

III.—BOTANY.

ART. XXXIII.—*On the Fertilization, etc., of New Zealand Flowering Plants.*

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[Read before the Otago Institute, 11th May, 1880.]

Plate X.

THE collection and examination of the flowering plants of this colony have occupied a good deal of my spare time during the last four or five years, and have enabled me to accumulate some materials for working out the various modes of fertilization which are to be found among them. These materials, even when made the most of, are however only sufficient to show how little is really known of this most interesting subject. In giving, then, the results of my imperfect observations, I do so in the form of a preliminary notice, which I trust will pave the way for fuller and more detailed work in the future. This subject of the fertilization of our flowering plants is necessarily so mixed up with the question of our insect fauna that I am led to unite the two to a certain extent, and show the relationship which exists between them.

At the risk of repeating to many here information which they already possess, I will—for the benefit of the uninitiated—shortly explain the phenomena of fertilization of flowering plants, as far as external manifestations are concerned. The sexual organs of such plants are contained in those parts of the flower termed, respectively, *stamens* and *pistil*. A stamen consists essentially of a 1-, 2-, or 4-celled cavity, called the *anther* (which may or may not be mounted on a stalk, or *filament*), and which contains, usually, a vast number of small, variously-shaped, cellular bodies, the *pollen-grains*, which either are themselves, or contain, the male fertilizing element. The pistil consists of a 1- or more-celled cavity, the *ovary*, containing *ovules*, in which the female element occurs. External to the ovary is a glandular portion (of extremely various shapes in various plants), termed the *stigma*, which at a certain stage of the development of the flower becomes viscid, and so fitted to catch and retain the pollen-grains. In some cases the stigma is on a stalk, the *style*, in others it is sessile. The pollen-grains, when in contact with and apparently excited by the viscid secretion of the stigma, produce very slender tubes which grow down and penetrate the ovary, and finding their way to the *micropyles* (or apertures)

of the ovules, bring about fertilization. Into this part of the subject I do not propose to enter, but will confine myself to the modes in which the pollen is transferred to the stigma. In a very large number of species, both stamens and pistil occur in the same flower, which is then said to be *hermaphrodite*. In other species, the stamens and pistil are in separate flowers, which are then *unisexual*. Unisexual plants are *monœcious* when the staminate and pistillate flowers are on the same plant, as in *Carex*, etc., and *diœcious* when they are on different plants, as in *Coprosma*. Lastly, some plants, as manuka (*Leptospermum scoparium*), produce both hermaphrodite and unisexual flowers, and are then said to be *polygamous*.

At first sight it would seem as if all hermaphrodite flowers were self-fertilized, *i. e.* that the pollen from the anthers became transferred to the stigma of the same flower, and so brought about fertilization. On examination, however, it is found that this is not always the case; in fact it would seem not to be the case in a majority of instances. By a multiplicity of means and contrivances it happens that many hermaphrodite flowers cannot be self-fertilized, but are dependent upon the pollen of other flowers, which may be brought to them in various ways. Unisexual flowers of course are always dependent on other flowers for their fertilization. The two great agents which carry out this cross-fertilizing process are insects and the wind, and plants are termed *entomophilous* or *anemophilous*, according as they are dependent on one or the other agency. Some birds (chiefly tuis and honey-birds in New Zealand) aid in the process, but only seven or eight species of Otago flowers are fertilized by them. (The following are the species with which I am acquainted, which are thus visited and aided:—*Clianthus puniceus*, *Sophora tetraptera*, *Metrosideros lucida*, *Fuchsia excorticata*, etc. *Loranthus colensoi* (?), *Dracophyllum longifolium* occasionally, and *Phormium tenax*. Probably there are others.)

It is hardly worth while to discuss here and now the *pros* and *cons* of the theory first enunciated by Sprengel, but only fully explained by Darwin and his followers—that the characteristic features of each species of plant and animal have been acquired during a long “struggle for existence,” and are the result of the adaptation of the species to its environments. It is sufficient to affirm that it is now held by most biologists that the colour, odour, and honey of flowers are designed to attract insects, and have been produced in accordance with the law of the survival and accumulation of favourable variations. Other flowers not furnished with these means of attraction have been developed into their present forms by the gradual production of certain other characters favouring their fertilization by wind, until they have become strictly *anemophilous*. In New Zealand we seem to see the transition stage to this state of things taking place among some species.

