.—A terminal branch, much enlarged to show the circular openings of the hydrothecæ, within which the polypes are withdrawn, and also the general spiral arrangement of the hydrothecæ. The surface is covered with tortuous grooves,

bounded by dark lines, indicating the edges of the perisarc, and is studded with nematophores seen at the edges of the branch. Hy. Hydrothecæ. P. nematophores.

Figure 7.—A longitudinal section of a small branch, showing the skeleton. The tubes of which the branch is composed are seen to be very irregular, but to run, especially towards the central part, in a direction generally parallel to the length of the branch. *E.* spaces or grooves, immediately beneath the thin external layer. *Hy.* hydrothecæ. *P.* thin external layer of perisarc. *P'.* the continuation of *P.* to form an operculum at the mouth of the hydrothecæ. *P''.* the nematophores. x 35.

Figure 8.—A transverse section of a small branch, to show the tubes of which it is composed. The tubes vary in size, and open into one another. The outer ones are incomplete externally, forming grooves, the lips of which are usually touched by the thin external layer of perisarc. Two hydrothecæ are cut through. The perisarc is thicker towards the outer than in the inner part of the branch. Letters as in Fig. 7, x 70.

Figure 9.—A small portion of the external part of a branch very much enlarged to show the roughly concentric layers of which the perisarc is formed. Letters as in Fig. 7.

Figure 10.—Small portion of a cœnosarcal tube with the perisarc walls from the interior of a branch. *Ect.* the ectoderm in which the outline of the cells cannot be clearly distinguished, and which varies in thickness in various parts coming in contact, in certain places, with the perisarc walls. *End.* the unilaminar endoderm, the cells of which are larger than those of the ectoderm. *x.* globular structures of unknown significance containing darkly staining parts which lie apparently within the cavity of the tube. Drawn under Zeiss F. oc. 2.

Plates 21, 22, 23 refer to *Plumularia procumbens.*

Plate 21.

Figure 17.—Restoration of the soft parts only of *Plumularia procumbens.* The polysiphonic stem is shown in section with the transverse connections between the various tubes which compose it. Down the centre runs the main tube from which arise all the lateral branches—pinnæ and hydrocladia—which are in connection with a varying number of the surrounding tubes. The most external ones give off numerous machopolypes, and on the pinnæ are shown the groups of polypes, each consisting of one gastrozooid and three machopolypes. One blastostyle is shown with a gonophore, arising from the angle between a pinnule and the main stem of the pinna. x 30.

Figure 18.—Longitudinal section of a male gonangium with its contained blastostyle and gonophore. In the centre of the gonophore lies the manubrium. *Bl.*

blastostyle. *D*. swollen distal, end of blastostyle. *Sp*. sperm. *G*. walls of gonotheca.

Figure 19.—Transverse section of a male gonangium and gonophore. On the left side between the gonophore and the wall are seen traces of the much compressed blastostyle. *End*. endoderm of manubrium. *Ect*. ectoderm outside sperm cells (*sp*.)

PLATE 22.

Figure 20.—Portion of a colony of *Plumularia procumbens* showing the polysiphonic stem and the pinnæ arising irregularly from this, x 1½.

Figure 21.—Much enlarged portion of a pinnule or hydrocladium to show the alternate longer and shorter joints. The latter bears no hydrotheca or nematophores ; the former bears a hydrotheca with the nematophores at the level of the mouth of the former, and one in the median line below. The thickenings in the walls of the pinnule are shown in their positions and the two nematophores in the axil between the pinnule and the main stem of the pinna, and at A, the conical structure opening to the exterior. N^1. upper pair of nematophores. N^2. lower median nematophores. N^3. nematophores in the axil of the pinnule and pinna stem. A. conical process in the axil leading from the interior of the pinna to the exterior.

Figure 22.—Much enlarged view of a nematophore seen in optical section, and showing the two chambers.

Figure 23.—Much enlarged view of a male gonangium.

Figure 24.—Semi-diagrammatic drawing of a longitudinal section of the polysiphonic stem of the same to show the relationship of the hard and soft parts and the distinctness of the central tube with its walls slightly yellower than those of the surrounding tubes. C. central tube. H. central stem of pinna. H′. hydrocladia. L. lateral tubes. N. nematophores. T. transverse connections uniting the various tubes. x 30.

PLATE 23.

Figure 25.—Much enlarged view of the termination of a polysiphonic stem, showing the numerous nematophores on the stem and the pinnæ &c., arising irregularly. The basal parts of the pinnæ are strengthened by the formation of a thick perisarc wall continuous with that of the tubes forming the stem. x 20.

Figure 26.—A highly magnified portion of a pinna.

Figures 27 and 28.—Transverse sections of the polysiphonic stem to show the component tubes—skeleton only—with the large central one, from which in figure 28 a pinna is arising. The external tubes are studded with nematophores.

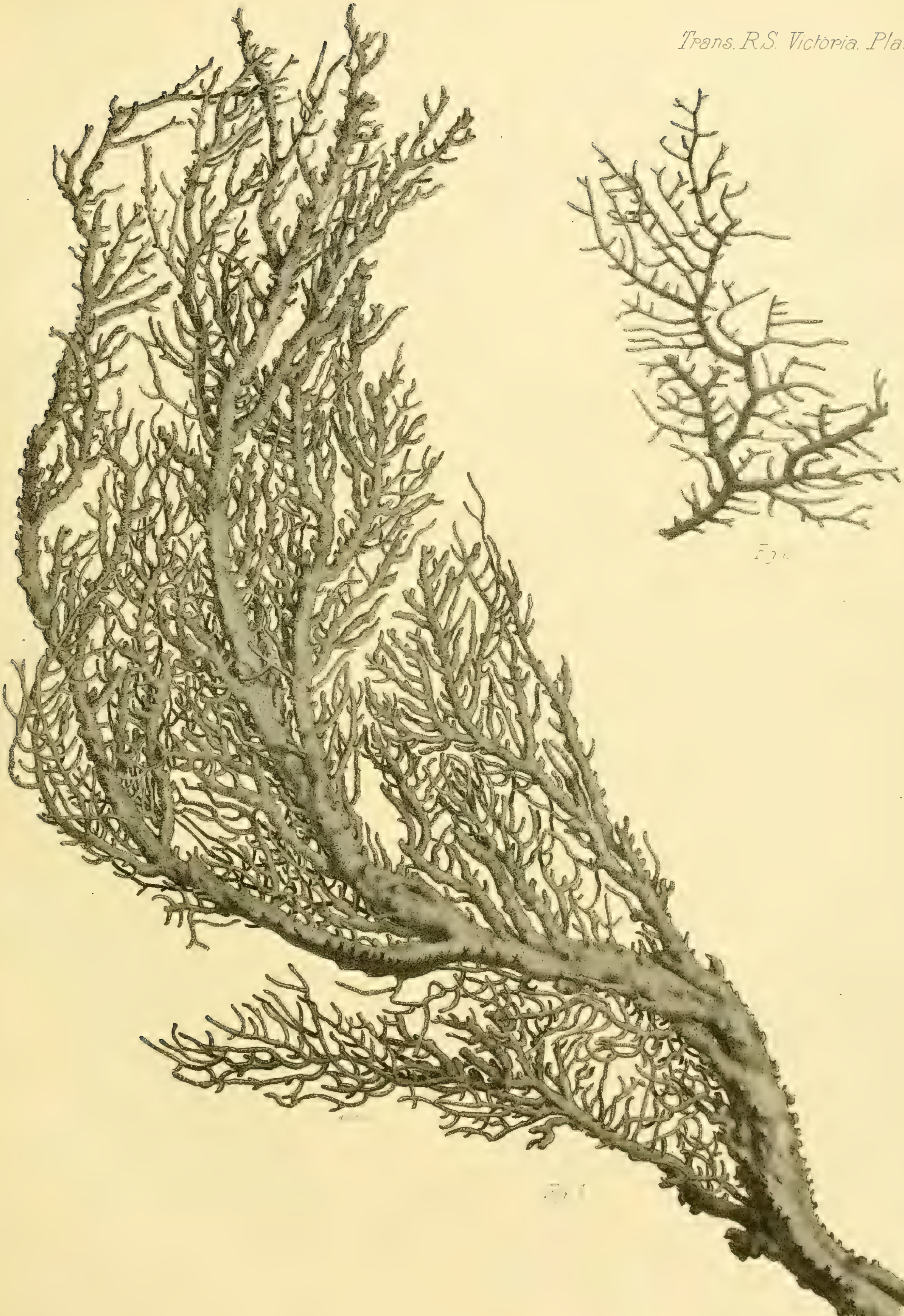
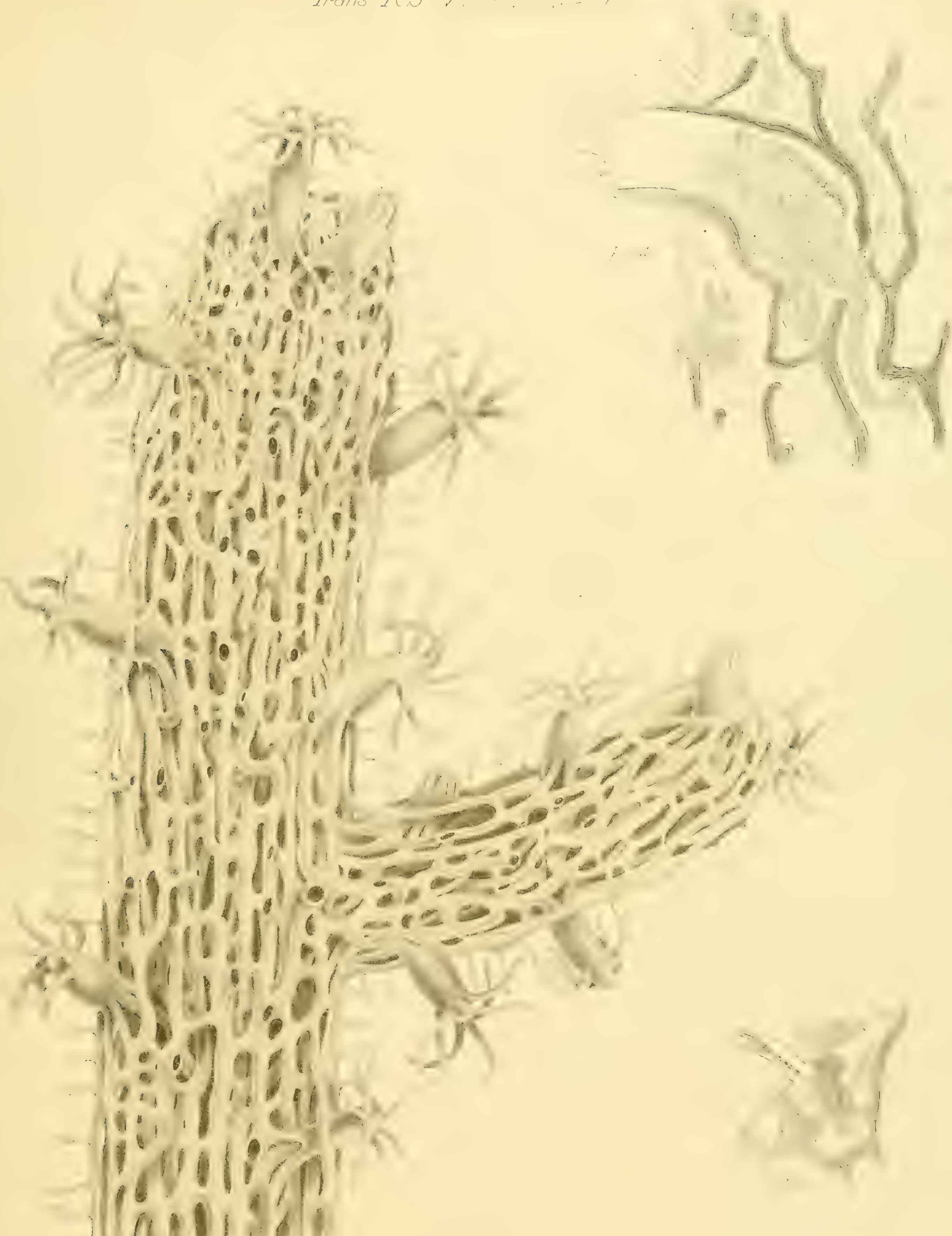


Fig. 2

Fig. 1

CLATHROZOON WILSONI.



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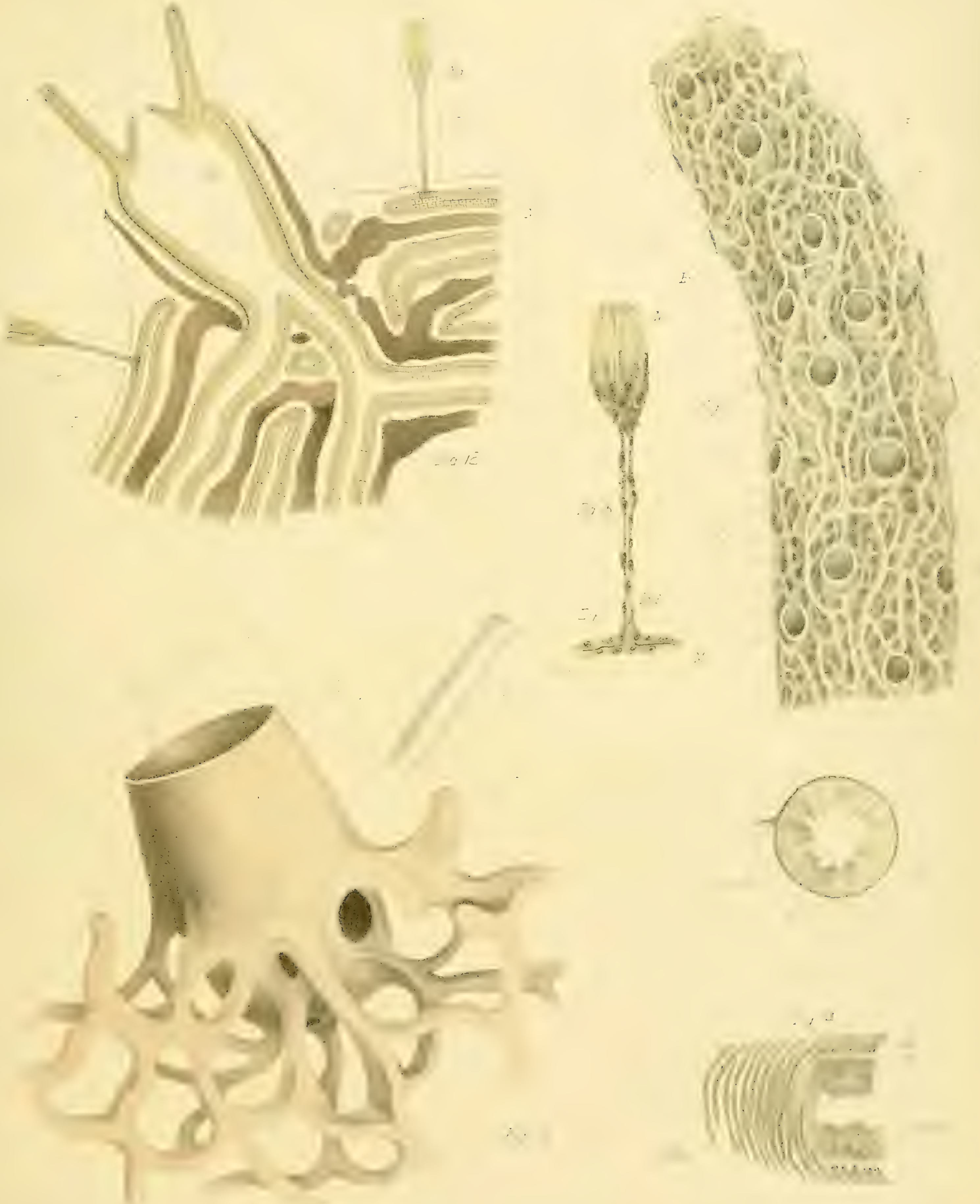

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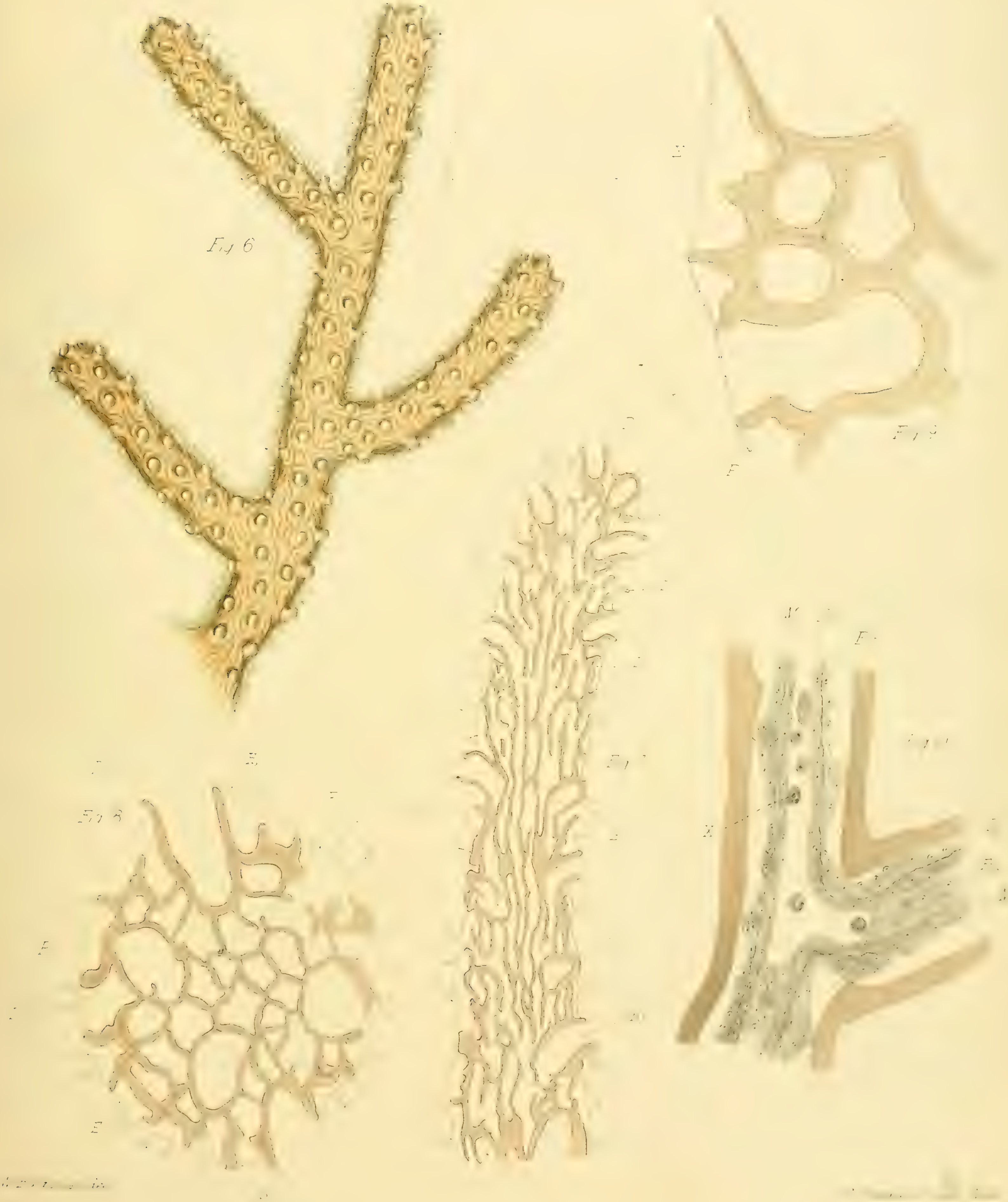