In whatever manner flowers may be fertilized, it is now known that pollen from a flower on a different plant seems to produce more and larger seeds, from which spring finer and stronger plants, than result from fertilization by pollen of the same flower applied to its own pistil. Hence probably, to a certain extent at least, the advantages of, and tendency to, separation of the sexual organs, which is so common a phenomenon among New Zealand flowers.

A point worthy of notice among entomophilous flowers is this,—that not only have flowers become modified for fertilization by insects, but even by certain insects only. Thus some are suited for fertilization by Lepidoptera alone, others by Diptera, Hymenoptera, or Coleoptera only, while some are actually dependent on certain species of insects. This seems to be the case with several species of the long-nectaried orchids of the sub-tropical genus *Angræcum*, and with *Trifolium pratense* (the common red clover), which is apparently only fertilized by long-trunked bees of the genus *Bombus*. But even the converse probably holds good, viz., that many insects have become modified in certain respects by their becoming to some extent dependent on certain species of flowers. Thus it can only be moths or butterflies with an extremely long proboscis which can obtain honey from the whip-like nectary of *Angræcum sesquipedale*, which attains a length of eleven inches (though no species has yet been found which accomplishes this); and we can understand how completely dependent the flowers of this plant are upon such moths, and how the insects themselves must be advantaged in that no others can compete with them for this supply of food.

Among hermaphrodite flowers in which no special arrangement or contrivance exists for preventing self-fertilization, it does not follow that the pistils are always pollinated by the stamens which are included in the same perianth with them. Darwin* has pointed out that in very many plants the flowers of which are quite fertile with their own pollen, the pollen from other flowers is found to have a greater fertilizing power, and to produce fertilization of the ovules even after their own pollen has been scattered on the stigmas; so that the visits of pollen-carrying insects to such flowers are sure to be advantageous, even although not absolutely necessary for the production of seed. Hermaphrodite flowers show every gradation between perfect self-fertility, such as prevails in various species of Cruciferous and Caryophyllaceous plants, and absolute self-sterility, as in *Oxalis magellanica*, in which no seed is produced even after the stigma has been abundantly smeared with pollen from the adjacent anthers. This latter state of self-sterility is, however, attained in a variety of ways. Thus in some flowers, the anthers dehisce and scatter all their pollen before the stigmas are ready

* "Cross- and Self-Fertilization of Plants," p. 391.

to receive any—this occurs in *Wahlenbergia*, *Gentiana*, etc., and such flowers are functionally unisexual, and are said to be *proterandrous*. But all have not this character so fully developed, and every gradation may be noticed from complete proterandry to the opposite extreme. Thus in buttercups, the outer anthers commence to dehisce first, and the process extends from without inwards; but considerably before the inner anthers have dehisced the stigmas have become viscid. In *Epilobium* again, at least among New Zealand species, I have never been able to notice any difference of time between the maturing of the anthers and stigmas. Here cross-fertilization, when it takes place, will be chiefly accomplished through the prepotency of the pollen brought from other flowers by insect visitants. But this functional separation of the sexes is equally well accomplished by the opposite arrangement, viz., the maturing of the stigmas first, and the protrusion and dehiscence of the anthers only after the former have been pollinated and are withered up. This is very well exemplified in the various species of *Coriaria* (tutu). Such flowers are called *proterogynous*, while the term *dichogamy* is applied generally to the maturing of the sexual whorls at different times.

Another means of accomplishing the same end, viz., cross-fertilization, is attained by the occurrence of two or more forms of flowers in the same species (*heterostylism*). Thus some species of *Primula* are *dimorphic*, having two forms, one with long style and short stamens, the other with short style and long stamens. Some few flowers are even *trimorphic*. For a more complete description of these forms I must refer to Darwin's work already quoted. I have not detected distinct heterostylism in any New Zealand plant as yet, though in some *Pimeleas*, *Asperula*, etc., I have found something very like it. Special structures of the perianth, or of the sexual whorls, serve to prevent self-fertilization among certain flowers, and to ensure their proper pollination, but these are so numerous and varied as to obtain only a passing notice here. I have detailed in the body of this paper the most conspicuous of these modes, as they are exemplified among New Zealand plants.

It is worthy of notice that entomophilous plants are usually furnished with flowers possessing, more or less markedly, the following characters:— (1.) *Conspicuous appearance*, attained in a variety of ways, viz., by individual size as in *Clematis indivisa*; aggregation into more or less dense clusters as in *Rubus australis*, and many of the Compositæ, etc.; or, brilliancy of colour as in our iron-wood, (*Metrosideros lucida*). (2) *Fragrance*. (3) *Honey*. Sometimes all three characteristics are present, as in certain of the wild roses of Europe, but as a general rule a principle of economy prevails, so that if any one attraction is present to a great extent, the others are usually wanting. Thus *Clematis indivisa* has very conspicuous flowers, but they

lack both scent and honey. *Clematis fœtida* is overpoweringly fragrant, but is not strikingly conspicuous and has no honey. *Fuchsia excorticata* and *Phormium tenax* are only partially conspicuous (as far as colour is concerned), have no scent, but produce great quantities of honey. *Tupeia antarctica* is very fragrant, and produces a comparative abundance of honey, but is extremely inconspicuous. Besides these three characteristics of attraction, we may note that entomophilous plants usually have comparatively small stigmas, and produce relatively a small quantity of pollen, and that both stigmas and anthers are so placed that it becomes difficult for insects to enter the flower without coming into contact with one or other. In some flowers there are also irritable organs, as in the lamellate stigmas of *Mimulus*, the stamens of *Berberis*, etc. Very few such contrivances have, however, been noticed among our local flowers.

Before leaving this part of the subject, it is interesting to note that several species produce both entomophilous and also strictly self-fertilized flowers. These latter are usually very inconspicuous (hence called *cleistogamic*), and are produced after the ordinary conspicuous flowers. I have already recorded their occurrence in the genus *Viola*,* and believe they also occur in *Hypericum japonicum*. I have not investigated the subject, but I think that all the winter-produced flowers of *Trifolium minus*, a very common introduced plant, are cleistogamic. Flowers of this kind have been recorded as occurring in the following genera, which are represented in New Zealand, though I have never found them in our species, viz.:—*Oxalis*, *Drosera*, *Campanula* (*Wahlenbergia*), *Cuscuta*, *Thelymitra*, *Juncus*, and *Danthonia*. Probably others have been recorded, which I have not noticed.

Among anemophilous plants, the following characteristics usually prevail:—(1) flowers usually inconspicuous and destitute of honey and fragrance, these being of no use to them; (2) the pollen usually light and powdery, and produced in great quantity in anthers which are generally so constructed as to be easily shaken; and (3) the stigmas of comparatively large size, greatly protruded and very papillose,—all characters favourable to the dispersion of the pollen by wind, and its transportation to and retention by the pistils.

Having noted shortly the means of fertilization among flowering plants, it may be asked,—How is the prevalent imperfection of our New Zealand flowers to be accounted for? That they are imperfect to a great degree (if separation of the sexes constitutes imperfection) is a fact well-known to botanists; perhaps in no other part of the world is this found to such an extent. Species, genera, and orders which are characterized by hermaphrodite flowers in other parts are frequently unisexual here. I am afraid

* "Trans. N.Z. Inst.," Vol. XI., p. 415.