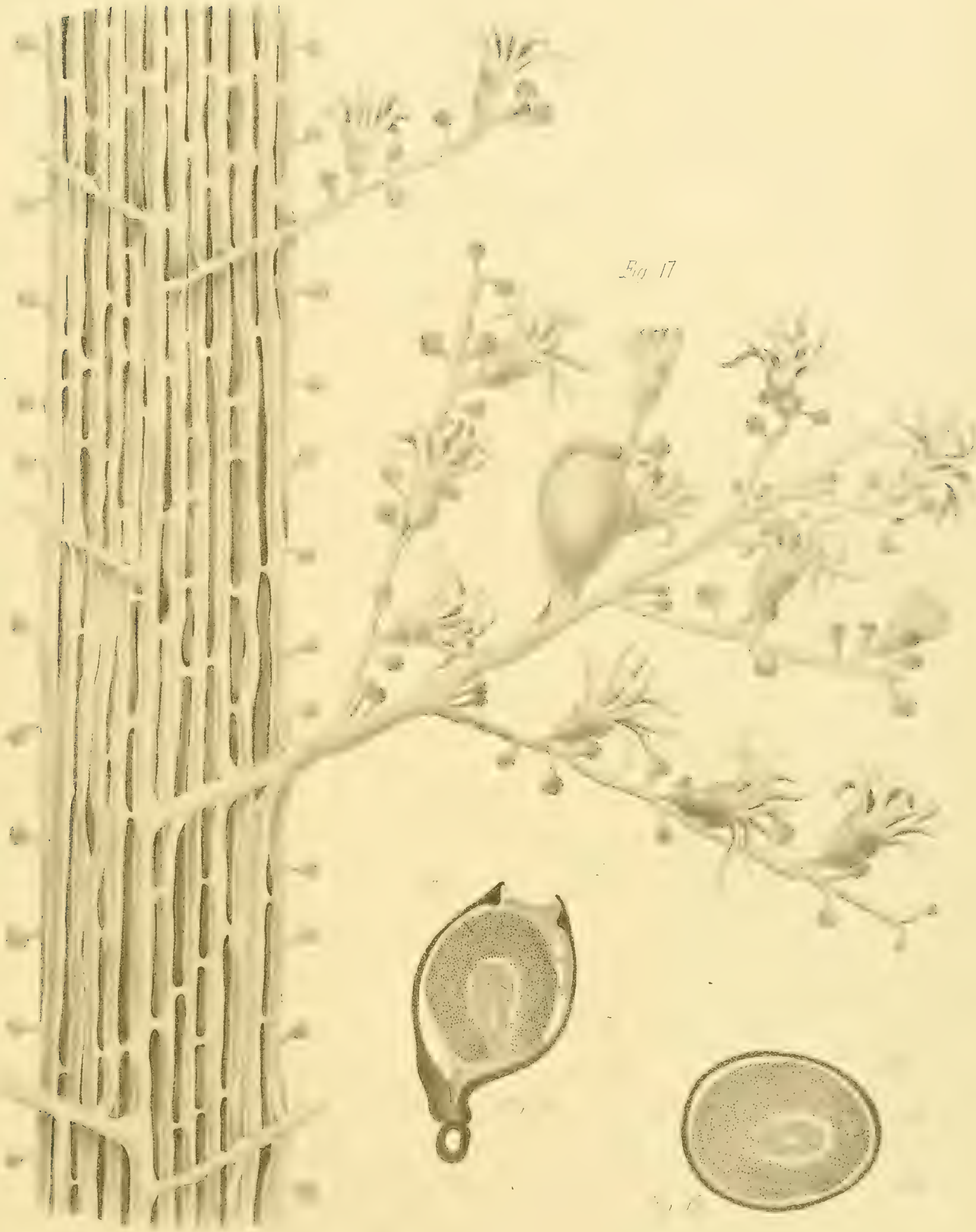

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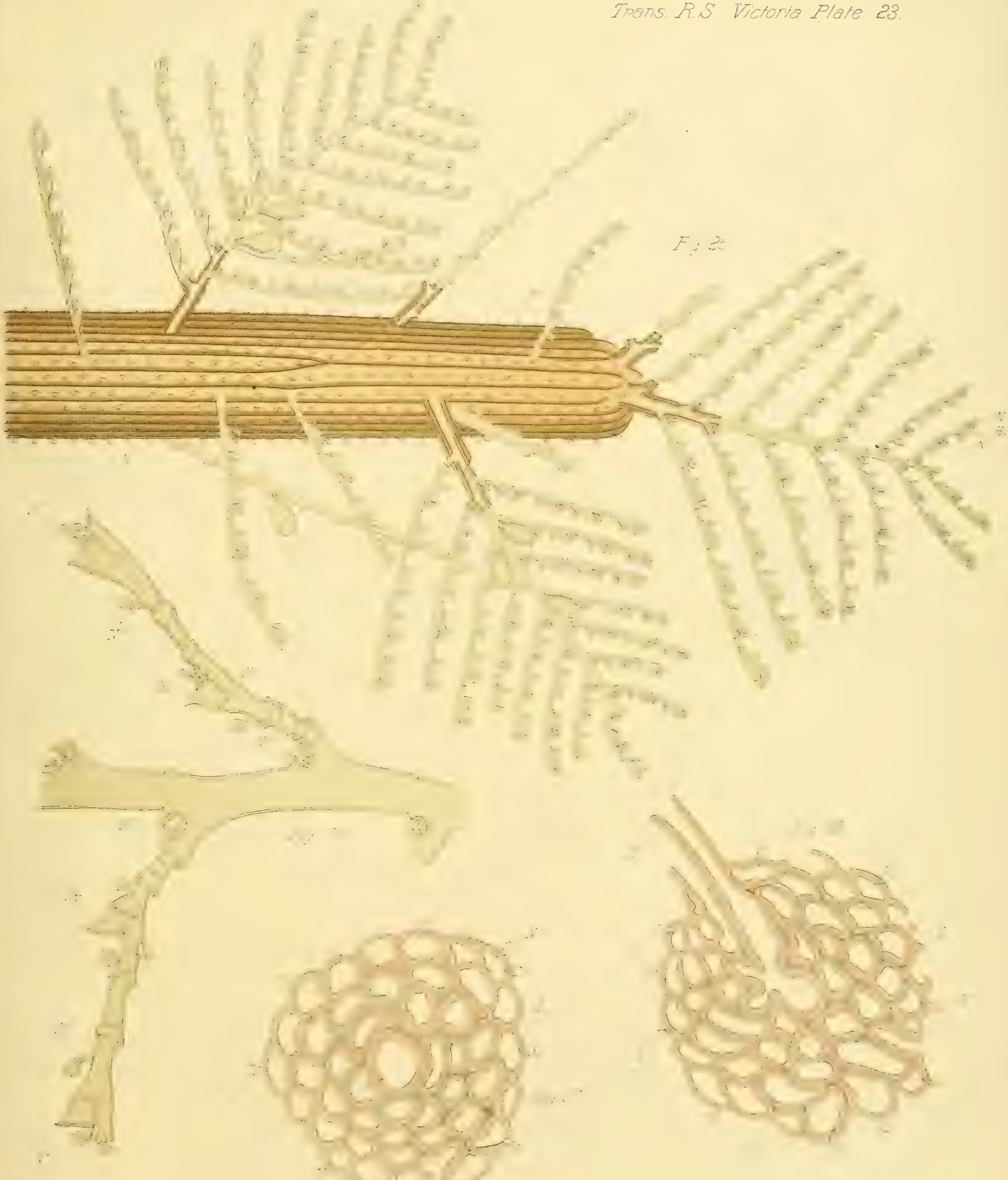

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TRANSACTIONS

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VOL. II. PART II.

1891.

CONTENTS.

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ARTICLE I.—On the Occurrence of the Genus Belonostomus in the Rolling Downs Formation (Cretaceous) of Central Queensland, by R. Etheridge, Junr., Paleontologist to the Geological Survey of New South Wales, Sydney, and Arthur Smith Woodward, F.Z.S., &c., of the Department of Geology, British Museum (Nat. Hist.), London. (With Plate I.)

I. Introduction.

The fine specimen about to be described was entrusted to our care by Mr. George Sweet, of Brunswick, Melbourne, by whom it was obtained when on a collecting tour in Central Queensland, during the year before last (1889); together with many other very interesting fossils, which one of the present writers hopes some day to have the pleasure of working out.

The principal fossil exhibits a long, slender fish, with deep narrow ganoid scales and feeble fins, bent upon itself at about the middle point, and wanting the greater part of the head. The remains are preserved on counterpart slabs, one side being shown, reduced one-half in Plate I., Fig. 1, while various details are illustrated of the natural size in the accompanying Figs. 2-7.

The information afforded by this specimen is supplemented by four other fragments in a similar matrix, numbered M. 31, M. 26 A, M. 28, and M. 30 respectively. The first exhibits an imperfect cranium, much fractured and imbedded in hard rock. In the second the remains of the gill arches are preserved. No. M. 28 shows part of the operculum, supraclavicle, supratemporals, and adjoining scales in counterpart; and No. M. 30 is a connected series of six large vertebral centra, bearing parts of their arches. Taken together, the specimens make known nearly all the more important features in the skeleton of the fish; and it is at once obvious that we are concerned with an unusually large species of the well-known Upper Mesozoic "Ganoid" *Belonostomus**, and with which we have much pleasure in associating the name of Mr. Sweet as *B. sweeti*.

Species that are apparently allied have already been recorded from the Upper Cretaceous of Western Europe, India, and Brazil; and the present discovery is of great interest as extending still further the ascertained geographical range of the genus during Cretaceous times.

* L. Agassiz, Poiss. Foss., 1884, II., Pt. 2, p. 140.

2. Previous Notices of Fish-remains in the Rolling Downs Formation.

The first record of the existence of fish-remains in the immense expanse of rocks, now termed by Mr. R. L. Jack, Government Geologist of Queensland, the "Rolling Downs Formation," is due to the late Mr. Charles Moore, of Bath, England, who found numerous fragments of teeth and scales in the Wollumbilla blocks submitted to him by the late Rev. W. B. Clarke, M.A. He regarded the teeth and certain of the scales as those of *Hybodus*, and other scales as representing the genus *Lepiodotus*.* Subsequent researches have so far failed to reveal further traces of these genera.

The next reference to Australian Cretaceous fish with which we are acquainted is the brief record by Mr. R. Etheridge, F.R.S., of the caudal portion of the vertebral column and several scales of *Aspidorhynchus* in the Hughenden beds,† Central Queensland, associated with Ammonites, and other fossils of Cretaceous age.

After a lapse of some years, Mr. R. L. Jack, whilst engaged with General Fielding in the exploratory traverses for the Queensland Trans-Continental Railway, discovered at Kamilaroy, Leichhardt River, a bed of magnesian limestone, containing, with other fossils, sharks' teeth and small vertebræ.‡ The associated fossils clearly proved this bed to belong to that portion of the great Rolling Downs Formation extending from Cloncurry to Hughenden. These remains were determined by one of us to be the teeth of *Otodus appendiculatus*, Ag., and the vertebræ those of a small Teleostean fish.§ Subsequent to this these teeth were described and figured,|| together with a portion of the vertebral centrums of a large *Lamna* from the Walsh River beds of the Rolling Downs Formation. This interesting specimen forms a portion of the collection of the Queensland Museum, Brisbane, and was kindly communicated by Mr. C. W. de Vis, M.A., the Curator of that Institution. For the Selachian of which these bones formed a portion, the name of *Lamna daviesii* was proposed. The old genera, *Otodus* and *Lamna* have now been united,¶ and in consequence the teeth before mentioned must in future be known as *Lamna appendiculata*. What relation they may bear to the vertebræ of *L. daviesii* remains for the future to prove.

No other remains of Fish have been described from the Rolling Downs formation.

* Quart. Journ. Geol. Soc., 1870, XXVI., p. 238.

† Quart. Journ. Geol. Soc., 1872, XXVIII., p. 346.

‡ Reports on the Geological Features of Parts of the District to be traversed by the proposed Trans-Continental Railway. *Queensland Parl. Papers*, 1885 (pp. 22, fcap., Brisbane, by Authority, 1885), p. 8.

§ R. Etheridge, Jun. Appendix to R. L. Jack's Report, *loc. cit.*

|| Proc. Linn. Soc. N.S.W., 1888, III (2), Pt. I., p. 156.

¶ A. S. Woodward, Cat. Foss. Fishes Brit. Mus., 1889, p. 392.

3. *Belonostomus sweeti*, sp. nov.

The state of preservation of the large fossil does not permit any precise estimate of the original proportions of the fish. Judging, however, by the analogy of the allied Brazilian species, the trunk cannot have been less than 0·9 in length, with a maximum depth of 0·14 in the abdominal region; while the head, with the opercular apparatus, may have added about 0·4, making the total length approximately 1·3. The individual under consideration is thus and by far the largest member of the genus hitherto discovered.

(*a.*) *Head and Opercular Apparatus.*—As shown by the fragment M. 31, the cranium is well ossified in the occipital, otic, and prefrontal regions. The exoccipital extends considerably into the lateral wall of the brain-case, and is bounded in front by a large pro-otic element, separated only by suture, extending downwards to the base of the cranium, and exhibiting near its hinder border a large oval foramen, evidently for the exit of the glosso-pharyngeal nerve. The membrane bones of the cranial roof are thick; and there is a robust parasphenoid bone, expanding in front of the orbit. The jaws are not preserved, and the only element of the suspensorium exhibited is the hyomandibular, which lies beneath the opercular apparatus of the left side in the large fossil. As usual in *Belonostomus*, this bone is lamelliform, with a much expanded, squamous, inferior moiety, and a narrow, more robust, superior portion, from which at the hinder border would arise a short, stout process for the articulation of the operculum. Externally, remains of large suborbital membrane bones (Fig. 1, *so.*) are conspicuous between the orbit (*orb.*), and the preoperculum (*p.op.*); these being ornamented with coarse tuberculations rarely fused into irregular rugæ. The preoperculum (*p.op.*) is a deep triangular bone, tapering, though notably robust, above, and terminating in a truncated expansion below. Its upper extremity reaches a point not far below that of the operculum, and the length of its inferior border exceeds half the height of the bone. The operculum (*op.*) is approximately quadrate in form, with a somewhat truncated and rounded postero-superior angle. Its maximum depth and breadth are nearly equal; the upper border is somewhat turned inwards, and the articular pit (*a*) for the reception of the process from the hyomandibular is especially prominent near the antero-superior angle. The sub-operculum (*s.op.*) is comparatively small, deepest and truncated in front, gradually tapering to a posterior apex at the postero-inferior angle of the operculum. All these bones are superficially ornamented with prominent tuberculations of ganoine, which are partly fused into irregular radiating series, but still more conspicuously arranged in concentric lines.

(*b.*) *Branchial Apparatus.*—As shown by the small fossil M. 26 A, the gill-arches are slender, and shaped like those of modern Teleosteans, being a series of narrow, elongated laminæ, ⊃-shaped in transverse section. To each arch is affixed a close series of long, slender, compressed appendages, only superficially calcified, and apparently to be interpreted as supports of the gill-filaments.

(*c.*) *Axial Skeleton of the Trunk.*—The vertebral centre (Figs. 2 and 3) are well ossified throughout, and the slender neural and hæmal arches, with their spines seem to be fused to them. They are deeper than long, and so far as can be determined from impressions of the terminal concavities (Fig. 3), the notochord was completely constricted, no central perforation of the bone being distinguishable. A secondary development of longitudinally-fibrous bone completely surrounds the primitive double-cone of each centrum externally, and imparts to the vertebra the robust appearance well shown in Fig. 2.

(*d.*) *Appendicular Skeleton.*—Of the fins, only fragmentary remains of the pectoral and caudal are preserved in the large fossil (Fig. 1). The rays are all robust, laterally compressed, undivided for some distance proximally, but soon branching and marked by numerous articulations. Of the supporting elements, nothing can be discerned, and even of the membrane bones accompanying the pectoral arch there remains little evidence. It is clear from the small fossil, M. 28, that there was a pair of large supra-temporal bones externally ornamented with tubercles fused into radiating and somewhat reticulating rugæ. The same specimen also exhibits a small, triangular, supraclavicle, adjoining the truncated postero-superior angle of the operculum, and ornamented with tubercles of irregular size, partly fused into concentric lines. Of the clavicle and pectoral arch itself, however, there are no fragments sufficiently worthy of note.

(*e.*) *Squamation.*—As usual in *Belonostomus* one series of flank scales is excessively deepened, these being abruptly truncated below, but slightly rounded and reflexed forwards at the upper extremity. A restoration of one example from the anterior abdominal region is given, of the natural size, in Fig. 4. This scale is about five times as deep as broad, crossed at its flexure by the lateral line; and the overlapped portion is relatively narrow. Immediately posterior to the hinder margin of the overlapping scale is an area of nearly smooth ganoine, bounded by a nodose longitudinal ridge. A parallel and more prominent longitudinal ridge, separated from this, and from the hinder area by a furrow, divides the scale into two nearly equal halves, and the posterior half is much ornamented. This ornament consists first of large irregular tubercles, passing behind into small, nearly parallel, though sometimes bifurcating transvere ridges, at right angles to the posterior border. The scale immediately below the principal flank series is much deeper than broad, and then follow about four small ventral scales, equally broad, but their depth not exceeding half their breadth. One of the latter is shown, somewhat restored, in Fig. 5; its overlapped superior border, with the large articular spine, is conspicuous, and there are some superficial rugæ in the lower half of the scale parallel with its inferior border. The squamation above the principal flank series is partly shown in the hinder half of the trunk, and some of the scales are well preserved (Fig. 6). There are at least two series between the upper extremity of the principal scale and the dorsal azygous series, both comprising imbricated rhomboidal scales, well ornamented with rugæ of ganoine, and each with a prominent oblique ridge in the middle of its exposed portion, almost diagonal; the rugæ are partly concentric with the hinder and inferior borders, partly at right angles to the former. Towards the extremity of the tail the flank scales gradually become less deep in proportion to their breadth, and at the origin of the caudal fin, all the scales of each ventral row are of nearly equal size (Fig. 7), rhomboidal, and closely resembling the ordinary dorso-lateral scales, except that the diagonal has become more prominent, and few of the rugæ are concentric with the borders.

4.—Specific Determination.