the question cannot be satisfactorily answered yet; our knowledge of the subject is of too fragmentary and incomplete a nature. Mr. A. R. Wallace, who may be considered one of the most leading authorities on such a question, concludes that the poverty of insect life here is one of the chief causes. He says*—and I must be pardoned for quoting his opinion at some length—“In New Zealand, where insects are so strikingly deficient in variety, the flora is almost as strikingly deficient in gaily-coloured blossoms. Of course there are some exceptions, but, as a whole, green, inconspicuous, and imperfect flowers prevail to an extent not to be equalled in any other part of the globe, and affording a marvellous contrast to the general brilliancy of Australian flowers, combined with the abundance and variety of its insect-life. We must remember, too, that the few gay or conspicuous flowering-plants possessed by New Zealand are almost all of Australian, South American, or European genera; the peculiar New Zealand or Antarctic genera being almost wholly without conspicuous flowers.† * * * The poverty of insect-life in New Zealand must, therefore, be a very ancient feature of the country; and it furnishes an additional argument against the theory of land-connection with, or even any near approach to, either Australia, South Africa, or South America. For in that case numbers of winged insects would certainly have entered, and the flowers would then, as in every other part of the world, have been rendered attractive by the development of coloured petals; and this character once acquired would long maintain itself, even if the insects had from some unknown cause subsequently disappeared.” “After the preceding paragraphs were written, it occurred to me that, if this reasoning were correct, New Zealand plants ought to be also deficient in scented flowers, because it is a part of the same theory that the odours of flowers have, like their colours, been developed to attract the insects required to aid in their fertilization. I therefore at once applied to my friend, Dr. Hooker, as the highest authority on New Zealand botany; simply asking whether there was any such observed deficiency. His reply was,—‘New Zealand plants are remarkably scentless, both in regard to the rarity of scented flowers, of leaves with immersed glands containing essential oils, and of glandular hairs.’ There are a few exceptional cases, but these seem even more rare than might be expected, so that the

* “The Geographical Distribution of Animals,” Vol. I., pp. 457-464.

† The following exclusively New Zealand or Antarctic genera are surely exceptions: *Notothlaspi* (white), *Hectorella* (white), *Hoheria* (white), *Entelea* (white), *Pennantia* (white), *Notospartium* (pink), *Ixerba* (white), *Stilbocarpa* (yellowish), *Corokia* (yellow), *Pleurophyllum* (purple), *Raoulia* (white), *Helophyllum* (white), *Colensoa* (blue), *Myosotidium* (blue), *Rhabdothamnus* (reddish), *Earina* (white and yellow), and *Phormium* (reddish). All these are more or less entomophilous.

confirmation of the theory is very complete. The circumstance that aromatic leaves are also very scarce, suggests the idea that these, too, serve as an attraction to insects. Aromatic plants abound most in arid countries and on alpine heights; both localities where winged insects are comparatively scarce, and where it may be necessary to attract them in every possible way.* Dr. Hooker also informs me, that since his 'Introduction to the New Zealand Flora' was written, many plants with handsome flowers have been discovered, especially among the *Ranunculi*, shrubby *Veronicas*, and herbaceous *Compositæ*. The two former, however, are genera of wide range, which may have originated in New Zealand by the introduction of plants with handsome flowers, which the few indigenous insects would be attracted by, and thus prevent the loss of their gay corollas; so that these discoveries will not much affect the general character of the flora, and its very curious bearing on the past history of the islands through the relations of flowers and insects."

It is impossible to differ from this reasoning *in toto*, because the statements and facts on which it is founded are to a great extent correct, though in the light of more recent knowledge they require considerable modification. I do not see, however, that the imperfection alluded to, viz., the great tendency among our plants to sexual separation, is yet explained. It may help to solve the question if the proportions of the various kinds, forms, colours, etc., of our flowers be examined. The following numbers may be taken as approximately correct; they are drawn up from those species only which I have personally examined and noted:—

TOTAL OF SPECIES EXAMINED, 433.

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|---|------------------------------------|
| (1). Flowers conspicuous by themselves | 131; over 30 per cent. |
| " " " association† | 91; " 21 " |
| " " " inconspicuous‡ | 211; nearly 49 " |
| (2). If we take, now, the colours of the whole we find—White (142 sp.), nearly 33 per cent.; yellow (48 sp.), over 11 per cent.; red, of all shades (21 sp.), about 5 per cent.; blue or purple (11 sp.), or about 2½ per cent.; the remainder being greenish, or inconspicuous.‡ | |
| (3). In regard to the possession of fragrance, the numbers are— | |
| Sweet scented | 95 species; or nearly 22 per cent. |
| No scent perceptible | 338 " " " 78 " |
| (4). Those noted as being melliferous, or not | |
| Possessing honey | 189 species; over 43 " |
| Not having honey | 244 " " 56 " |

* Anyone who has botanized on our mountains must have been struck with the number and brilliancy of the flowers, mostly white (*Celmisias*, *Raoulia*s, *Ranunculi*, *Veronicas*, etc.), which grow in such localities. Many fine insects are also confined to the mountains, however.