In the absence of definite information as to the proportions of the species now described, it is necessary to refer exclusively to the scales for diagnostic characters. It seems, however, almost certain that we are concerned with a much less slender fish than the typical Jurassic species, *Belonostomus tenuirostris*, *B. sphyrænoides*,* &c.; while neither of these, so far as we can discover, exhibit so conspicuous and elaborate a superficial ornamentation. It thus suffices to refer only to the known Cretaceous species, which may be enumerated as follows:—

Belonostomus attenuatus, Dixon, Geol. and Foss., Sussex, 1850, p. 368, Pl. XXXV., f. 4 [Portion of mandible], Chalk, Sussex.

Belonostomus cinctus, L. Agassiz, Poiss. Foss., 1844, Vol. II., Pt. II., p. 142, Pl. LXVI*a*, Figs. 10—13; F. Dixon, *op. cit.*, p. 367, Pl. XXXV., Fig. 3; A. S. Woodward, Quart. Journ. Geol. Soc., Vol. XLIV., p. 145, Pl. VII., Figs. 7—13, and Proc. Geol. Assoc., Vol. X., p. 305.—Chalk; S.E. England. [Mandible and scales.]

Belonostomus comptoni, Agassiz, A. S. Woodward, Proc. Zool. Soc., Nov. 18th, 1890. *Aspidorhynchus comptoni*, L. Agassiz, Edin. New Phil. Journ., 1841, Vol. XXX., p. 83, and Comptes Rendus, 1844, Vol. XVIII., p. 1009.—Upper Cretaceous; Serra de Araripe, North Brazil. [Imperfect fishes.]

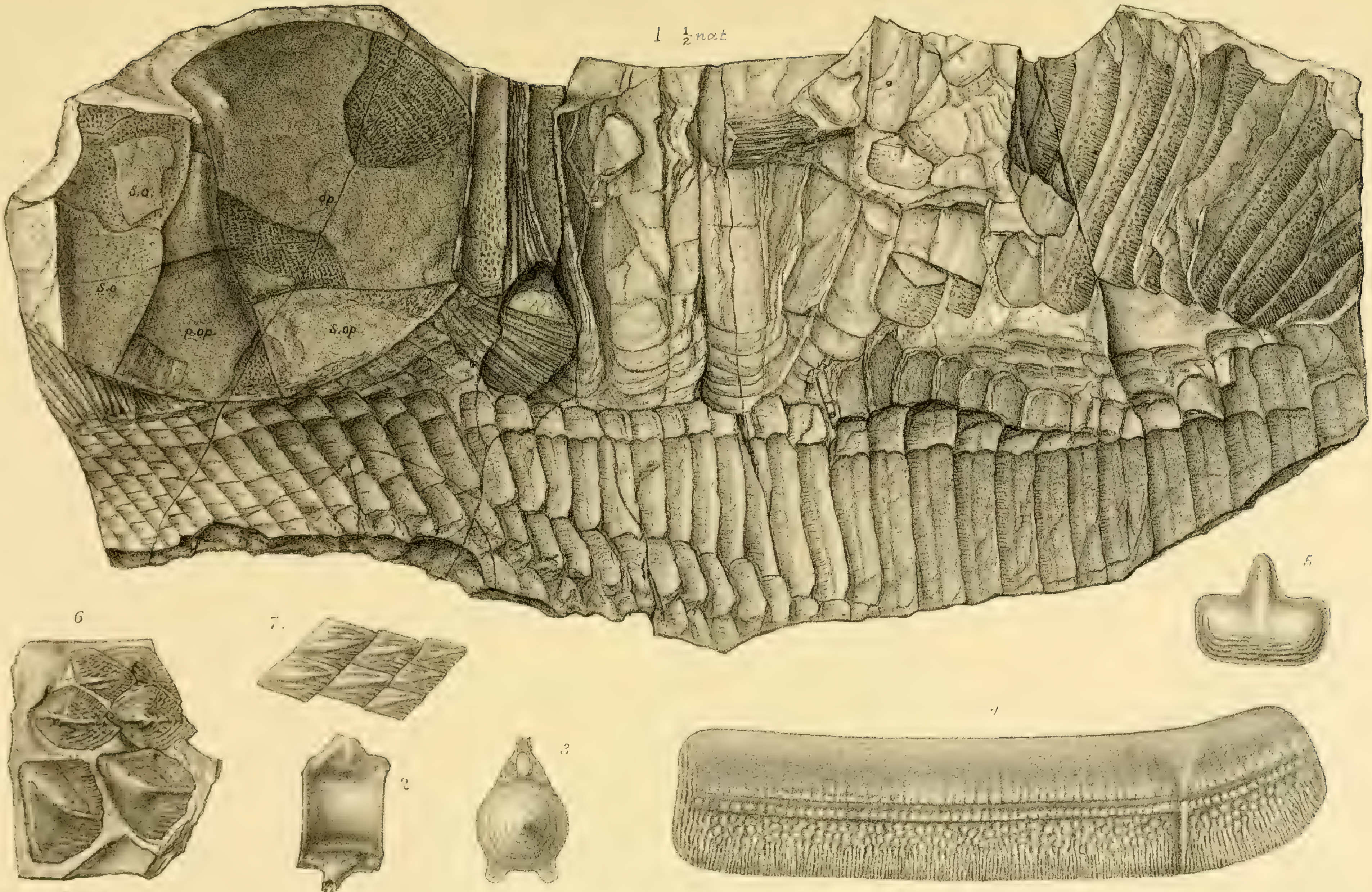
* L. Agassiz, Poiss. Foss., II., Part 2, p. 140; A. Wagner, Abth. Math. Phys. Cl. K. Akad. Wien, 1863, IX., p. 689.

Belonostomus crassirostris, O. G. Costa, Pal. Regno Napoli, Pt. II., p. 33, Pl. II., Figs. 1, 2. *Belonostomus gracilis*, O. G. Costa, *ibid.*, p. 35, Pl. II., Fig. 3.—Upper Cretaceous; Pietraroja, near Naples. [Imperfect fish.]

Belonostomus (?) indicus, A. S. Woodward, Rec. Geol. Surv. India, 1890, Vol. XXIII., p. 23. Upper Cretaceous (Lameta beds); Dongargdon, Nagpur, India. [Imperfect skull and mandible.]

Belonostomus lesinæensis, F. Bassani, Denkschr. math.-naturw. Cl. k. Akad. Wiss. Wien, 1882, Vol. XLV., p. 198, Pl. I., Fig. 10. Upper Cretaceous; Isle of Lesina, Dalmatia. [Imperfect fish.]

Of these species *B. attenuatus*, and *B. ? indicus*, are not strictly comparable, being known only by parts of the head; but the absence of ornamentation on these fossils renders most improbable any intimate relationship with the Queensland fish. The feeble character of the ornament of *B. cinctus*, which is known by scales, as well as jaws, also excludes this species from comparison. *B. crassirostris*, and *B. sleinæensis* are small slender fishes, apparently as much elongated as any of the Jurassic species. Indeed, the only form which seems to approximate at all closely to the species now under consideration is the large *B. comptoni* from Brazil. The few proportions that can be compared are very similar, and the superficial ornamentation in adult fishes is equally conspicuous. The principal flank scales of *B. comptoni*, however, never appear to exhibit the prominent, fine, transverse striations, so characteristic of the hinder margin of all the flank scales of *B. sweeti*, and we thus venture to regard the latter as specifically distinguished by its superficial ornament.



[illegible] del. et lith.

Hanhart imp

[illegible] STOMUS SWEETI

PLATE 1.

Description of Figures.

Fig. 1.—Portion of fish, with remains of opercular apparatus.

op. operculum.

p.op. pre-operculum.

s.op. sub-operculum.

orb. orbit, half nat. size.

Fig. 2.—Portion of a vertebra, side view, with parts of the neural and hæmal arches.

Fig. 3.—The same, end view.

Fig. 4.—Restoration of a scale from the anterior abdominal region.

Fig. 5.—A ventral scale, somewhat restored.

Fig. 6.—Scales from above the hinder principal flank series.

Fig. 7.—Scales of one of the ventral rows at the origin of the caudal fin.

ARTICLE II.—ON THE STRUCTURE OF CERATELLA FUSCA (GRAY), BY W. BALDWIN SPENCER, M.A., PROFESSOR OF BIOLOGY IN THE UNIVERSITY OF MELBOURNE. (With Plates 2, 3, and 3a.)

(Read Thursday, June 11th, 1891.)

I have to thank Dr. Ramsay and the Trustees of the Australian Museum, Sydney, for the opportunity of examining the structure of this interesting hydroid form. The specimens examined came from Bondi on the New South Wales coast and from Lord Howe Island, where they were collected by Mr. Whitelegge of the Australian Museum, whom I have to thank for kind assistance. The Lord Howe Island specimen had the zooids beautifully expanded.

Dr. Gray* was the first to describe and figure Ceratella and the closely allied genus Dehitella from specimens in the British Museum. He had dried specimens only at his disposal and his description necessarily refers only to the hard parts and these having the form of a horny network somewhat resembling in general appearance the skeleton of a horny sponge, led him to place the two forms provisionally amongst the sponges. For their reception he constituted the family *Ceratelladæ*. Five years later Mr. H. J. Carter† published a paper entitled "Transformation of an Entire Shell into Chitinous Structure by the Polype Hydractinia, with short Descriptions of the Polypodoms of five other Species." In this he refers to *Ceratella fusca* and *Dehitella atrorubens* and describes two new forms belonging to the former genus under the names of *C. procumbens* and *C. spinosa*. Both of these came from South Africa the former from the Cape of Good Hope and Natal the latter from Natal. In the same paper he describes a new genus Chitina with a single species *C. ericopsis* which came from New Zealand. Reference to these will again be made after the anatomy of *Ceratella fusca* has been described, meanwhile it is sufficient to note that Mr. Carter's investigations of a species of Hydractinia (*H. levispina*) with a skeleton composed of a horny network which incrusts and eats its way into univalve shells led him to re-examine the two forms placed by Dr. Gray in the family Ceratelladæ and in consequence of his finding undoubted traces of thread-cells in the dried specimens both of these and of the two new species of Ceratella mentioned above, he rightly recognised them as belonging to the

* Proc. Zool. Soc., Nov., 1868.

† An. and Mag. Nat. Hist., Jan., 1873.

Hydroidea and not to the sponges in which group Dr. Gray had provisionally placed them. At the same time it may perhaps be well to note that the finding of thread-cells in dried specimens with a skeleton in the form of a horny network is not in itself absolute proof of their belonging to the Hydroidea inasmuch as at the present time sponges are known to exist the substance of which is pierced by hydroid growths so that it would be possible to find thread-cells in the dried skeletons of sponges. At the same time Mr. Carter was perfectly right, as events have proved, in removing the Ceratelladæ from the Porifera though the subsequent discovery by Mr. Bale of the nature of their soft parts has shown that they cannot be placed, where Mr. Carter put them, in the family Hydractiniidæ.

The next notice of these forms occurs in the Proceedings of the Linnean Society of New South Wales for 1886 (p. 575) when Mr. Brazier recorded the occurrence of *Ceratella fusca* from various localities near Sydney such as Bondi Bay and Coogee. In the Proceedings of the same Society for the year 1888 (p. 745) Mr. Bale for the first time gave some description of the soft parts and showed that the zooids were formed on a very different type from those of the Hydractiniidæ. The latter have a single circlet of filiform tentacles surrounding the hypostome whilst those of Ceratella are irregularly distributed over the body and are capitate. Mr. Bale accordingly removed Ceratella from its position amongst the Hydractiniidæ assigned to it by Mr. Carter and placed it in a distinct family to which he gave the name Ceratellidæ. He apparently overlooked the fact that Dr. Gray had already adopted the name of Ceratelladæ for the family including his two genera Ceratella and Dehitella, so that this name given in 1868 must now be retained. With a more abundant supply of material I have been enabled to work out the structure in greater detail than was possible to Mr. Bale to whom we owe the first description of the soft parts and the determination of the fact that Ceratella belongs to a family distinct from the Hydractiniidæ.

Description of the Structure of Ceratella fusca.

I have endeavoured so far as possible to give a complete account of the anatomy of both soft and hard parts the only figures yet published being those of the external form given by Dr. Gray* both of which suffice to clearly identify the genera.

Skeleton.

The colonies of Ceratella procured on the New South Wales coast measure from 1½—5 inches in height and are of a rich brown colour. The largest specimen which I have seen is the one procured by Mr. Gabriel which came from Flinders Island in Bass Straits where it had been washed ashore. The figure given by Dr. Gray

* *Loc. cit.*

represents fairly well the macroscopic characters of the skeleton but conveys the idea of one which has been much water-worn and has lost many of its smaller branches. The branching is much richer and closer than is represented by him and the projecting hydrophores are more distinct and regular. At the same time there is a certain amount of difference in the growth of various colonies some of which are more bushy in appearance than others. That secured by Mr. Gabriel has the branches more distinctly arranged in one place than is the case with the others. The whole colony may be described as follows:—The colony arises from a much-branching root-like base encrusting foreign objects. The root-branches unite to form a strong stem common to the colony which is flattened in the same plane as that in which the branches of the colony, generally, expand. The common stem may have the appearance of being formed of intertwined branches and from it arise irregularly larger or smaller branches the former being more or less flattened in the same plane with itself.

From the larger arise irregularly on either side smaller branches which again branch until a somewhat bush-like or fan-shaped colony is formed the whole being more or less flattened in the plane of the main stem. Except the main stem close to the root branches and the latter all the branches may bear bracket-like projections—the hydrophores—which are arranged in a roughly spiral manner and are especially abundant on the smaller branches except the growing ends which are somewhat swollen and flattened in a plane at right angles to that in which the branching of the colony takes place.

In addition to considerable variations in the general form of the colony some appear to have the hydrophores so arranged that they lie along the two opposite sides only of the branches whilst in others they are arranged all around. The more bush-like the growth is, to the greater extent does the latter obtain and *vice versa.* Usually there is only one main stem arising from the root-branches but at times one or more smaller ones may arise independently. (Fig. 1.)

The skeleton when examined by the lens has much the same appearance as that of Hydractinia and differs considerably from that of Clathrozoon and more still from that of the polysiphonic stem characteristic of certain species of Plumularia. It forms in the larger branches a meshwork of chitinous tissues so similar at first sight to that of certain horny sponges that as Mr. Bale says "a portion broken off and examined separately might well be mistaken for sponge tissues." This however is only true with certain limitations for, if the soft parts are present, the distinction between the two is readily seen as is also the case when the hydrophores are present. Apart from this also nothing comparable to the layer of cells secreting the sponge skeleton is present nor are the chitin fibres of the two similar in their minute structure.

The meshwork is extremely irregular in the larger branches as is shown in the sections represented in figs. 9 and 11. There seem to be two not clearly distinguishable portions present (1) large and strong fibres (2) smaller ones which form connecting bars and often have the appearance of thin web-like plates which are especially well developed on the hydrophores. Fig. 5 represents a medium-sized branch, from which the soft parts have been removed by potash, seen by reflected light. At times the fibres seem to run for some distance parallel to the long axis of the branch though this is much more strongly marked in some branches than in the one figured. There are no definite hydrothecæ present within which the zooids can be completely retracted but the branches are studded sometimes only at the sides sometimes all over with little bracket-like projections which give a characteristic serrate appearance to the branches, very different however from that which is produced by the hydrothecæ of the Sertularians. Mr. Bale has aptly suggested that the term "*hydrophores*" (originally applied by Allman to the calyces of Halecium) should be used to describe these structures which form merely supports for the hydroid zooids. Each one may perhaps be best likened to a very concave scallop shell with ribs formed by the strong fibres continuous with those of the branch whilst the spaces between them are filled up by a thin fenestrated web of chitin. In some hydrophores the ribs are more strongly marked than in others and project as small points around the margin. (Figs. 5 and 6.) The growing ends of the smaller branches usually contain two or three longitudinal fibres connected by transverse bars, often somewhat web-like, and each of these growing ends is clearly distinguishable (1) by its being flattened in a plane at right angles to that in which general growth takes place and (2) by the entire absence of hydrophores and zooids. It may be added that the longitudinal arrangement of the fibres in the branches is more clearly noticeable in specimens with the soft parts present than in those in which the latter are absent since the soft parts conceal from view largely the connecting and the deeper-lying fibres and thus prevent to a large extent the network structure from being seen. The whole skeleton also in living specimens is completely enclosed by the soft parts though only a thin layer of tissue is present over the external surface. (Figs. 9, 10 and 11 E.) There is no protective covering for the reproductive structures.

Soft Parts.

The structure of these has, as yet, been only briefly described once and that by Mr. Bale, whose short account refers only to the external form of the hydroid zooids. He pointed out, as stated before, that these possessed irregularly scattered capitate tentacles and that hence they differed considerably from those of Hydractinia.

Amongst the specimens from the Australian Museum is one collected by Mr. Whitelegge on Lord Howe Island with the zooids fully expanded and others with the soft parts well preserved.

(1). *Hydroid zooids* (Figs. 2, 4, 6, 7, 9, 13).—These may be found on all the branches, large and small except at the growing ends. Often also they are absent on the larger main branches and are always fewer in number on these than on the smaller ones (Fig. 4). Each zooid, in a well preserved spirit specimen, reaches a length of about 1·4 m.m. and in the general form of the body resembles, as Mr. Bale says, those of Coryne. The body (Figs. 4 and 6) is somewhat elongate with a terminal almost conical portion, at the apex of which lies the mouth opening. The basal portion which is seated upon the hydrophore is broad, this is followed by a slightly contracted portion, then comes a slightly swollen part which gradually diminishes in size towards the mouth end. Over the surface are scattered irregularly the capitate tentacles from 10-14 or perhaps even more in number (Figs. 4 and 6), and one or two of these are frequently placed close to or upon the basal region.

The minute structure is generally that which is typical of hydroid forms and is represented in Figs. 2 and 7. The ectoderm (*Ect.*) is unilaminar over the general surface the cells being in close apposition each with a large nucleus and except in the capitate ends of the tentacles there are no thread cells present. At the ends of the tentacles the ectoderm is swollen out and apparently forms a mass of cells in which large nematocysts are present with barbed threads (Fig. 7). The nematocysts here and elsewhere seem to be all of the one size. The ectoderm lies on a thin layer of mesogloea scarcely visible in extended zooids but more prominent in retracted ones. There cannot be detected any fibrous muscular elements such as form so distinct a feature around the basal region of the zooids in, for example, Clathrozoon. The endoderm consists of large vacuolate cells each one subtending the base of, as a general rule, at least three ectoderm cells. The protoplasm appears to be always concentrated at the inner ends where the nuclei are placed and where in preserved specimens the cell outlines are completely lost. In zooids which are feeding (Fig. 7) this inner end of the cell is filled with minute food particles the digestion being evidently, in part at least, intracellular.

The ectoderm is continuous at the base with the layer which covers externally the whole colony whilst the endoderm is continuous with that of two or more of the cœnosarc tubes.

(2.) *Gonophores.*—I have only been able so far to find the male gonophores which are present on three colonies secured at Coogee on the New South Wales coast. Each of these colonies carries numbers of minute somewhat pear-shaped structures which are only from one-third to one-quarter of the length of the hydroid zooids and which are seen when rendered transparent or cut into sections to be medusoid in nature.

These gonophores arise directly from the cœnosarc and are not carried by modified zooids or blastostyles.

They may be very numerous indeed especially on the medium-sized branches where their number in one specimen far exceeds that of the hydroid zooids. Two are represented as seen by reflected light in figure 6 and in all specimens examined the gonophores are at the same stage of development. I have been unable to detect any indication of the formation of reproductive elements in the hydrophyton.

The gonophores much resemble in structure those figured by Weismann* in *Pennaria cavolina* or *Cladocoryne floccosa.* In essential structure the transverse section of the gonophore of the former is identical with that of a similar section of a Ceratella gonophore as shown in figure 8. The longitudinal section again of the gonophore of Cladocoryne or of Pennaria as figured by Weismann agrees almost precisely with that of Ceratella represented in figure 12. In the latter the manubrium is well developed and surrounding this lie the reproductive elements which in longitudinal section (Fig. 12) form a horseshoe-shaped mass and in transverse section a ring. External to the latter is a thin layer of ectoderm (ect.') which comes in contact with the external layer of ectoderm (*ect.*) at the part corresponding to the mouth of the medusa bell where the former layer dips inwards. (Fig. 12, *M.*) This layer must correspond to the sub-umbrella ectoderm of the medusa and the special point mentioned indicates also the position at which, in development, the " glockenkern " of Weismann grew in by proliferation of the ectoderm cells. I have been unable to find any gonophore younger than the stage figured though many have been cut in section, the manubrium being in every case well developed.

Between the two layers of ectoderm lies the endoderm with four radial canals seen clearly in transverse sections (Fig. 8) whilst in longitudinal sections (Fig. 12) the indication of a ring-shaped space around the distal end can always be detected.

Each gonophore may be connected with more than one of the cœnosarc tubes and its ectoderm is continuous with that which covers the colony externally.

(3.) *The Hydrophyton.*—This may be divided into two parts (1) the external layer common to the whole colony and (2) the branching network of tubes.

The external layer is formed entirely of ectoderm cells (Figs. 3 and 12) and is only one cell thick though it may come into contact with the ectoderm of the tubes lying immediately beneath it. It is especially well marked in the younger branches and may be worn away to a greater or less extent in older ones though typically it forms a covering for the whole of the colony (Figs. 9 and 13). It is directly

* Die Entstehung der sexualzellen bei den Hydromedusen. Pl. XVII., Figs. 1-5 and Fig. 7; Pl. XVIII., Fig. 1.

continuous with the ectoderm of both the hydroid zooids and the gonophores, and has in many respects a close resemblance to the superficial layer of ectoderm as described and figured by Professor Moseley in Millepora.* In the latter the exact relationship of the superficial ectoderm to the zooids could not be ascertained but in Ceratella where the latter are not retracted into spaces within the skeleton its direct connection with the ectoderm of the zooid can easily be seen in sections. Figure 3 represents a small portion of the layer as seen under a high power. The outlines of cells cannot be definitely distinguished in the specimen in question though a somewhat light space with a fairly distinct outline surrounds the thread cells. The inner ends of the cells are in contact with the ectoderm of the tube beneath and the layer thins out just where it passes over the projecting point of a portion of the skeleton. In younger branches (Fig. 14) the cells of the layer are much more definite in form and outline being each cubical with a distinct nucleus whilst comparatively very few thread-cells are present.

This superficial layer is only known to exist in the Hydrocorallinæ, the Hydractiniidæ and, now, in the Ceratelladæ. In the last mentioned the soft parts of only *Ceratella fusca* are known as yet but the skeleton of Dehitella is so closely similar to that of the former that we may with much probability infer that a close agreement exists in the nature of their soft parts. The cœnosarc tubes form a richly branching network of tubes occupying all the spaces in the chitinous meshwork which forms the skeleton. In Figures 9 and 10 this is represented diagrammatically by the grey colour the former being a longitudinal and the latter a transverse section of a branch. Throughout the whole system the endoderm is never more than one cell thick whilst the ectoderm is very irregular. Very often the endoderm cannot be recognised or else it forms an indistinct layer which stains more darkly than the ectoderm and contains no space, a result probably due to the action of reagents. At other times (Figs. 3, 11, 12, and 14) a distinct tubular space can be distinguished. The number of tubes varies naturally according to the size of the branch. Figure 13 represents a longitudinal section through a portion of a small branch with a smaller offshoot which formed part of a specimen brought by Mr. Whitelegge from Lord Howe Island. The general appearance of a part of the same specimen viewed as a solid object is represented in Figure 4. This particular specimen has the branches much finer than those of the others and the skeleton and cœnosarc tubes somewhat more regular in arrangement, whilst the hydrophores are not very strongly developed. Up the small offshoot pass the main skeletal ribs united by cross bars which are thin and almost web-like and up the centre runs a single cœnosarc tube (*B*) which is connected with at least three of those in the larger branch. This tube consists of an internal layer of endoderm (Fig. 13 a, *end.*) and

* On the Structure of a Species of Millepora occurring at Tahiti, Society Islands. Phil. Trans. R.S. London, 1876, Vol. CLXVII., p. 117.

an irregular external layer of ectoderm (*ect.*) the former being continuous with that of the zooids. The whole is covered by a unilaminar ectoderm (E). A few thread cells are present. Up the layer branch the tubes run more regularly than usual and three or four may be traced for a considerable distance running parallel to its length but giving off lateral branches. In sections both transverse and longitudinal of Ceratella these connecting bars or webs crossed by cœnosarc tubes form a very characteristic feature (Figs. 11 and 13. C).

As stated above there is a strongly-marked difference between the endoderm and ectoderm. The former (Fig. 3) is regular and takes stain somewhat more readily than the latter, which is often very irregular and several cells thick, though most often the outlines of cells cannot be recognised, and a structure resembling a syncytium is formed. In the latter are found (1) nuclei, (2) thread cells, (3) bodies surrounded by a clear space and staining evenly and deeply (Fig. 3A). The thread cells are apparently confined to the ectoderm, though of this I cannot feel absolutely sure, and are found in great abundance in the inner parts of the branch whence they must migrate to the surface if they are to be of service to the colony. It is a somewhat curious fact that they are as a rule present in far greater numbers in the ectoderm of the cœnosarc tubes than in the most external layer. Figure 3 represents a small portion of the latter on a part of a colony where the gonophores were numerous and here thread cells were present in greater numbers than elsewhere. Of the nature of the third-named structures it is difficult to be certain but it is probable that they are ectoderm cells in which thread cells are being formed. There is at all events a curious agreement in appearance between them and the structures which Professor Moseley has described as developing thread cells in Millepora.* He says "the thread cell appears to be developed out of the nucleus of the ectodermal cell, the ectodermal cell becoming much enlarged and forming a wide chamber, in which the process of development takes place. The ovoid nucleus becomes enlarged together with the cell, but not at all in the same proportion the cell always appearing as a wide cavity around it. The nucleus as it enlarges has a rounded nucleolus developed at one end of it." The nucleolus has large granules developed within it, whilst the nucleus becomes finely granular. In the next stage one large coil of the thread appears in the nucleus."

The earlier stage seen in Millepora when the nucleus with nucleolus at one end of it lies in the cell which forms a clear cavity around it, corresponds exactly to that represented in figure 3A.c. in the case of Ceratella. Though a complete series of stages could not be obtained still those drawn in figure 3A. will serve to show that in all probability Ceratella resembles Millepora closely in the formation of thread cells. In figure 3A.*a.* the cell is small and the nucleus but little larger than that of an

* *Loc. cit.*, p. 129.

ordinary ectoderm cell though stained very deeply and having a homogeneous appearance; in *b.* the cell has increased in size, the nucleus is much larger, and has a clear space all around it between it and the cell wall; this is clearly marked in *c.* and *d.* where, in the former, a nucleolus is present and in the latter two darker thread-like lines possibly indications of the commencing formation of the thread; in *e.* what is evidently a very young thread cell is seen—it is somewhat darkly stained without a definite thick wall such as is seen clearly in later stages, and down the centre is a lighter line corresponding to the thicker attached part of the thread. It has also the shape of the thread cell but there is no trace of the clear space present in earlier stages, a certain amount of stained protoplasm being attached to it. In *f.* and *g.* two later stages are shown in which the thick cell wall is present and the coiled thread can be clearly seen. These thread cells evidently resemble closely in structure the three-barbed ones described by Professor Moseley in Millepora.

The only other point to notice in regard to the cœnosarc is the structure of the finer growing branches which are somewhat flattened out. A longitudinal section of one of these is represented in figure 14. Up the centre runs a cœnosarc tube with a large cavity and clearly-marked endoderm the ectoderm being as usual irregular. From this central tube short branches are given off (*D*) which run outwards towards the external layer with which, as at the point x, they may come into direct contact. At this point the cells of the two layers are well marked, and in all probability this shows us the earliest stage in the formation of a zooid. It has already been noted that the ectoderm of the latter is in direct connection not with that of the cœnosarc tubes but with the common external layer and this method of formation would explain this otherwise somewhat curious fact. The endodermal process grows out into a bud—the early stage of a zooid—carrying with it the external ectoderm layer which thus, as further growth takes place, naturally gives rise to that of the zooid itself. At the same time the cœnosarc tube branches as the stem increases in size and thus the zooid, if the branching be near the base of the latter, will become connected with two or more tubes.

Affinities of the Ceratelladæ.

When Dr. Gray first described these forms there were only two specimens available neither of which possessed the soft parts. The hard parts whilst agreeing in important points differed from each other sufficiently to be regarded by him as species of two distinct genera Ceratella and Dehitella.

Mr. Carter, with more material at his disposal, recognised the fact that they were hydroids and owing to similarities in their skeleton and that of Hydractinia placed them in the family Hydractiniidæ, thus abandoning Dr. Gray's family Ceratelladæ which had been created under the assumption that the two forms were allied to the sponges.

Undoubtedly in many respects Ceratella and Dehitella call to mind the Hydractiniidæ, but it is doubtful if even our knowledge were confined to that of the structure of the hard parts whether Mr. Carter's classification could be upheld. The one point of resemblance—and at first sight it is the most striking feature—is that the skeleton of both consists of a very irregular branching chitinous network. In the Hydractiniidæ however this has the form of an encrusting network with at most very feebly developed branches arising from it; these may more correctly be described as spines and they do not appear to carry any zooids. In the Ceratelladæ the whole colony consists of a much-branching structure arising from a comparatively small encrusting root-portion which may itself be made up of branches more or less entwined. In addition to this all the branches bear hydrophores or special developments of the network to support the hydroid zooids. These are never present in the Hydractiniidæ but always in the Ceratelladæ. Now that the soft parts are known there can be no doubt about separating the two families. The hydroid zooids are quite different those of Ceratella being provided as are those of Coryne with scattered capitate tentacles whilst there is no trace of protective zooids such as are present in Hydractinia and Podocoryne. In addition to this the gonophores arise directly from the cœnosarc and not from modified zooids. The most important points of agreement lie in (1) the existence in Hydractinia and Ceratella of a common external layer of cœnosarc which covers over the whole skeleton mass whether this be encrusting or branching in nature; (2) the presence in both of a network of cœnosarc tubes forming the hydrophyton. It may however be noted that in both these points we find a similar agreement to exist between Ceratella and, for example, Millepora amongst the Hydrocorallinæ as between the first named and Hydractinia.

The presence of this external layer which, in the Hydrocorallinæ and Ceratella at all events, consists simply of a layer of ectosarc is very difficult to explain. Professor Moseley* has represented it in Millepora as if it formed the outer layer of the surface cœnosarc tubes though even in this case it passes over all the parts (occupied by the calcareous skeleton) which on the surface lie between the tubes, and is very different in appearance and in the relative size of its cells from the ectoderm which elsewhere forms the outer wall of the tubes. In Ceratella it is perfectly independent of the tubes all of which have their own ectoderm covering though at the surface this comes in direct contact with the outer layer. I am not aware of any determination in Hydractinia of the exact relationship of this outer layer though very probably it will be found to agree with that of Ceratella.

It is not apparently connected in any special way with the formation of the chitinous network as this lies deep within the structure of the branch, and the only

* *Loc. cit.*, Pl. 3., Figs. 10 and 16.

purpose which it can apparently serve is that of a covering layer which prevents foreign objects from passing in between the meshes of the network and interfering with the general welfare of the colony. It is strange however to note, if this be its function, that most usually the internal cœnosarc contain a far greater number of thread cells than this external layer does in Ceratella.

In Millepora Professor Moseley was unable to determine its exact relationship to the zooids but in Ceratella by its means all the ectodermal structures lying on the external surface are brought into direct continuation with one another.

It may be noted in passing that though in the genus Clathrozoon* the branches of the colony are formed of a somewhat similar network of soft parts there is nothing present resembling this external layer the whole branch being in this instance covered with a thin protective perisarc.

Taking both the hard and soft parts we find the following points of agreement to exist between the Hydractiniidæ on the one hand and the Ceratelladæ on the other though it must be borne in mind that we only know as yet the structure of the soft parts in one member of the latter family.

(1.) The skeleton has the form of a branching chitinous network.

(2.) The hydrophyton consists of a network of freely branching and anastomosing cœnosarcal tubes.

(3.) The zooids arise directly from this network and no true hydrothecæ or gonothecæ are formed.

(4.) A common external layer is present enclosing the whole colony.

The two differ from one another in the following points :—

(1.) Hydractiniidæ form encrusting masses with at most spinulose branches arising from the surface which do not bear zooids. The Ceratelladæ always form freely branching masses either erect or procumbent: the basal part which serves to attach the colony being alone of an encrusting nature whilst even this has the form of intertwined branches.

(2.) The Ceratelladæ always possess hydrophores or special developments of the skeleton which serve as a support for the basis of the hydroid-zooids and nothing similar to which is found in the Hydractiniidæ.

(3.) The hydroid zooids Ceratelladæ possess scattered capitate tentacles those of the Hydractiniidæ being filiform and arranged in a single circle beneath the mouth.

* Trans. R.S., Victoria, 1890, p. 121. Pl. 18, Fig. 3; Pl. 19, Fig. 12.

(4.) The gonophores of the Ceratelladæ arise directly from the cœnosarc and are not developed on special zooids as in the case of the Hydractiniidæ.

Whilst the points of agreement detailed above serve to show a general resemblance between the members of the two groups those of difference are of sufficient importance to justify their separation into two distinct families.

As stated previously Dr. Gray's name Ceratelladæ will be retained and the following gives the characters of the family (modified from Dr. Gray's and Messrs. Carter and Bale's descriptions) and the list and characters of the genera and species yet known.

Family *Ceratelladæ* (Gray, Proc. Zool. Soc., 1868, p. 575).

Forming branching colonies. Skeleton in the form of a chitinous network with slight bracket-like or tubular projections (hydrophores) serving as a support for the bases of the gastrozooids.

Hydrophyton a network of branching anastomosing tubes the whole enclosed by a common ectoderm layer.

Gastrozooids naked.

Gonophores medusoid: fixed and arising directing from the hydrophyton.

Genus. Dehitella. (Gray.)

Colony dichotomously branched, expanded growing in a large tuft from a broad creeping base. Stem cylindrical, smooth; branches tapering and cylindrical. Hydrophores slightly tubular and on the smaller branches divergent nearly at right angles from the stem.

(1.) *Dehitella atrorubens.* (Gray.)

The description of the species is the same as that of the genus. It is known at present simply from that given by Dr. Gray* who states that the genus "is distinguishable from Ceratella by the greater thickness and cylindrical form of the stem, by the more tufted and irregular manner of growth and by the tufts of spicules (oscules or cells) being more abundant and equally dispersed on all sides of the branches and branchlets." The "oscules or cells" of Dr. Gray must be the structures which, following Mr. Bale, have been described above as "hydrophores."

Locality.—Delagoa Bay, Africa.

* Proc. Zool. Soc. 1868, p. 579. Fig. 1.

Genus. Ceratella. (Gray.)

Colony irregularly branching; more or less expanded in one plane; growing from a creeping base. Main stem flattened, branches rounded and beset with bracket-like hydrophores.

(2.) *Ceratella fusca.* (Gray.)

Colony branching and fan-shaped; expanded in the one plane; erect. Skeleton consisting of a light or dark-brown chitinous network; the main stem broad and flattened; branches numerous with the bracket-shaped hydrophores arranged on them in a roughly spiral manner and formed of ribs continuous with the fibres of the stem and united by thin perforated laminæ the ribs projecting at the outer margin. All the spaces within the chitinous network filled by a much branching hydrophyton and the whole enclosed by an external layer of ectoderm. Gastrozooids seated on the hydrophores, erect, with capitate tentacles irregularly scattered (10-14). Gonophores medusoid, fixed.

Localities.—Coogee, Bondi (N.S.W.), Broughton Island, Flinders Island, Lord Howe Island.

(3.) *Ceratella procumbens.* (Carter*).

Colony procumbent, thickly branched on the same plane; the larger stems chiefly on one (the lower) side, hard, flexible, of an ochre-brown colour, tinged here and there with purple. Trunk short, solid, compact, compressed vertically, soon dividing irregularly or subdichotomously into round branches which are confined to the lower surface, ending in branchlets with sub-clavate ends, that appear on the upper or opposite side, not reuniting or anastomosing. Hydrophores consisting of a little semitubular plate, extending outwards and forwards from the side of the stem on the proximal border of an aperture in the latter; scattered thickly over all the branches, but most prominent on the branchlets; frequently represented by the little hole alone in the stem where the projecting portion has been worn off; scanty on the lower side of the main stems. *Minute structure;* composed of clathrate chitinous fibre throughout, whose meshes are subrectangular; hydrophore formed of the semitubular scoop-like plate mentioned supported on its proximal side by an extension of the clathrate structure of the stem and bordering the little hole also above mentioned, which extends into the centre of the stem; surface of the larger stems bluntly microspined. Size of largest specimens 11 inches long by 5 inches broad, and about 1 inch thick or vertically.

Locality.—Cape of Good Hope, Natal.

* Ann. and Mag. Nat. Hist., 1873. Transformation of an entire shell into chitinous structure by the Polype Hydractinia, with short descriptions of the Polypidoms of five other species (Pl. 1). The descriptions of *C. procumbens*, *C. spinosa* and *Chitina ericopsis* are taken with only slight alterations from this paper.

(4) *Ceratella spinosa.* (Carter.)

Colony procumbent; thickly branched hard flexible of a dark rich red-purple colour. Main branches round, brownish, covered with small, smooth, often subspatulate erect spines. Stem dividing subdichotomously into purple branchlets, which terminate in abruptly pointed extremities. Hydrophores the same as in the foregoing species; most prominent in the round branchlets to which they give, *en profil*, a serrate somewhat sertularian appearance, the teeth of which are inclined forward. *Minute structure:* Main stems composed of clathrate chitinous fibre, of which the meshes are more or less oblong, passing into prominent longitudinal lines on the branchlets where they terminate on the backs of the semitubular plates which respectively form the floors of the hydrophores, to which they thus give support. Size of specimen, which is merely a branch 4½ inches long by 2 broad.

Locality.—Port Natal.

Mr. Carter adds that "the spines on the surface distinguish this from the foregoing species, add to which its longer and more pointed branches, longitudinally ridged clathrate fibre and rich red-purple colour."