† Includes all the (conspicuous) *Compositæ*.

‡ Includes most of the lower *Monocotyledons* (*Juncæ*, *Cyperacæ*, *Graminæ*, etc.)

- (5). Always hermaphrodite, were noted .. 235 species; or 54 per cent.
 „ more or less unisexual* .. 198 „ nearly 46 „
 (6). Apparently self-fertile 208 „ „ 48 „
 (This is a very doubtful approximation.)
 Certainly entomophilous 102 species; or over 23 „
 „ anemophilous† 123 „ nearly 29 „
 (7). Of the 235 hermaphrodite species, 87 sp., or 37 per cent., are proterandrous;*
 18 sp., or nearly 8 per cent., are proterogynous; while 130 sp., or 55 per cent., are not decidedly one or other.

If we take out the most prominent of these figures we shall see that a very large proportion of our plants are dependent on insect aid, more or less. While 23 and 29 per cent. respectively are solely dependent on insects and wind, the remaining 48 per cent. are put down as more or less self-fertile. But even of these it is probable that a large proportion have their fertilization aided if not exclusively effected by insects. Again, no less than 51 per cent. have conspicuous flowers, while had I excluded from these results the large, inconspicuously-flowered orders of Gramineæ, Cyperaceæ, etc., the average of this class would have stood very much higher. Of course it is a good deal a matter of private judgment and opinion as to how large a flower or flower-cluster must be before it merits the term conspicuous. I have included under this head such flowers as *Cardamine*, *Oxalis*, *Geranium*, etc., because, though small, they are very readily seen; but I have excluded the large solitary *Pterostylis*, and the dull clusters of *Fagus*, *Grisebinia*, etc., which are of too green a hue to be readily distinguished. But again it must be remembered that a flower may be conspicuous enough to an insect, even if not so to us. The fragrant-flowered plants only amount to 22 per cent., and the honey-producing to 43 per cent. of the whole, but here it is to be said that flowers do not produce honey and are not fragrant at all stages of their development. It is probable that the secretions which serve to attract insects are only produced under certain conditions of weather, temperature, etc., which we are at present ignorant of; and when the various sexual whorls are at a proper condition to receive or benefit by the visits of insects. My numbers, therefore, in these two last items are probably considerably under the mark. Here, again, it may be noted that a flower may be possessed of a kind or an amount of fragrance which is not appreciable to our olfactory nerves, though it may be to those of an insect. This remark applies particularly to the Diptera, which, as an order, have probably attained the greatest perfection in this respect. Everyone must be aware of the marvellous power of scent possessed by the ordinary blue-flies, for example, and the faculty is, no doubt, fairly well developed in the flower-visiting species also.

* Includes all the (conspicuous) Compositæ.

† Includes most of the lower Monocotyledons (Juncæ, Cyperaceæ, Gramineæ, etc.)

It may also be pointed out that with regard to the two hundred and thirty-five species of hermaphrodite flowers examined, there are several (*Oxalis magellanica* being a good example) which appear quite capable of self-fertilization, but are in reality self-sterile.

Having now considered the flowering plants, I would shortly draw attention to what is known as to the relations of our insects to them. As far as I can make out, this amounts to very little. One thing is clear, however, viz., that the prevalent impression as to the poverty of insect life here (as it is expressed in Wallace's work), is not quite correct. Certain prominent classes of insects are very poorly represented, both in species and individuals, but others almost make up for them. Mr. Wallace's figures are in this respect misleading, not from error on his part, but owing to the immense number of new forms which have been described since his work was published. I give shortly the approximate number of species of the various orders of insects, as far as they are known at present. I am indebted for this part of my subject—and I would thankfully acknowledge it here—to Capt. Broun, Prof. Hutton, and Messrs. W. Colenso and R. Fereday, who have given me valuable information regarding those orders which they have respectively examined. Mr. Wallace's figures are subjoined for comparison.