Genus. Chitina. (Carter.)

Colony erect, bushy, fragili flexible, fawn coloured. Trunk long, hard, irregularly round, composed of many stems united clathrately and obliquely into a cord-like bundle, which divides and subdivides irregularly into branches which again unite with each other in substance (anastómose) when in contact and finally form a straggling bushy head. Hydrophores long clathrate tubular, terminating the ends of the branchlets, or prolonged from some of the proliferous tubercles which beset the surface of the trunk and larger stems. *Minute structure:* Composed of clathrate chitinous fibre throughout, whose network is subrectangular and massive in the stems, where there is no difference between the centre and circumference, with the exception that the fibre is stouter in the former or oldest part; hydrophores composed of several longitudinal fibres or ridges lattice-worked together transversely into a tubular form, somewhat contracted at the extremity, in the centre of which is an aperture of the meshwork a little larger than the rest. Height of specimens about 14 inches, trunk about 1 inch in diameter; hydrophores averaging 1-3rd of an inch long by 1-60th of an inch in its broadest part and an aperture 1-90th of an inch in diameter.

(5) *Chitina ericopsis.* (Carter.)

The description of the species is the same as that of the genus.

Locality.—New Zealand.

Description of Plates.

PLATE II.

Fig. 1.—*Ceratella fusca*. Life size. The specimen of which this is a drawing was washed up on Flinders Island, Bass Straits. The main stem of the colony springs from a root-like structure made up of intertwined branches. On the left side arises from the roots a very small independent stem.

Fig. 2.—Transverse section through a portion of the wall of an expanded gastrozooid. Externally is the layer of ectoderm consisting of cubical cells. The mesoglœa is an extremely thin layer and the endoderm consists of large vacuolate cells with granular protoplasm aggregated at their inner ends which face into the gastral cavity. The nuclei are conspicuous and placed at the same end. Camera. Zeiss E, oc. 2.

Ect. ectoderm. *End.* endoderm. *M.* mesoglœa.

Fig. 3.—A small portion of the external surface of a branch in the region in which gonophores are numerous to show the external ectoderm containing thread cells and a portion of one of the cœnosarc tubes. In the latter the endoderm forms a definite layer of darkly-stained, small cubical cells. Surrounding this is the ectoderm in contact with the external layer and containing developing thread cells.

E. external layer of ectoderm. *Ect.* ectoderm of cœnosarc tube. *End.* endoderm. *A.* developing thread cells. *Sk.* skeleton. Camera. Zeiss E, oc. 2.

Fig. 3a.—Developing thread cells found in the ectoderm within the branches. a. an ectoderm cell in which the nucleus is slightly larger than usual and appears homogeneous. b. the nucleus has increased in size, stains very darkly, lies at one end and is surrounded by a clear space. c. the nucleus begins to show a darker spot within it. d. two darkly-staining thread-like structures are present. e. the nucleus (?) does not stain so deeply, and is not surrounded by a clear space but has a small amount of protoplasm clinging to it; within it at the somewhat pointed extremity can be seen a light line indicating the larger terminal part of the thread. f. the wall of the thread-cell and the thread itself are clear. 9. The fully developed thread-cell.

PLATE III.

Fig. 4.—Portion of a small branch with the zooids expanded. The skeleton is covered by the soft parts but the dark lines indicate the external parts of the chitinous network which show through the soft structures.

Fig. 5.—Portion of the skeleton of a somewhat larger branch showing the chitinous network of which it is composed and the little bracket-like hydrophores. (*Hy.*) x 12.

Fig. 6.—Highly magnified small portion of a branch seen partly by direct and partly by transmitted light. Two gastrozooids are shown each of which is placed upon a hydrophore. The latter shows prominent ribs which project beyond the margin and are connected by a thin fenestrated web of chitin. Two male gonophores arise from the cœnosarc and they and the gastrozooids are quite naked. The whole branch is covered by a thin external layer of ectoderm. x 20.

G. gastrozooids. *Gon.* gonophore. *E.* external layer of ectoderm. *Hy.* hydrophore. *Hy.'* web connecting the ribs of the latter.

Fig. 7.—Transverse section across the body of a gastrozooid. The tentacles are solid with swollen ectoderm ends filled with thread cells. The zooid has been feeding and the endoderm cells are full of little food particles. *F.*—Remnant of small crustacean on which the zooid is feeding. It lies close against the endoderm on one side and the food particles are passing into the interior of the cells. Outline drawn with Camera, Zeiss E, oc. 2.

Fig. 8.—Transverse section across a gonophore. *Mn.* endoderm of the manubrium. *Sp.* sperm cells in the ectoderm of the latter. *Ect.* ectoderm of the medusa. *R.* radial canals. *Ect'.* ectoderm of the sub-umbrella surface. Outline drawn with Camera, Zeiss E, oc. 2.

PLATE IIIA.

Fig. 9.—Semi-diagrammatic drawing of a longitudinal section through a small branch. The skeleton is coloured brown the soft parts grey. *E.* external layer of ectoderm. *Gon.* gonophore. *G.* gastrozooid. *Hy.* hydrophore. *Sk.* general network of skeleton cut across in various directions. Outline drawn with Camera, Zeiss A*, oc. 2.

Fig. 10.—Semi-diagrammatic drawing of a transverse section across a good-sized branch. Letters as in figure 9. *Ect.* ectoderm of endosarc tubes. *End.* endoderm. Outline drawn with Camera, Zeiss A*, oc. 2.

Fig. 11.—More highly magnified portion of a branch cut in transverse section. The ectoderm of the gastrozooid is directly continuous with the external layer of the branch and the base of the zooid is continuous with two of the cœnosarc tubes. At *C.* is represented the characteristic feature of the latter crossing over five connecting strands of the chitinous network. *C.* points at which the soft parts

cross thin connecting strands of the skeleton. *E*. external layer of ectoderm. *Ect*. general ectoderm. *G*. gastrozooid. *Hy*. hydrophore. *Sk*. general skeleton. Outline drawn with Camera, Zeiss A*, oc. 2.

Fig. 12.—Portion of a longitudinal section of a branch from which arise two gonophores. The latter are cut in longitudinal section. *E*. external layer continuous with the ectoderm of the gonophore. *End*. endoderm of the manubrium. *Ect*. ectoderm. *Ect'*. ectoderm of sub-umbrella layer of the medusa. *G*. gastrozooid. *M*. point at which the ectoderm dips in corresponding to the mouth of the medusa. *R*. radial canals. Outline drawn with Camera, Zeiss C, oc. 2.

Fig. 13.—Longitudinal section of a branch from which another small one arises. In this specimen the skeleton has more than usual a more or less definite arrangement into ribs which run parallel to the length of the branch and are connected by transverse bands. Outline drawn with Camera, Zeiss A*, oc. 2.

Fig. 13A.—A small portion of the small branch in figure 13 more highly magnified to show the single cœnosarc tube passing along the centre. The ectoderm is irregular. Letters as before. Drawn under Zeiss F, oc. 2.

Fig. 14.—Portion of a terminal branch devoid of zooids. Up the centre runs a single tube with an internal unicellular layer of endoderm and an irregular ectoderm. The endoderm gives off hollow processes which at certain parts (x) come into direct contact with the external ectoderm (*E*). Further growth of these will probably give rise to the gastrozooids the external layer of the colony thus forming their ectoderm. Drawn under Zeiss E, oc. 2.

CERATELLA FUSCA

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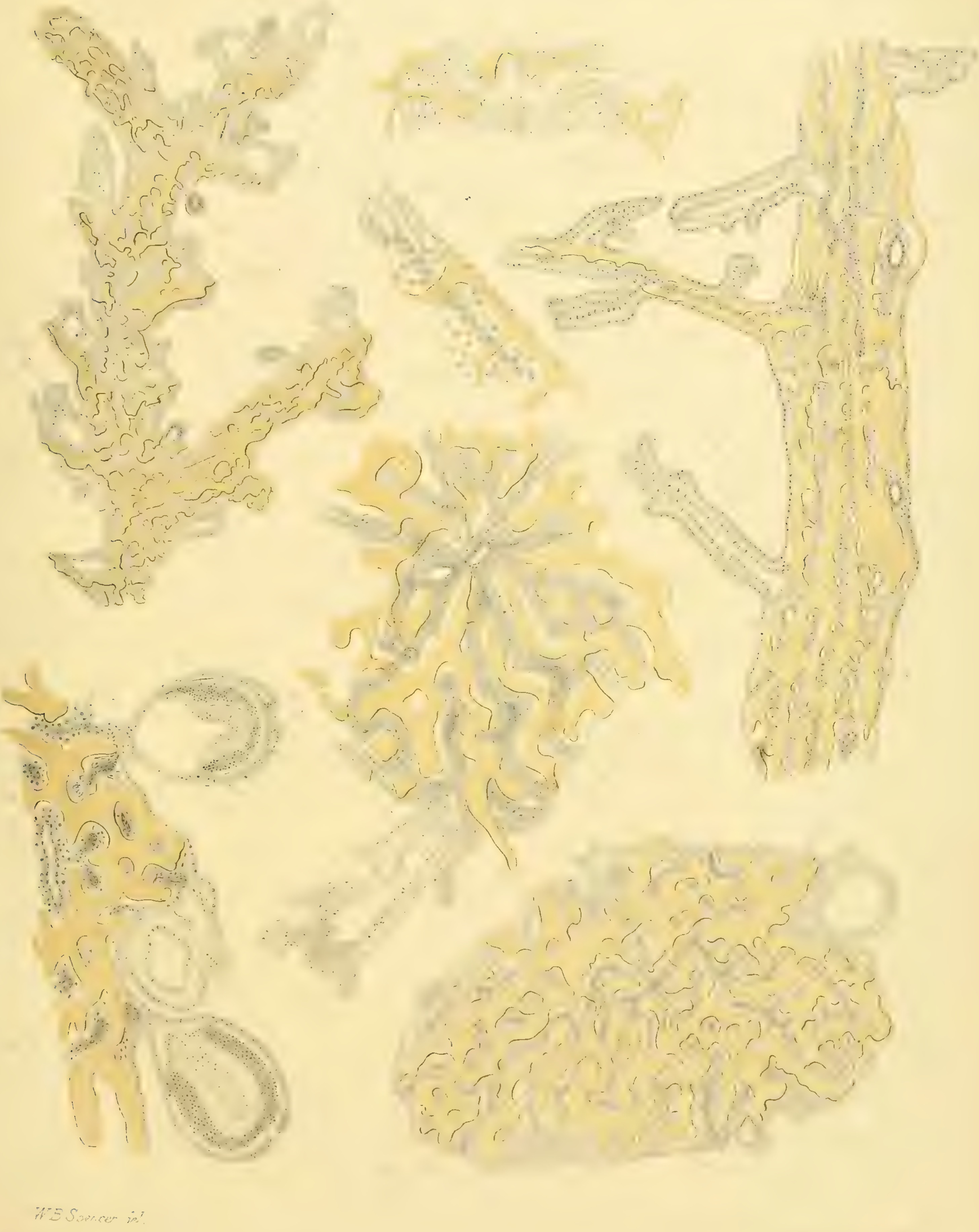


W B Spencer del.

ARTICLE III.—Additional Observations on the Victorian Land Planarians,

by Arthur Dendy, D.Sc. (With Plate IV.)

(Read June 12th, 1891.)

Since my last paper "On the Victorian Land Planarians" was read before this Society I have been able to collect a considerable amount of further information concerning this interesting group of worms, and the present observations are intended to bring our knowledge of the group up to date by describing species or varieties hitherto unknown and especially by giving full details as to the variation in colour and markings and as to the distribution within the colony of those species which have already been described.

In my previous memoir I recorded fifteen Victorian species; this number has now been brought up to twenty-two, the additional seven species being *Geoplana dendyi*, Spencer, *G. frosti*, Spencer, *G. howitti*, Dendy, *G. ventropunctata*, Dendy, all of which are new to science since I last wrote; with *G. sulphurea*, Fletcher and Hamilton, and *G. sanguinea*, Moseley, hitherto recorded only from New South Wales, and *Bipalium kewense*, Moseley, an introduced species recorded by Fletcher* from near Eltham. The genus *Rhynchodemus* has not again been met with.

G. howitti and *G. ventropunctata* are now fully described and figured for the first time, and I have also taken the opportunity of giving figures of several other species or varieties which I had not been able to figure previously.

The question of the distinctness of the different "species" remains where it was, but I hope that the observations concerning the variation in pattern and colour recorded in the present contribution will be of assistance in ultimately settling it. These observations are given systematically under the headings of the different species, and I have thrown out hints as to the possible relationship of the different forms, which may or may not be followed by future workers.

I have also been in communication with Professor L. von Graff, of Gratz, who is engaged in the preparation of an elaborate monograph of the whole group and wrote to me for specimens of our Australian Planarians. I am glad to have been able to send Professor von Graff a large number of our species, which he intends to examine

* Linnean Society of New South Wales, February 25th, 1891. (Zoologischer Anzeiger, April 20th, 1891, p. 139.)

anatomically, and when the results of this anatomical investigation are combined with the observations of Australian zoologists upon the living animals we may hope to arrive at a fair idea of the relationship of the various forms.

In the systematic part of this paper the species are arranged in what appears to me to be the most natural order, commencing with the forms without stripes. Fifteen of the species thus appear to fall into five groups, within each of which the species are all closely related. The remaining seven species do not to my mind fall into any of these groups and are also very distinct from each other. The following is the complete list up to date, the related species being bracketed together in groups :—

1. *Geoplana alba*, Dendy.
2. ,, *sanguinea*, Moseley.
3. ,, *spenceri*, Dendy.
4. ,, *cærulea*, Moseley.
5. ,, *dendyi*, Spencer.
6. ,, *walhallæ*, Dendy.
7. ,, *frosti*, Spencer.
8. ,, *sugdeni*, Dendy.
9. ,, *mediolineata*, Dendy.
10. ,, *quinquelineata*, Fletcher and Hamilton.
11. ,, *m'mahoni*, Dendy.
12. ,, *sulphurea*, Fletcher and Hamilton.
13. ,, *hoggii*, Dendy.
14. ,, *quadrangulata*, Dendy.
15. ,, *ventropunctata*, Dendy.
16. ,, *munda*, Fletcher and Hamilton.
17. ,, *adæ*, Dendy.
18. ,, *fletcheri*, Dendy.
19. ,, *lucasi*, Dendy.
20. ,, *howitti*, Dendy.
21. *Rhynchodemus victoriæ*, Dendy.
22. *Bipalium kewense*, Moseley.

With regard to the distribution of the species within the colony, I have been able to collect a considerable amount of information; and, for the benefit of collectors, to whom it may be of service to know what localities have been explored and what species found in each, I give the following table of distribution. I at first thought of giving also a list of the months of the year in which each species has been found, but this appears to me to be superfluous. Land Planarians may, I believe, be found at all times of the year by diligent searching, but they seem to be much more abundant in spring (or early summer) and autumn than in the great heat and drought of the summer or the cold and excessive moisture of the winter months.

Toorak.—*Geoplana cœrulea.*

Heidelberg.—*G. quinquelineata*; *G. munda.*

Eltham.—*Bipalium kewense.*

Croydon.—*G. alba*; *G. mediolineata*; *G. sulphurea*; *G. munda*; *G. adæ.*

Fern Tree Gully.—*G. alba*; *G. mediolineata*; *G. sulphurea*; *G. munda*; *G. adæ*; *G. m'mahoni*; *G. ventropunctata.*

Warragul.—*G. alba*; *G. sugdeni.*

Between Lilydale and Seville.—*G. m'mahoni.*

Warburton.—*G. spenceri*; *G. mediolineata*; *G. adæ.*

M'Mahon's Creek (Upper Yarra).—*G. alba*; *G. m'mahoni*; *G. spenceri.*

Between Marysville and the Source of the Yarra.—*G. alba*; *G. spenceri*; *G. dendyi*; *G. walhallæ*; *G. frosti*; *G. mediolineata*; *G. m'mahoni*; *G. sulphurea*; *G. munda.*

Walhalla.—*G. spenceri*; *G. mediolineata*; *G. walhallæ*; *G. sulphurea.*

Upper Wellington River.—*G. alba*; *G. sulphurea*; *G. quadrangulata*, var. *wellingtoni*; *G. lucasi*; *G. howitti.*

Croajingolong.—*G. cœrulea*; *G. dendyi*; *G. alba*; *G. lucasi*; *G. sulphurea*; *Rhynchodemus victoriæ.*

Castlemaine.—*G. sanguinea.*

Sandhurst.—*G. quinquelineata.*

Ballarat.—*G. alba*; *G. quinquelineata*; *G. munda.*

Creswick.—*G. sugdeni*; *G. mediolineata*; *G. quinquelineata*; *G. hoggii*; *G. quadrangulata*; *G. munda.*

Macedon.—*G. alba*; *G. sugdeni*; *G. mediolineata*; *G. hoggii*; *G. adæ*; *G. quadrangulata*; *G. fletcheri.*

Otway Forest.—*G. sulphurea*; *G. quinquelineata*; *G. munda.*

From this it will be seen that, so far as Planarians are concerned, a very large proportion of the colony is unexplored, and we may expect considerable additions to our Planarian fauna in the near future.

Bipalium kewense is undoubtedly an introduced species, whose natural habitat is unknown. It was obtained from the Kew Botanical Gardens near London, and described by Professor Moseley. Since then it has been found in various parts of England and also in Sydney,* and still more recently, as I have already noticed, Mr. Fletcher has recorded its occurrence at Eltham, and likewise in Samoa. Good figures of this interesting Planarian are given by Bell in his "Note on *Bipalium kewense*, and the Generic Characters of Land-Planarians."†

Concerning *Rhynchodemus* and *Bipalium* I have nothing further to add, and we may pass on to the systematic observations on the 20 species of *Geoplana*. As the present memoir is merely a continuation of my earlier paper "On the Victorian Land Planarians," published in the Transactions of this Society for 1890, I have not thought it necessary to give constant references to that paper, to which I would refer the reader for further information and references.

1. *Geoplana alba*, Dendy.

This is one of the most widely distributed and abundant of our Victorian Land Planarians. Since the publication of my description and figures Professor Spencer has recorded the species‡—on the occasion of the Field Naturalists' Expedition to the Yarra Falls—and has figured two specimens which are of a rather darker colour than usual and thus approach *G. sanguinea*. As already noted in my original description the species varies a good deal as to the depth of colouration, from almost pure white to peach-coloured or yellow flesh. I may add that the eyes are very small and difficult to make out. In addition to the localities already mentioned I have now obtained the species from Croydon, Fern-Tree Gully, Ballarat (abundant under stones close to the edge of the lake, Mr. Avery), and the Upper Wellington River.

2. *Geoplana sanguinea*, Moseley.§

This species has not hitherto been recorded from Victoria, but I have now received seven specimens collected by Mr. T. S. Hall, M.A., at Castlemaine, under fallen bark and stones. The specimens were received by me in alcohol, with the following note as to the colours of the living worm:—"Rich Indian red above, paler below." The specimens (in spirit) are about 25 mm. long, and 4 mm. broad, much flattened on the ventral surface but pretty strongly arched on the dorsal. The anterior end of the body tapers off gradually, the posterior end terminates much

* Fletcher. "Remarks on an introduced Species of Land-Planarian, &c.," Proc. Linn. Soc., N.S.W., May 25, 1887.

† Proc. Zool. Soc. Lond., 1886, p. 166. Plate XVIII.

‡ Proceedings of the Royal Society of Victoria, 1891, p. 88.

§ Quarterly Journal of Microscopical Science, Vol. XVII., N.S., p. 285.

more abruptly. The peripharyngeal aperture is situate at about the junction of the middle and posterior thirds of the body and the genital aperture nearer to it than to the posterior end.

The eyes are, as in *G. alba*, very small and difficult to make out.

Geoplana (Cœnoplana) sanguinea was very imperfectly described by Moseley as follows:—" Closely resembles C. Cœrulea, with the exception that it is coloured of a uniform light red, which is lighter upon the under surface of the body. Actual length when living 7 cm.; breadth 4 mm., Parramatta, near Sydney. Amongst earth at the roots of a Eucalyptus stump." *(Loc. cit.)*

It seems probable that Fletcher and Hamilton's *G. rubicunda** is identical with *G. sanguinea*, a conclusion at which I understand Mr. Fletcher has himself now arrived. My *G. alba* is also evidently closely related to *G. sanguinea* and may have to be considered merely as a variety of that species.

G. sanguinea (as represented by the Castlemaine specimens), *G. rubicunda* and *G. alba* all agree in the general shape of the body, in the position of the apertures and in the curious indistinctness of the eyes.

The Castlemaine specimens of *G. sanguinea* are all markedly smaller than the average size of *G. alba*, but Moseley's examples seem to have been of about the same size as the latter.

3. *Geoplana spenceri*, Dendy.

This species has again been met with by Professor Spencer† on the occasion of the Field Naturalists' expedition to the Yarra Falls, in a locality intermediate between the Upper Yarra district and Walhalla, whence it had been previously recorded. Though extremely abundant in these parts it does not seem to occur in other localities, so that its distribution appears to be curiously limited in extent.

4. *Geoplana cœrulea*, Moseley.

(Pl. IV., Fig. 7.)

In my previous memoir on the Victorian Land Planarians I recorded this species from Croajingolong, where it was collected by Professor Spencer. Since then I have only met with a single specimen and that in a somewhat remarkable

* Proceedings of the Linnean Society of New South Wales." Series II., Vol. II., p. 370.

† *Loc. cit.*

situation, viz., in the earth around the roots of a chrysanthemum which was given to me by Mr. G. W. Officer and which was taken out of the ground in Toorak, near Melbourne, in June, 1890. This specimen when alive was of a very dark Prussian blue colour on the dorsal surface and paler blue on the ventral. There was a narrow median dorsal stripe of yellow, and an indistinct median ventral very pale blue stripe traceable back nearly to the genital aperture. There was no different colour at the anterior extremity. In spirit the specimen measures about 35 by 2·5 mm.; the peripharyngeal aperture is very slightly behind the middle of the body and the genital aperture at rather more than one-third of the distance from the peripharyngeal opening to the hinder end of the body. The eyes are easily visible with a lens. This specimen, although now preserved in spirit for a year, has preserved its blue colour remarkably well. It is impossible, of course, to determine how it was introduced into Mr. Officer's garden at Toorak, and it is interesting to note in this connection a remark made by Messrs. Fletcher and Hamilton* concerning the same species to the effect that the specimens usually found by them have an orange-red tip (as appears to have also been the case in the Croajingolong specimens) but that "on three different occasions we have found on the pavement in Hyde Park alongside the enclosure at Captain Cook's statue a number of blue Planarians (about fourteen altogether), which are without the red tip, and in which the median stripe varies from a dirty white to a distinct yellow, changing to white in spirit. . . . . The enclosure referred to has probably been stocked with these Planarians from the Botanic Gardens, but we do not know from what locality. The differences in living specimens in the two cases seem to be constant, and are sufficiently marked to make one a variety of the other, if not to separate them as distinct species." They consider that the red-tipped variety is probably the typical form, although Moseley does not mention the red colour of the anterior extremity. It is curious that the "introduced" Toorak specimen, if I may use the term, should exhibit exactly the same peculiarity as the "introduced" Sydney specimens, and this is an argument for supposing them to belong to a distinctly marked variety whose natural habitat is not known, but which is characterised by the absence of any red colour at the anterior extremity.†

5. *Geoplana dendyi*, Spencer.‡

This species is evidently very closely related to *Geoplana cœrulea*, being distinguished from it perhaps only by the presence of the median dorsal line of blue

* *Loc. cit.*

† On the evening on which this paper was read another specimen of this variety was found on the floor in the house at Toorak from the garden of which the first specimen was obtained almost exactly twelve months ago. Mr. Officer kindly brought this second specimen to me alive, so that owing to this remarkable coincidence I am able to give a figure of the worm in its living condition. The second specimen agrees so closely with the first that no special description is necessary.

‡ *Loc. cit.*

in the middle of the yellow stripe. Some of the specimens brought by Professor Spencer from Croajingolong (in spirit), which otherwise resemble *G. cœrulea*, have the dorsal light band thus divided into two by a dark line, and I find that I had accordingly placed them in separate bottles away from those which I definitely identified with *cœrulea*. Probably, therefore, these Croajingolong specimens are also referable to *G. dendyi*, so that we have the two closely allied species, *cœrulea* and *dendyi*, inhabiting the Croajingolong district. The Croajingolong specimens appear to be more flattened than those described by Professor Spencer.

6. *Geoplana walhallæ*, Dendy.

Only a single specimen of this species has been obtained since it was first described, and that by Professor Spencer, who found it in the country lying between Marysville and the source of the Yarra along the Wood's Point Road, and has described and figured it in the Proceedings of the Royal Society of Victoria.* The genital opening, as figured by Professor Spencer, is much nearer to the peripharyngeal opening than in the type specimens.

7. *Geoplana frosti*, Spencer.†

This species, as pointed out in the original description, is obviously very closely related to *G. walhallæ*, from which it is distinguished only by the presence of two light yellow stripes one on each side of the mid-dorsal line and by the absence of the brown speckles along the mid-ventral line. I do not feel disposed to lay any stress on the latter character. Professor Spencer has figured an interesting connective form in which the dorsal yellow stripes are absent throughout the greater part of the length of the body.

I have identified‡ a small specimen which I found near Mount Wellington, Gippsland, with this species. In life the ground colour of the dorsal surface was very dark indigo blue, so dark that the exact colour was difficult to determine, with two narrow stripes of whitish separated by a very fine, dark, mid-dorsal line. The ventral surface was pale brown flecked with darker brown. Even in the spirit-preserved specimen a light mid-ventral line, devoid of specks, is distinctly visible, and the opening into the peripharyngeal chamber is situate in about the centre of the body and the genital aperture (?) only a short way behind it. The specimen (in spirit) measures 12mm. in length by a little under 3mm. in greatest breadth.

* *Loc. cit.*

† *Loc. cit.*

‡ Victorian Naturalist, June-July, 1891, p. 44.

8. *Geoplana sugdeni*, Dendy.

I have received specimens of this species from Creswick, collected by Mr. Fiddian, and have also obtained more specimens from Macedon, whence it was originally recorded. At Macedon I have again observed it crawling about in broad daylight. Professor Spencer informs me that he has found this species at Warragul.

9. *Geoplana mediolineata*, Dendy.

I identify with this species specimens obtained from Fern Tree Gully, Croydon and Creswick, and Professor Spencer has figured* a variety of the species from the country lying between Marysville and the source of the Yarra along the Wood's Point Road. As Professor Spencer has pointed out, specimens in which the lateral stripes are well developed make an approach to *Geoplana quinquelineata;* on the other hand, the species seems also to merge into *G. sugdeni.* Hence although typical specimens of *G. sugdeni* and *G. quinquelineata* appear very different indeed it seems not impossible that they may have to be united with *G. mediolineata* as varieties of one species. *G. mediolineata* occupies an intermediate position between the other two, not only as regards the stripes but also in the shape of the body, being not usually so flattened as *G. quinquelineata* and less cylindrical than *G. sugdeni.*

In *G. mediolineata* the median stripe is always much darker in colour than the others (if they be present). In this it agrees with *G. quinquelineata* and differs from *G. m'mahoni.*

10. *Geoplana quinquelineata*, Fletcher and Hamilton.

This species seems to be characteristic of the Sandhurst district and in addition to the localities mentioned in my previous memoir I have now to record it from Ballarat, Creswick and Heidelberg. In some of the Creswick and Ballarat specimens the lateral stripes show a strong tendency to disappear and it is difficult to say whether the specimens should be called *quinquelineata* or *mediolineata.* The genital aperture is very difficult to observe but appears to me to be rather nearer to the pharyngeal aperture than to the hinder end of the body, while the peripharyngeal aperture is more easily visible and situate about the middle of the ventral surface. Hence *G. sugdeni*, *G. mediolineata* and *G. quinquelineata* agree pretty closely in the position of the apertures.

* *Loc. cit.*

11. *Geoplana m'mahoni*, Dendy.

(Pl. IV., Fig. 1.)

Since the publication of my previous memoir I have met with several interesting specimens of this species at Fern Tree Gully. The ground colour in the living worm was bright canary yellow on the dorsal surface, paler on the ventral. Some specimens had (like the original type) only the two stripes on the dorsal surface, both broad and black, or nearly so. Others had, in addition, a much narrower median dorsal stripe of the same colour, and yet others were intermediate between these two, the median band being very narrow and discontinuous. The paired stripes are, in this species, the characteristic and constant ones, and not, as in *G. mediolineata* the least persistent; they are always much more prominent than the median stripe. The position of the genital and peripharyngeal orifices in the Fern Tree Gully specimens agree in one specimen with that described for the type, though in another the peripharyngeal aperture is almost central. I do not set much value on *slight* differences in this respect, as the position of the apertures must depend to a certain extent upon the state of contraction of the specimen.

Professor Spencer* records the species from the country lying between Marysville and the source of the Yarra along the Wood's Point Road.

I have also a slight variety of this species from between Lilydale and Seville. The colour when alive was bright yellow all over except for the brown anterior tip and two strong dorsolateral stripes (one on each side) of brown starting from the anterior tip and dying out about one-third of the way down the body, and also a very short, thin, median dorsal stripe of brown starting from the anterior tip but soon dying out. When alive the specimen measured about 60 mm. in length. In spirit it is rather broad and flat and the peripharyngeal aperture is situate slightly in front of the middle of the body and the genital aperture not very far behind it, much nearer to it than to the posterior end of the body; obviously, however, the anterior half of the body is much more contracted than the posterior, thus bringing the apertures forward.

The occurrence of the Fern Tree Gully variety with the median stripe is interesting as showing how an even-striped form may be derived from an odd-striped form by disappearance of the median stripe, and as pointing out a possible relationship between *G. mediolineata* (and its close allies), and *G. m'mahoni.*

* *Loc. cit.*

12. *Geoplana sulphurea*, Fletcher and Hamilton.

(*Geoplana sulphureus*, Fletcher and Hamilton, *loc. cit.*).

This species was found by Professor Spencer in the country between Marysville and the source of the Yarra, along the Wood's Point Road, and is identified and figured by him in the Proceedings of this Society.* I have in my collection a number of specimens from other parts of Victoria, viz., the Otway Forest (two very large specimens), Croydon, Walhalla, Croajingolong, Fern Tree Gully, and the Upper Wellington (a number of very small specimens). Some of these specimens have been in my possession for a long time but the original description is so short that I had not ventured upon an identification. Neither Messrs. Fletcher and Hamilton nor Professor Spencer mention the position of the external openings. In spirit specimens I find the peripharyngeal aperture situate in about the centre of the body and the genital aperture at about one-third of the distance between the peripharyngeal aperture and the posterior end.

In *G. sulphurea* the outer stripes are broader than the inner, in *G. hoggii*, which comes very near it, the reverse is the case.

The ground colour in *G. sulphurea* is yellow. The inner stripes are dark brown, or sometimes greenish grey, the outer ones are darker, usually black or nearly so. In one of my Wellington specimens the two inner stripes are so close together that in the spirit-preserved specimen they appear as one, so that the specimen appears to have three stripes of equal width. In an interesting specimen from Fern Tree Gully all four stripes are extremely thin and discontinuous and almost entirely absent from the posterior part of the body; the outer stripes, however, are still distinctly stronger than the inner ones.

13. *Geoplana hoggii*, Dendy.

I have little to add to my original description of this worm. I have again collected it at Macedon, where it is very abundant, and have also received typical specimens from Creswick, collected by Mr. Fiddian. The form certainly comes very near to *G. sulphurea*, and had I realised what *G. sulphurea* was really like at the time when I wrote my description I should possibly have considered it as a variety of the latter. *G. hoggii*, however, differs from *G. sulphurea*, as pointed out above, in having the inner stripes broader than the outer ones, the green colour being at the same time more pronounced; hence it may perhaps stand as a fairly well-marked variety, though probably not a distinct species.

* *Loc. cit.*

14. *Geoplana quadrangulata*, Dendy.

I have again collected this very beautiful and distinct little Planarian at Macedon, where it is by no means uncommon, and I have also received a specimen from Creswick, collected by Mr. Fiddian. These specimens all exhibit in a more or less marked degree the pale spots along the junction of the dorsal and lateral surfaces; these spots are merely the foreshadowings of the characteristic mottled appearance of the Mount Wellington variety.

14*a*. *Geoplana quadrangulata*, var. *wellingtoni*, nov.

This pretty little variety was obtained in abundance under logs near the foot of Mount Wellington and its occurrence has already been recorded by me in the "Victorian Naturalist."* The worm is a rather difficult one to collect as it crawls into the crevices of the rotten wood in a very provoking way and readily breaks to pieces.

When alive the ground colour of the dorsal surface was pale brown, with a median dark brown line and on each side of it numerous thickly scattered speckles of dark brown.

The lateral surfaces were very pale brown thickly flecked with dark brown, and the ventral surface was white, devoid of speckles. All the specimens obtained were a good deal smaller than the typical form of the species from Macedon usually is. More than a dozen specimens were collected.

15. *Geoplana ventropunctata*, n. sp.

(Pl. IV., Figs. 2, 2*a*.)

I obtained this very beautiful little species in abundance under rotten logs at Fern Tree Gully, on the occasion of the Field Naturalists Club's excursion to that locality in March last.

When at rest the body is very broad and flat (Pl. IV., Fig. 2*a*), but when crawling, which is done very actively, the body becomes greatly elongated and very narrow, measuring about 20 mm. in length and a little under 2 mm. in greatest breadth.

The eyes are arranged as usual on the horse-shoe shaped anterior extremity and sides of the body.

* *Loc. cit.*

The opening of the peripharyngeal chamber (in spirit) is somewhat behind the middle of the ventral surface and the genital aperture about one-third of the way between it and the posterior end of the body. The protruded pharynx (in spirit) is cylindrical.

The ground colour of the dorsal surface is really nearly white, but almost entirely obscured by the abundant markings, which are arranged as follows:—(1) A rather narrow, nearly black median stripe with irregular margins. (2) On each side of the black stripe and extending to the lateral margin of the body are a great number of small, closely set, irregular longitudinal streaks of various shades of brown, in some specimens a good deal lighter than in others. Each side of the body, between the dorsal and ventral surfaces, is occupied by an irregular stripe of very dark brown, made up of a series of splotches of pigment more or less run together. The anterior extremity is dark brown.

The ventral surface is white, very beautifully spotted all over with small, distinct and isolated specks of dark brown.

When the animal is alive the lateral stripe is visible from the ventral surface but not from the dorsal; in spirit it is just visible from the ventral surface.

In general appearance and size this species closely resembles *Geoplana quadrangulata* var. *wellingtoni*, but we may note the following points of distinction:—(1) The body is not so distinctly quadrangular in section and the sides do not slope inwards nearly so much, so that the ventral surface is much wider. (2) There is a distinct, though irregular lateral stripe of a very dark colour, instead of the sides of the body being lighter in appearance than the dorsal surface as in *G. quadrangulata* and its variety. (3) The ventral surface is, in all specimens which I have seen (a considerable number), very distinctly spotted with brown; while in all specimens of *G. quadrangulata* which I have seen it has no spots at all.

It a curious fact that while this species was found abundantly at Fern Tree Gully in March, in company with large numbers of *Geonemertes australiensis*, yet we could not find a single specimen of either of these worms when we visited the spot a few weeks later in May.

16. *Geoplana munda*, Fletcher and Hamilton.

This species has proved to be one of the commonest and most easily recognisable of our land Planarians. Since writing my last memoir on the subject I have had specimens from Croydon, Fern Tree Gully, Heidelberg, Creswick and Ballarat. At

Croydon, on December 17th, 1890, I found more than fifty specimens of this species under a single log, all agreeing closely in colour and markings.

I was at first much puzzled at not being able to find the genital aperture in this species. I could not find it in the Otway Forest specimens recorded in my previous memoir, nor could I find it in the specimens collected at Croydon in December, 1890, though I carefully examined a considerable number. When, however, I came to examine specimens collected at Creswick in March, 1891, I found it at once in ten out of eleven specimens, the eleventh being a very small one. The Croydon specimens were fully of the average size and the obvious conclusion seems to be that the genital aperture is visible only at certain times of the year (autumn). With this we may associate the fact, recorded in my last memoir, that *Geoplana mediolineata* copulates in the beginning of April. Possibly all our land Planarians breed in the autumn.

The peripharyngeal aperture in *G. munda* is nearly central and the genital aperture only a short way behind it, as originally described by Fletcher and Hamilton.

Professor Spencer* has also recorded the species from the country lying between Marysville and the source of the Yarra along the Wood's Point Road, and has given an excellent coloured figure of the living worm.

I have now to mention a slight variety of the species which I found at Heidelberg and which was again obtained by Mr. Fiddian at Creswick. The Heidelberg specimens, three in number, are thus described in my notes on the living animals:—"In size and shape closely resembles *G. munda*, the ground colour is also very similar, on the dorsal surface a slightly mottled olive brown; ventral surface pale yellow. In the mid-dorsal line a fine, very pale brown band, edged on either side by a fine dark brown line which forms a margin to the ground colour. No other stripes." The Creswick specimens presented exactly the same peculiarity, viz., the absence of the dorso-lateral dark stripes; they were collected in May, and show the genital aperture distinctly.

17. *Geoplana adæ*, Dendy.

(Pl. IV., Figs. 3, 3*a*.)

I have again collected this very handsome Planarian at Macedon and have also found it at Croydon and Fern Tree Gully. The genital aperture, which I had not been able to distinguish when I first described the species, is situate only a short way behind the peripharyngeal and a long way from the posterior end of the body; it appears to vary in distinctness with the time of the year, as in *G. munda*.

* *Loc. cit.*

My original description and figure did scanty justice to the beauty of this species, partly because the specimens were not so fine as those which I have since obtained.

The two specimens from Croydon were about 65 mm. in length and 4 mm. in width when crawling. The ground colour of the dorsal surface was light, mottled brown, and the paired stripes were very broad, of a dark greeny brown colour, with a fine, well-defined, very dark outline on each side. One of the specimens shows a fine, light-brown mottling on the ventral surface, except in the mid-ventral line, the other only shows a trace of this mottling at the anterior end.