Of butterflies, Lepidoptera, only 18 species (A. R. W., 11 sp.) are known, but of moths (not mentioned by Wallace) several hundreds are described in numerous publications, while probably half as many more are undescribed. These latter insects are also extremely numerous in individuals, and many of our flowers (as *Leucopogon*, etc.) appear to be exclusively fertilized by them. Of Coleoptera about 1300 species are now described (A. R. W., 300). Of these a great number are not flower-visitants, but others again are greatly concerned in this work of flower-fertilization. I quote with pleasure here some extracts from a memorandum on the subject which Captain Broun kindly furnished me with:—"Of the family Palpicornes, two genera—*Hydrobius* and *Philhydrus*—consist of water-loving species as is usual in other countries; but one peculiar New Zealand genus, *Rygmodus*, of six species, is of quite abnormal habits. One, *R. modestus*, which is commonly found on the inflorescence of *Brachyglottis repanda*, *Cordyline banksii*, etc., has finely spinous legs, and, though somewhat metallic above, is hairy underneath. It undoubtedly plays an important part in the fertilization of flowers, a remarkable trait in the case of an insect belonging to that family—I think the only instance known to science. Most of the others are rare, and though described by me were found by other collectors, so that I cannot speak authoritatively as to their habits; I suspect, however, that all frequent plants. * * * Of the Melolonthidæ,

the pretty *Pyronota festiva*, metallic above, hairy below, is found in profusion on the inflorescence of *Leptospermums*. * * * The Buprestidæ (A.R.W., 1 sp.) and Elateridæ (A.R.W., about 12 species) about 80 species, are wood-feeders in the larval state, but when perfect insects occasionally visit flowers. Nearly all the Dascillidæ do so too, and must, being hairy, render important services. * * * All the Melandryadæ and Mordelliæ frequent flowering shrubs; one insect—*Selenopalpus cyaneus*—is never found away from them, chiefly ti-tree (*Cordyline australis*); but I once noticed numbers of this species on grass when in blossom. The Curculionidæ, an extensive family, in most cases having scaly or hairy clothing, to a great extent aid the seeding of flowers. The species of *Eugnomus* are very partial to the lawyer (*Rubus australis*) when in bloom. Altogether about 40 species of the Eirrhinidæ may be found on most of the indigenous flowering shrubs. *Apion metrosideros* confines itself almost exclusively to the pohutukawa (*Metrosideros tomentosa*). *Oropterus coniger* lives entirely on the native fuchsia (*F. excorticata*). The Longicornia are wood-feeders, but often visit flowers. *Zorion minutum* confines itself almost exclusively to flowers. Some, but not all the Phytophaga, are found on flowering plants. *Arnomus brouni*, though very rare, is generally found on *Leptospermum*; 11 species of the genus *Colaspis* (A.R.W., 2 sp.), usually found in abundance, frequent the inflorescence of many shrubs." It will be noticed from these quotations that Captain Broun's observations are made on North Island plants. Had we similar observations continuously made on the flora of other parts, and particularly of mountain districts, we should soon be able to solve many problems which are very obscure at present. Hymenoptera (A.R.W., only a score of species) are very poorly represented, the only flower-visitants being 10 species of bees. The Orthoptera probably do not visit flowers; but many of the Hemiptera-Heteroptera do, only as no attempt has been systematically made to catalogue them yet, I am in utter ignorance as to the number of species. Prof. Hutton informs me that the following flower-visiting species are very abundant in individuals, viz., *Anubis vittatus*, *Rhopalimorpha obscura*, *Nysius huttoni*, and *N. zealandicus*. The most important flower-visiting order in New Zealand is probably, however, the Diptera (not noticed by Wallace). Only about 100 species have been described, but this, Prof. Hutton informs me, is probably only about one-tenth of the whole number. As far as I can make out, the Diptera depend chiefly on scent in their search for food, and certainly this would explain the fact of their being the sole fertilizers of many inconspicuous or green flowers, as *Tupeia antarctica* and various species of *Pterostylis*, etc. I was formerly of opinion that the part apparently taken by the New Zealand Diptera in this work of fertilization was quite an exceptional case, and that

here they performed the work done by bees and butterflies in other countries; but a short and suggestive letter by H. Müller in "Nature" (Vol. XXI., p. 275) shows that among alpine (European) flowers generally Diptera come next in importance to Lepidoptera as flower-visitants, while among lowland flowers they are only exceeded by the Hymenoptera. In the absence of any more definite information on the subject, I would only advance it as a suggestion that here Diptera will be found to be by far the most numerous class of flower-fertilizers. In concluding this introductory portion of my paper, I would point out that my observations do not extend to many of our purely mountain forms, among which are to be found some of the finest flowers in New Zealand.

I now give in detail the results of my investigations on a number of our flowering plants. These deal chiefly with their mode of fertilization, but include some other points which have been noted as well.

Nat. Ord. RANUNCULACEÆ.

Of this order only two genera are represented in this part of Otago, and these by a few species.

All the New Zealand species of *Clematis* are hermaphrodite or unisexual in structure, but all are dioecious in function. The male flowers are furnished with stamens only, without any trace of carpels, while the female flowers have a row of stamens surrounding the mass of carpels, but these have abortive anthers which never appear to produce pollen.

Clematis indivisa and *hexasepala* depend solely on the size and brilliancy of their large white flowers, which are always displayed in most conspicuous situations. They appear to be destitute of scent and honey, and though apparently suited only for insect-fertilization, I have never seen them regularly visited. As is usually the case in entomophilous dioecious plants, the male flowers are larger and brighter than the female, which have more or less of a greenish hue. While the former are usually two to three inches in diameter, the latter seldom exceed one inch and a half.

Clematis fatida, grossly misnamed by Raoul. This is a much lower-growing, altogether humbler, plant than the first-named, and its flowers are only a little over half an inch in diameter. They are greenish-yellow in colour, and tolerably conspicuous from their number; but their chief attraction lies in their overpoweringly strong perfume. I have never found honey in them.

Of the genus *Ranunculus* I have observed six species, viz., *R. sinclairii*, *R. plebeius*, *R. lappaceus*, *R. macropus*, *R. rivularis*, and *R. acaulis*. These species are all hermaphrodite, nor have I detected a trace of abortion in their parts. All appear also to be more or less proterandrous, and to be furnished with a scale-like nectary on the petals. This is better

developed in the larger and brighter flowered species such as *R. lappaceus*, than in such as *R. acaulis*, while in some forms of *R. plebeius*, in which the petals are much reduced both in size and number, it shares the same fate, and is nearly rudimentary. I believe all these species are self-fertile, but as they are frequently visited by insects they will often be crossed by pollen of other flowers. Specimens of *R. plebeius* grown by me under bell-jars, and carefully excluded from the visits of insects and from currents of air, have produced abundance of large and fine capsules.

Nat. Ord. MAGNOLIACEÆ.

Drimys axillaris, the common form of pepper-tree in this part, is certainly not *D. colorata*, Raoul, as described in the appendix to the "Hand-book of the Flora of New Zealand," p. 724, but agrees completely with the description of *D. axillaris* as given at p. 10 of that work.

I have never been able to make out satisfactorily its mode of fertilization. The flowers are hermaphrodite and quite inconspicuous, being small and greenish-coloured, and almost solitary on the branches, where they occur nearly hidden on the under-side. They do not seem fitted in any way for insect-fertilization, and yet, from the sparingness with which they produce fruit, I can hardly think them self-fertilized. They are destitute of scent and honey, but produce a considerable amount of pollen.

Nat. Ord. CRUCIFERÆ.

I have examined the following—*Nasturtium palustre*, *Sisymbrium novæ-zealandiæ*, and *Cardamine hirsuta*—and find nothing which would lead me to think them only cross-fertilized. The last named is perfectly self-fertile, isolated plants under bell-jars producing abundance of good seed, and the same probably applies to the other New Zealand species, these being all occasionally crossed by insects.