At Fern Tree Gully, on March 14th, 1891, a number of fine specimens were secured which again showed some interesting variations in colour. The ground colour of the dorsal surface was very pale, yellow brown, generally, at any rate, more or less mottled, but only very slightly. The ventral surface was very pale yellow brown, often slightly mottled and sometimes with two broad bands of distinct, slightly mottled brown one on each side of a narrower median band of almost pure white. In some specimens the three stripes on the dorsal surface were coloured as in the specimens originally described and figured. The most striking variety, however, is that represented in Figs. 3, 3*a*., Pl. IV. In this specimen the ground colour of the dorsal and ventral surfaces was very pale brown very slightly mottled, with slight indications of a lighter median stripe on the ventral surface. The two broad stripes on the dorsal surface, instead of being simply brown, or purple brown as in some specimens, were of a dark brown colour with very minute blue specks thickly scattered all over. Viewed as a whole these stripes appeared of different tints according to the light thrown on them, but the general impression was dark olive green.

When at rest *G. adæ* is very broad and flat, and the green variety closely approaches *G. frosti* in appearance. The broad, dark bands are, however, edged on the outside with ground colour, and do not extend to the lateral margin as in *G. frosti*. In other words, what appears as ground colour in *G. frosti* appears as a definite stripe in *G. adæ*.

18. *Geoplana fletcheri*, Dendy.

(Pl. IV., Fig. 6.)

I have again found this species at Macedon but have not seen it from any other locality. I take this opportunity of emphasising the fact that this Planarian, which at first sight might easily be mistaken for one of the common yellow forms, is really very distinct indeed. The much flattened ventral surface, sometimes becoming strongly concave in spirit, and the markedly posterior position of the apertures, the genital being close to the hinder extremity of the body, readily distinguish the species.

In one of my specimens the copulatory organs are partially protruded, and exhibit the very remarkable peculiarity that while the female copulatory organ is single there are two distinct male organs. The appearance and arrangement of these parts is shown in Figure 6. Whether or not this condition is constant I cannot say, but I am inclined to think that the species possesses anatomical peculiarities which would well repay investigation, and which may even necessitate the erection of a new genus for its reception. The eyes are arranged as is usual in *Geoplana*.

19. *Geoplana howitti*, Dendy.*

(Pl. IV., Fig. 5.)

Body (in spirit) much flattened on the ventral surface, strongly convex on the dorsal, much broader behind, where it terminates rather abruptly and bluntly, than in front, where it tapers gradually. Peripharyngeal aperture (in spirit) well behind the middle of the ventral surface, only 8mm. from the hinder extremity of the body. Genital aperture about 4mm. behind the peripharyngeal. Length of body (in spirit) about 25mm., greatest breadth 4mm. The eyes are arranged as usual in the genus but are difficult to make out owing to the dark pigment around them, so that I had to cut a slice off the side of the head end before I could find them.

When alive the ground colour of the dorsal surface was yellowish white ; in the mid-dorsal line a fairly broad band of ground colour, on each side of this a stripe of about equal width of dark purplish brown, outside this a rather broader band of ground colour thickly flecked with dark purplish brown and edged on the outside by a fine line of dark purplish brown, outside this fine line a very narrow edge of ground colour.

It is noteworthy, as showing a tendency towards variation in pattern, that in the mid-dorsal band of ground colour, just in one place near the posterior end, there are a few small flecks of dark purplish brown, as shown in the figure. The horse-shoe-shaped anterior extremity is, during life, dark purplish brown, and all the dark bands unite at each end of the body.

The ventral surface in life is pale yellowish white or grey, with no markings.

I found a single specimen of this Planarian beneath a log near the bank of the Upper Wellington River, at the foot of Mount Wellington, Gippsland, on the occasion

* A brief preliminary diagnosis of this species was given in the Victorian Naturalist for June-July, 1891, p. 43.

of an expedition made to that locality in company with Mr. A. W. Howitt and Mr. A. H. S. Lucas in December, 1890. I have much pleasure in naming the species after the leader of the expedition.

In the shape of the body and the markedly posterior position of the apertures *Geoplana howitti* resembles *G. fletcheri.*

20. *Geoplana lucasi*, Dendy.

(Pl. IV., Fig. 4.)

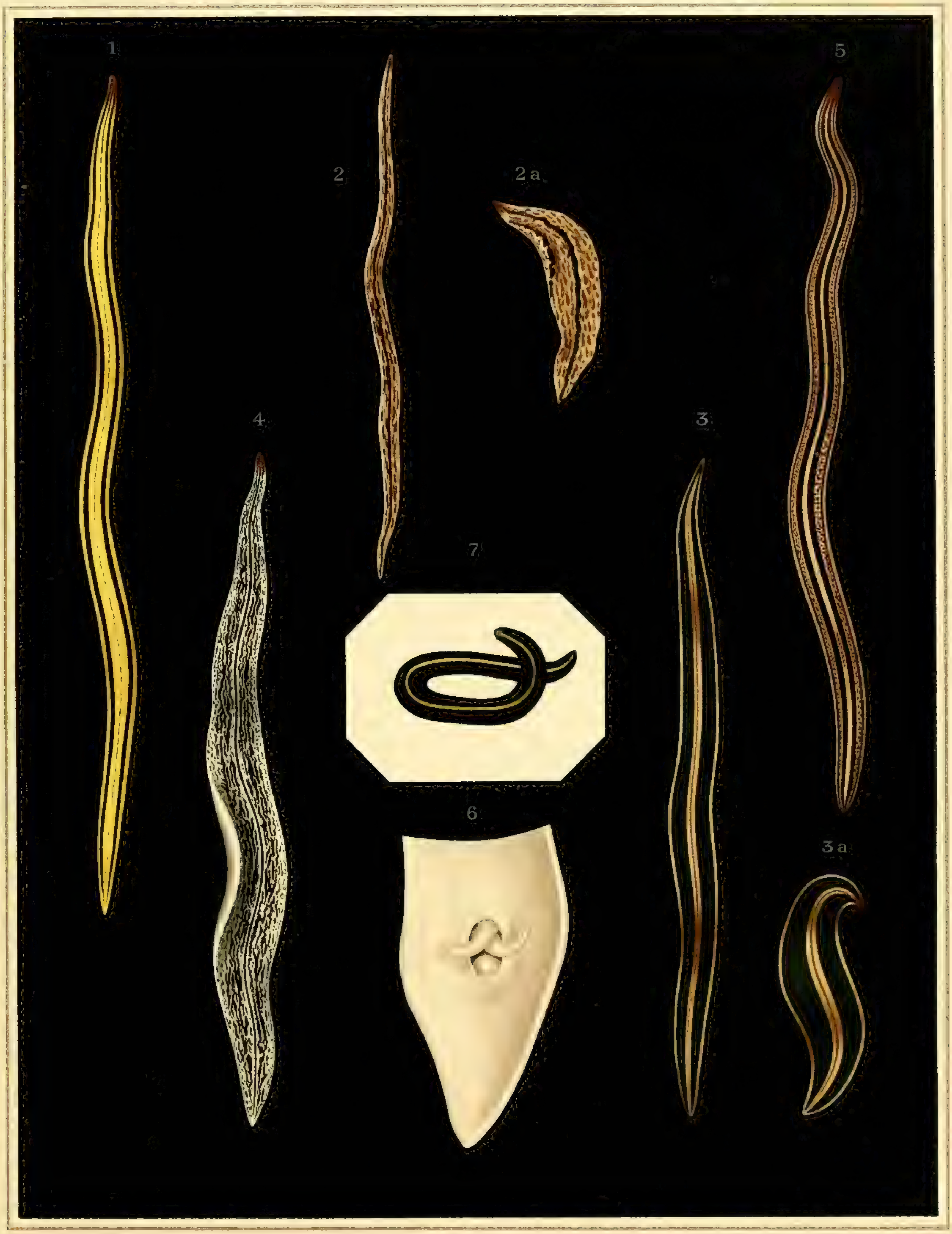
I found a single specimen of this interesting species under a log near Mount Wellington, Gippsland, on the same occasion and in the same locality as *G. howitti.* As I had not before seen this Planarian alive I was very glad of the opportunity of making careful notes of the appearance of the living animal, and I am also able to give a figure of the natural colour.

In life the dorsal surface is white, with dark grey or black markings arranged as follows :—There is a rather narrow median stripe of black and the remainder of the dorsal surface is thickly flecked with small specks and longitudinal dashes of dark grey. On either side of the median black line these specks and dashes are absent, or nearly so, leaving a very narrow band of almost clear ground colour, then they appear comparatively large and very close together and more in irregular longitudinal dashes which seem to be formed each of a number of small dots. Towards the margin of the body the dots and dashes get smaller and scarcer. The horse-shoe-shaped anterior extremity is reddish brown. The ventral surface is greyish white, with no markings.

When crawling the worm measured about 60 mm. in length.

The specimen after preservation in spirit closely resembles the spirit specimens from Croajingolong originally described. The eyes appear to extend (in abundance) for an unusual distance down the sides of the body, if not along the entire length of the animal, but it is difficult to be certain on this point owing to the resemblance between the eyes and the smaller specks of pigment.

In concluding these observations I desire again to express my indebtedness to those gentlemen who have kindly assisted me in collecting specimens of Land Planarians, viz., the Rev. W. Fielder, Mr. Officer, Mr. Avery, Mr. Fiddian, and Mr. W. Mann, of the Melbourne University; Mr. H. R. Hogg, Mr. Hennell, and other members of the Field Naturalists' Club of Victoria.



Arthur Dendy del.

Lith. Anst. v. Werner & Winter, Frankfurt a/M.

Description of Plate IV.

Fig. 1.—*Geoplana m'mahoni*, crawling, dorsal surface. From Fern Tree Gully.

Fig. 2.—*Geoplana ventropunctata*, crawling, dorsal surface. From Fern Tree Gully.

Fig. 2a.—*Geoplana ventropunctata*, at rest, dorsal surface. From Fern Tree Gully.

Fig. 3.—*Geoplana adæ*, variety with green stripes; crawling; dorsal surface. From Fern Tree Gully.

Fig. 3a.—*Geoplana adæ*, same specimen as represented in Fig. 3; at rest; dorsal surface.

Fig. 4.—*Geoplana lucasi*, crawling, dorsal surface. From Upper Wellington River.

Fig. 5.—*Geoplana howitti*, crawling, dorsal surface. From Upper Wellington River.

Fig. 6.—*Geoplana fletcheri.* Ventral surface of posterior end, showing copulatory organs protruded. From Macedon.

Fig. 7.—*Geoplana cœrulea.* Variety with blue tip. Dorsal surface. From Mr. Officer, Toorak.

Note.—All the figures are enlarged. The actual measurements are given in the text.

ARTICLE IV.—LAND PLANARIANS FROM LORD HOWE ISLAND, BY W. BALDWIN SPENCER, M.A., PROFESSOR OF BIOLOGY IN THE UNIVERSITY OF MELBOURNE.

PART I.—DESCRIPTION OF SPECIES. (With Plates 5 and 6.)

(Read Thursday, June 11th, 1891.)

The following paper deals with an interesting collection of land Planarians which were obtained by Mr. Thomas Whitelegge for the Australian Museum during a visit paid by a collecting party, despatched by order of the Trustees of the Museum to Lord Howe Island in 1887.

The material was first placed for examination in the hands of Mr. J. J. Fletcher, to whom we are indebted for the description of the various species of land planarians found in New South Wales. Mr. Fletcher being unable to devote the necessary time to their elucidation kindly offered, with the consent of the trustees of the Museum, to place the material at my disposal.

The specimens are excellently preserved, and I have had the advantage of the short notes made by Mr. Whitelegge at the time of collecting them giving some little information with regard to their colour and length. The specimens all came from under the leaves of palm trees.

On the Australian continent two genera of land planarians are well-known, viz., Geoplana and Rhynchodemus. Of the former 35 species have been described, and of the latter six species, five from New South Wales, and only one as yet from Victoria. The latter is known only from one specimen which I collected in Croajingolong, near to the New South Wales border, and to which Dr. Dendy has given the name of *R. victoriæ*. In addition to these two genera, the introduced form *Bipalium kewense* has been recorded by Mr. Fletcher from both New South Wales and Victoria.

Thus in Australia the genus Geoplana is the predominant one. New Zealand has as yet been scarcely worked for land planarians and from the Polynesian region so far as I am aware, the only land planarians recorded come from the Samoan Islands, from which place Grube has described two species of Rhynchodemus, viz., *R. bistriatus* and *R. quadristriatus.*

Lord Howe Island lies far away from the nearest mainland, in the north of what it is now proposed to call the Tasman Sea at about one-third of the distance between the Australian eastern coast and the most northerly point of New Zealand. It lies in about Lat. 32° S. and Long. 158° E. and in the line of the comparatively shallow soundings which indicate probably the existence of an ancient land connection between New Zealand and the north of the Australian continent. It is interesting hence to note that as far as our, at present, limited knowledge extends the genus Rhynchodemus would appear to be more common as we go northwards on the mainland, whilst there is only one species recorded from Victoria, five are known in New South Wales, and it will be of interest to see whether a knowledge of Queensland forms confirms this relative distribution of the two genera Geoplana and Rhynchodemus. Had a species of Geoplana been at any rate at all plentiful on Lord Howe Island it would have hardly escaped the notice of so careful a collector as Mr. Whitelegge though at the same time it must be remembered, judging by experience in Victoria, that forms commonly met with at one special time may at another be few and far between. Still there is not in Mr. Whitelegge's collection a single example of Geoplana.

The collection proves to contain eight species all, so far as can be ascertained, new to science. I am however unable to refer to the description of *R. bistriatus* and *R. quadristriatus* described by Grube from the Samoan Islands. It is just possible that these may be identical with two of the species now to be described but taking into account the distance which separates the two islands and the fact that even Victoria and New South Wales, though so close together, have very few species indeed of land planarians in common it seems most likely that the species of Rhynchodemus will be distinct on the Samoan and Lord Howe Islands.

The most interesting part of the collection consists of two species which must be referred to a new genus for which the name of Cotyloplana is proposed in consequence of the presence of a distinct sucker-like structure on the ventral surface anteriorly.

In Part II. of this paper I propose to describe the anatomy of this genus. The figures which accompany the paper are drawn from the spirit specimens and to preserve the relative dimensions proportional compasses have been used: at the same time it must be remembered that the form of these soft bodied creatures often changes very much when they are placed in spirit; still the markings and relative position of the pharyngeal and genital apertures may, together with colour markings, be taken as discriminative of the species.

The following is a list of the forms described :—

Genus. Cotyloplana, gen. nov.

1. *C. whiteleggei*, sp. n. (Figs. 1, 2, 3, 4.)
2. *C. punctata*, sp. n. (Figs. 5, 6, 7, 8.)

Genus. Rhynchodemus. (Leidy.)

3. *R. fasciatus*, sp. n. (Figs. 9, 10.)
4. *R. laterolineatus*, sp. n. (Figs. 11, 12, 13.)
5. *R. grandis*, sp. n. (Figs. 14, 15, 16, 17, 18, 19.)
6. *R. mediolineatus*, sp. n. (Figs. 20, 21, 22, 23.)
7. *R. dubius*, sp. n. (Figs. 24, 25.)
8. *R. fletcheri*, sp. n. (Figs. 26, 27.)

Cotyloplana, gen. nov.

Body flattened. A sucker is present on the ventral surface close to the anterior extremity. Eyes two.

Cotyloplana whiteleggei, sp. n. (Pl. V., Figs. 1, 2, 3, 4.)

Anterior end somewhat spathulate with the antero-lateral margins of the body crenate and a median semicircular projection with smooth margin. Eyes two; dorsal; one at each side of the base of the semicircular projection. A sucker is placed on the ventral surface at the anterior extremity with its longest diameter at right angles to the long axis of the body.

The dorsal surface is of a brown colour and the posterior part is covered with dark mottlings which become restricted anteriorly to form a broad median band which stops short of the anterior extremity. A dark band lies across the anterior extremity and is continued backwards on each side for about one-fifth of the length of the body where it merges into the mottlings which cover the whole of the posterior part of the dorsal surface.

Ventral surface mottled.

Pharyngeal opening 12 m.m. from posterior end. Genital opening 5 m.m. from posterior end. Length in spirits 24 m.m.

Locality.—Lord Howe Island. (Coll. Mr. T. Whitelegge.)

The sucker placed on the ventral surface at the anterior end is distinctive of this genus and the somewhat spathulate form of the head together with the crenate antero-lateral margins are characteristic of the species. It is possible that this crenate appearance may be due to the presence of tentacular structures retracted in the spirit specimens but Mr. Whitelegge makes no remarks in his notes of the presence of any such nor do I think that they are anything more than crenations.

I have much pleasure in naming the first species of this genus described after Mr. Whitelegge, and am now engaged in studying its anatomy an account of which will form Part II. of this paper.

Cotyloplana punctata, sp. n. (Pl. I., Figs. 5, 6, 7, 8.)

Body flattened with the posterior half somewhat wider than the anterior half. Sucker on the ventral surface close to the anterior end, circular in outline, margin of body smooth. Eyes two, placed close to the anterior extremity. Dorsal surface except the lateral margins mottled with brown spots and with a median light line which may or may not extend the whole length. Ventral surface mottled except along the lateral margins and around the sucker, and somewhat lighter than the dorsal surface.

Pharyngeal opening 9 m.m. from the posterior extremity; genital opening 4 m.m. from the posterior extremity. Length when alive 50 m.m. Length in spirits 42 m.m.

Locality.—Lord Howe Island. (Coll. Mr. T. Whitelegge.)

This species differs considerably from *C. whiteleggei* in the shape of its body whilst both agree in their notably mottled appearance on both dorsal and ventral surface though there is in the latter no indication of a median light line such as is present in *C. punctata*. This varies slightly being in one of the specimens figured (Fig. 5) continued to the posterior extremity whilst in the other (Fig. 6) it only passes along slightly more than one-half of the length of the body and there are indications of another light line on the left of the median one. The margins of the anterior part of the body are, in spirit specimens, curved over ventrally (Figs. 7 and 8) making the dorsal surface distinctly convex and the ventral concave.

The two forms agree however in the presence of a ventral sucker anteriorly though in *C. punctata* the margins of this are not so strongly marked as in *C. whiteleggei.*

Genus Rhynchodemus. (Leidy.)

Rhynchodemus fasciatus, sp. n. (Pl. V., Figs. 9, 10.)

Dorsal face marked by a median broad blackish-brown band tapering suddenly anteriorly; at either side of this are two dark bands separated by light lines the inner of the two former being broader than the outer. The edges of the upper surface are light coloured. The dark bands unite together some little distance in front of the posterior end leaving a distinct light margin. Eyes two placed close to the anterior end where the two outer dark bands unite together on each side.

Ventral surface of dun colour with broad darker band in the median line and a narrow dark line on either side. Dark bands not nearly so prominent as on the dorsal surface.

Pharyngeal opening 12 m.m. from the posterior end. Genital opening 9 m.m. from the posterior end. Length when alive, 50 m.m. In spirits 29 m.m.

Locality.—Lord Howe Island. (Coll. Mr. T. Whitelegge.)

The bands as described above are probably much more distinctly marked in spirit than in living specimens. Mr. Whitelegge notes the colour as blackish brown on the dorsal surface with two light lines on the laterals, the ventral surface being dun colour. There are seen very clearly in spirit specimens five dark bands as shown in the figure (10) dorsally and three bands on the ventral surface though the latter are faint when compared with the former. A characteristic feature is the way in which the broad median land suddenly narrows at the anterior extremity whilst posteriorly it is broad and merges into the lateral ones.

Rhynchodemus laterolineatus, sp. n. (Pl. V., Figs. 11, 12, 13.)

Body much flattened; pointed at both extremities. Edges of body with strongly marked dark bands tapering at both ends. Two dark lines along the body leaving between them a median narrow line of ground colour.

Ventral surface with two dark lines one on either side of the median line and uniting anteriorly and posteriorly before reaching either extremity. Close to the two lateral dark bands is a dark line on each side; the two unite together anteriorly but posteriorly merge into the lateral bands. The dark bands on the ventral surface may be broad and as many as six be present.

Pharyngeal opening 11 m.m. from post end. Genital opening 6 m.m. from the posterior end. Length of animal when alive 38 m.m. Length in spirit 25 m.m.

Locality.—Lord Howe Island. (Coll. Mr. T. Whitelegge.)

This species is marked by its very distinct bands of dark colour along the edges of the body. The latter is much flattened, broad in the middle and tapering to both ends ; there is no difference in the thickness of the body at any part, and the lateral margins are very distinctly marked. Whilst the dorsal surface is the same in all the specimens the ventral varies. Figures 12 and 13 serve to show the two extremes. The important dark bands consist (1) of two, one on either side the median line and (2) of two, one close to each of the lateral margins each of these falling into the lateral band before the posterior end is reached.

In addition to these there may be present two more bands one on each side intermediate between those already described. In addition to varying in number ventrally the thickness of the bands may vary considerably, with the exception of the outermost one which always remains thin. Thus in figure 13 the specimen drawn has four thick bands and the two lateral thin ones, whilst in figure 12 the specimen figured has only two thin median and the two thin lateral ones. In both cases the dorsal surface resembled the one drawn in figure 11.

Rhynchodemus grandis, sp. n. (Pl. VI., Figs. 14, 15, 16, 17, 18, 19.)

Dorsal surface with the ground colour fawn-brown, marked with streakings and spots of darker brown. The anterior end with the margins light-coloured and two dark bands, one on either side, which gradually become less marked posteriorly. They enclose between them at the front end a median light line, and the streaks show a tendency to form two dark lines one on either side the median line which remains light-coloured. Eyes two, one on either side in the lateral light lines close to the anterior somewhat bluntly pointed extremity. Ventral surface of a lighter fawn-yellow colour, spotted with a prominent median line of dark spots. Pharynx 35 m.m. from the posterior end. Genital opening 16 m.m. from the posterior end. Length when alive 6-7 inches, width $\frac{3}{8}$-$\frac{5}{8}$ inches.

Locality.—Lord Howe Island. (Coll. T. Whitelegge.)

In spirit specimens the lateral edges of the body become curved towards the ventral surface so as to produce a distinct concavity ventrally, but this only extends for a short distance.

The specimen figured (Pl. VI., Figs. 14, 15) represents the animal very much contracted after the action of spirit, but this is probably one of the largest examples of the genus yet known. Some two or three of our Australian land-planarians of the genus Geoplana, notably *G. dendyi* and *G. hoggii*, reach a length when crawling equal to that of *R. grandis*, but the width of the body when fully expanded is nothing like so much as five-eighths of an inch.

In Mr. Whitelegge's collection are some specimens which are in all probability young forms of the species. These are interesting as showing, what Professor Moseley* has already drawn attention to, the curious fact that the markings are often more definite in young than in old and full-grown examples. Two young specimens are represented in figures 16, 17, 18, and 19. The first of these shows dorsally three stripes of dark colour, (1) a median one and (2) two lateral ones. In the older form these stripes, as it were, break up into a series of streaks and spots, but the two lateral ones persist anteriorly, whilst the median one becomes more obscure and represented by two lines of darker streaks. Ventrally also three dark but not so prominent stripes are present each composed of closely placed spots.

The second shows dorsally the lateral stripes strongly marked only anteriorly, the median one being much fainter, whilst ventrally the lateral ones are only seen at the anterior end, and the median one is much as in the adult. In both of the young specimens figured only the pharyngeal opening is visible, the genital opening not being apparently developed presumably on account of the immaturity of the specimens.

Rhynchodemus mediolineatus, sp. n. (Pl. VI., Figs. 20, 21, 22, 23.)

Dorsal surface with a median dark stripe which may or may not extend the whole length of the body and on either side of which is a dark stripe anteriorly. The lateral edges are marked by dark lines. Two eyes close to the anterior end. Ventrally are two dark stripes one on either side the median line uniting anteriorly. Pharyngeal opening 12 m.m. from the posterior end. Genital opening 6 m.m. from the posterior end.

Locality.—Lord Howe Island. (Coll. Mr. T. Whitelegge.)

This species varies somewhat in the development of the stripe just as does the species *Geoplana mediolineata*, which is distinguished by its median stripe. Two specimens are figured. In the first of these (Figs. 20, 21) the three stripes are only present at the anterior end dorsally whilst ventrally two extend for the whole length and enclose the pharyngeal and genital openings uniting together at both ends. In the second (Figs. 22, 23) the anterior dorsal end is darker than in the first and the dorsal median stripe extends the whole length whilst ventrally the two stripes are only present for not quite one-third of the length. The genital opening in the latter was indistinguishable.

Rhynchodemus dubius, sp. n. (Pl. VI., Figs. 24, 25.)

Dorsal surface with ground colour of pale cream colour, anterior end with four dark lines extending back not quite one-fourth of the length of the body the two

* Trans. R. S. London. The Anatomy and Histology of the Land Planarians of Ceylon. Vol. 164, 1874, p. 110.

middle ones being more prominent than the outer ones and enclosing anteriorly a median light line of ground colour. The dark lines fuse at the anterior extremity leaving the margins of the body light coloured. The two eyes are placed in the dark lines where the four have fused close to the anterior end. The posterior three quarters of the body are marked by irregular, undulating, disconnected, dark lines the more prominent of which seem to form a broken up continuation of the two inner of the stripes. A median portion nearly one-third of the width of the surface is light coloured and there is present in this a median thin dark line made up of slightly discontinuous parts. The streaks have a tendency to form four lines at the very posterior end. Ventral surface pale cream colour with no streaks. Pharynx 36 m.m. from the posterior end. Genital opening 12 m.m. from the posterior end.

Locality.—Lord Howe Island. (Coll. Mr. T. Whitelegge.)

The length of the animal when alive is 4-5 inches. The spirit specimens are all much coiled and vary somewhat in marking especially in the distinctness of the four stripes anteriorly and in the development of the thin dark median stripe. In one or two this is very difficult to detect and it may be very irregularly developed. It is not apparently at all prominent during life. The characteristic features are the lines giving place to streaks posteriorly and the entire absence of markings on the ventral surface.

Rhynchodemus fletcheri, sp. n. (Pl. VI., Figs. 26, 27.)

Dorsal surface with median light line and two broad black bands one on either side of this. Lateral portions of body and ventral surface light coloured. Ventral surface with two lateral dark lines and median broad punctated band not extending quite to the anterior or posterior ends and showing indication of division into two lines. Anterior extremity bluntly rounded with eyes dorsal and close to the anterior edge. Pharyngeal opening 8 m.m. from the posterior end; genital opening 3 m.m. from the posterior end.

Locality.—Lord Howe Island. (Coll. Mr. T. Whitelegge.)

The animal when alive measures 25 m.m. in length the spirit specimen measuring 19 m.m. In the latter the pharyngeal opening has the form of a transverse slit with a light margin lying in the middle of the median dark band; the genital opening is distinct and more noticeable than the pharyngeal and has a light-coloured circular margin the dark band being divided in its region into two by a median light line.

The body in spirit specimens is somewhat flattened and band like the anterior end blunt and rounded the posterior more pointed.

The median dorsal line swells out slightly on the head and does not quite reach the posterior end.

Description of Plates.

Plate V.

Fig. 1.—*Cotyloplana whiteleggei*, dorsal view. x 3.

Fig. 2.—*Cotyloplana whiteleggei*, ventral view of the same. x 3.

Fig. 3.—*Cotyloplana whiteleggei*, enlarged view of the dorsal surface of the anterior extremity to show the semicircular end with the crenated antero-lateral margins and the two eyes. x 7.

Fig. 4.—*Cotyloplana whiteleggei*, enlarged view of the ventral surface of the same specimen as figure 3, to show the sucker with its slit at right angles to the long axis of the body and prominent margin. x 7.

Fig. 5.—*Cotyloplana punctata*, dorsal view. x 2.

Fig. 6.—*Cotyloplana punctata*, dorsal view of a larger specimen in which in addition to the median light line which does not extend the whole length of the body there is an indication of another light line at the side of the median one. x $1\frac{1}{2}$.

Fig. 7.—*Cotyloplana punctata*, ventral view of the same specimen as figure 6, showing the sucker anteriorly. x $1\frac{1}{2}$.

Fig 8.—*Cotyloplana punctata*, enlarged ventral view of the anterior extremity of the specimen represented in figure 6 to show the sucker. In figures 6, 7, 8, the lateral margins are seen to be strongly contracted so as to produce at the anterior end a very concave surface ventrally and convex dorsally.

Fig. 9.—*Rhynchodemus fasciatus*, ventral view. x 3.

Fig. 10.—*Rhynchodemus fasciatus*, dorsal view of the same. x 3.

Fig. 11.—*Rhynchodemus laterolineatus*, dorsal view. x 2.

Fig. 12.—*Rhynchodemus laterolineatus*, ventral view of the same. x 2.

Fig. 13.—*Rhynchodemus laterolineatus*, ventral view of another specimen, in which the dark bands ventrally are strongly developed. x 3.

Plate VI.

Fig. 14.—*Rhynchodemus grandis*, dorsal view. Actual size of spirit specimen.

Fig. 15.—*Rhynchodemus grandis*, ventral view of the same. Actual size of spirit specimen.

Fig. 16.—*Rhynchodemus grandis*, young specimen, dorsal view. Actual size of spirit specimen.

Fig. 17.—*Rhynchodemus grandis*, young specimen, ventral view of the same. Actual size of spirit specimen.

Fig. 18.—*Rhynchodemus grandis*, young specimen, dorsal view. Actual size of spirit specimen.

Fig. 19.—*Rhynchodemus grandis*, young specimen, ventral view of the same. Actual size of spirit specimen.

Fig. 20.—*Rhynchodemus mediolineatus*, dorsal view. x 3.

Fig. 21.—*Rhynchodemus mediolineatus*, ventral view of the same. x 3.

Fig. 22.—*Rhynchodemus mediolineatus*, dorsal view of another specimen in which the median line passes along the whole length of the body. x 3.

Fig. 23.—*Rhynchodemus mediolineatus*, ventral view of the same, the two lines only being present at the anterior end of the body.

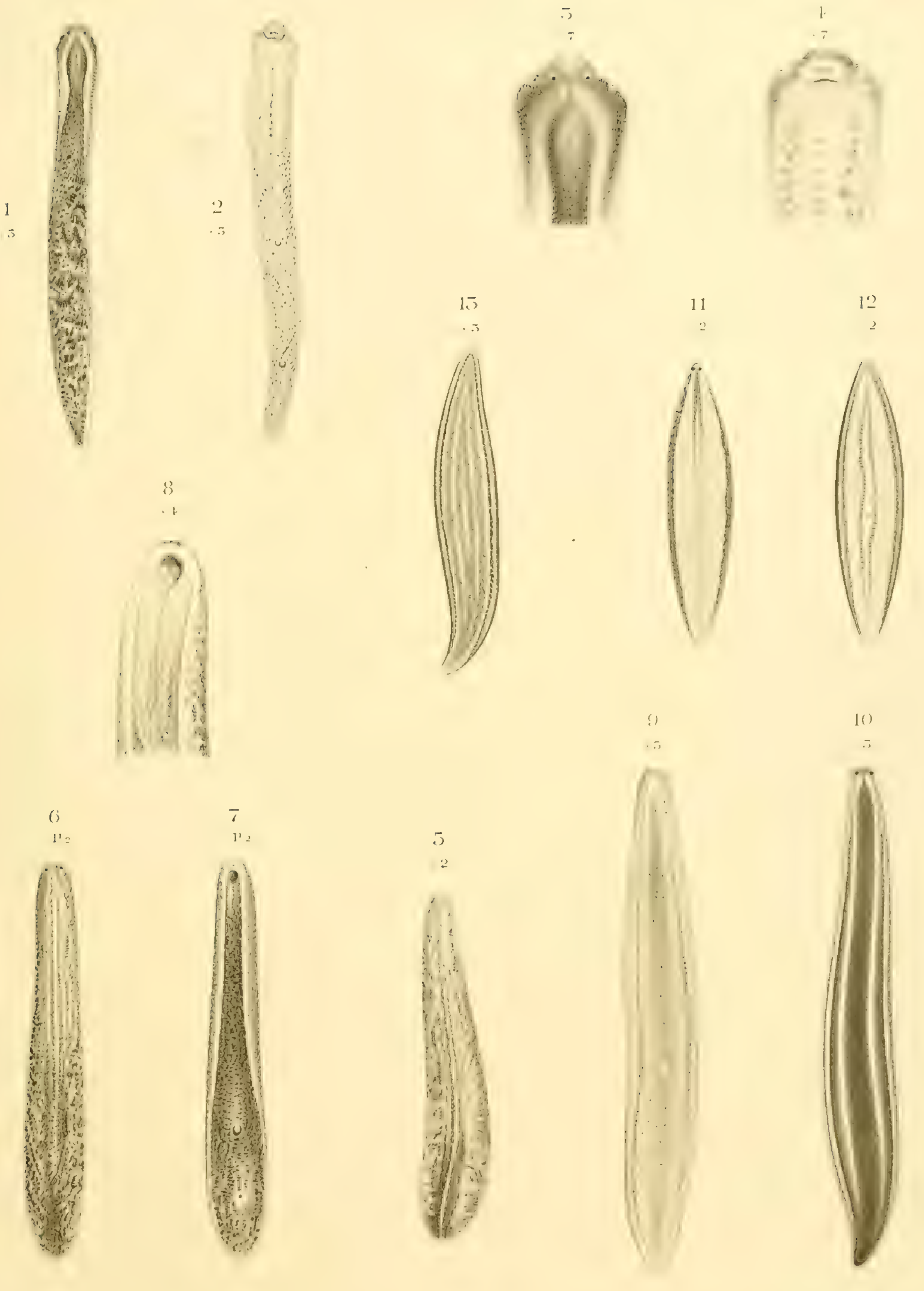
Fig. 24.—*Rhynchodemus dubius*, dorsal view. x 1½.

Fig. 25.—*Rhynchodemus dubius*, ventral view of the same. x 1½.

Fig. 26.—*Rhynchodemus fletcheri*, dorsal view. x 3.

Fig. 27.—*Rhynchodemus fletcheri*, ventral view of the same. x 3.

Note.—The blue tint in figures 14, 15, 16 and 18 should not be present.



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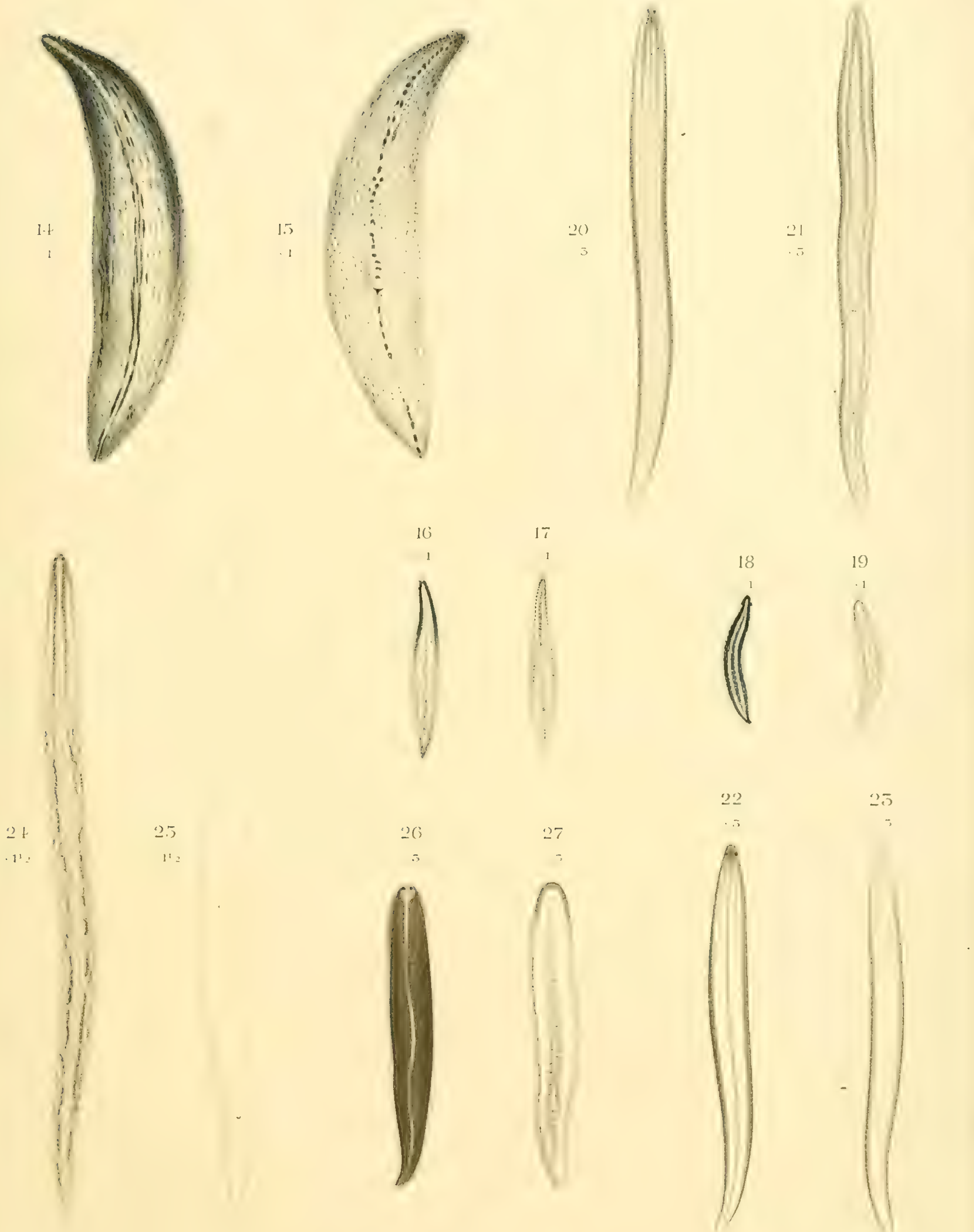

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