Nat. Ord. VIOLARIÆÆ.

Two species of *Viola* are common, viz., *V. filicaulis* and *V. cunninghamii* but the structure of their flowers is similar. As has been already pointed out,* these produce two kinds of flowers, the ordinary showy form, and—later on in the season—an inconspicuous (cleistogamic) form. The ordinary flowers are white, more or less streaked with blue or purple, and these streaks act as guiding lines to the few insects which visit the flowers, being all on the large lower petal, and converging towards its base. The anthers are connate, and the contained pollen, being of a rather dry or mealy consistence, falls out of the nodding flowers very easily. The short spur contains a little honey, which could not be well reached by an insect without disturbing the anthers; and the stigma is so placed as to be in the way of any insect entering the flower. In his

* "Trans. N. Z. Inst." Vol. XI., p. 415,

work on "British Wild Flowers in relation to Insects," Sir John Lubbock gives a memorandum of Mr. Darwin's on the fertilization of *V. tricolor*, the common heartsease or wild pansy, which is applicable, to a great extent, to the whole genus. He remarks how rare it is to see any insect visiting the flowers, and how he watched many times daily in a fortnight before he saw a single bee visiting a certain clump of heartsease. I have myself repeatedly watched patches of our violets, and have never seen them visited by any insect.

Species of thrips are to be found in these flowers—as, indeed, in most flowers—and Mr. Bennett considers that the fertilization of *V. tricolor* is due to this insect. It seems to me, however, that this view must be erroneous. Thrips is an insect which lives *in* the flower it frequents, feeding probably on the pollen, and only flying to other flowers to lay its eggs in them. In the course of its running about inside a flower, it probably frequently carries pollen from the anthers to the stigma, but this would only bring about self-fertilization, whereas the flowers are specially constructed to avoid this. Even where several flowers are crowded together in the same inflorescence, if the pollen of each was distributed to others, the fertilization—if it took place—would not be that of a true cross.

I have not verified, experimentally, whether the ordinary flowers of both our violets are self-fertile, but from the fact of frequently finding withered flowers in which the ovaries showed no signs of enlargement, I think it improbable that they are. I have never been able to detect any scent in the flowers of either *V. filicaulis* or *V. cunninghamii*.

The genus *Melicytus* contains four New Zealand species, all of which occur in Otago, but I have only examined two of them. The name of the genus—literally, *honey-cavity*—suggests the occurrence of abundant nectar. This is secreted by the so-called scale at the back of each anther. This is a thick succulent club-shaped organ, on the apex of which a bead of honey is produced. The flowers are polygamous, ranging from perfect unisexuality to complete hermaphroditism. The male flowers occasionally have imperfect pistils, though the total want of the pistil is commoner. The female flowers, on the contrary, seem always to be furnished with stamens, though the anthers are frequently abortive, and the reason of this may be the adaptation of part of the anther for the secretion of honey.

M. ramiflorus produces enormous numbers of flowers of a greenish-yellow hue, conspicuous by their mass, fragrant and abundantly supplied with nectar. These cannot be wind-fertilized growing as they do in dense bush where the wind can hardly affect them, and having somewhat waxy pollen.

M. lanceolatus has relatively larger flowers, and they are individually more conspicuous, being yellowish in their lower part, and having the

recurved portion of their petals purplish. Like those of the preceding species, they are crowded chiefly along the under-sides of the branches, but are even more hidden by the foliage. They are sweet-scented, and contain abundant nectar.

Nat. Ord. PITTOSPOREÆ.

About twelve species of *Pittosporum* occur in New Zealand, and two of these are common in the east of Otago.

P. tenuifolium, belonging to the section of the genus having solitary flowers, is a very handsome little tree. Its flowers are a good deal hidden by the foliage, but are tolerably conspicuous, the petals being bright purple when first expanded, and gradually deepening in colour as they begin to wither. As soon as the flower opens the stigma is seen to be viscid, and it remains so long after the pollen is shed. The base of the ovary is hairy, and between it and the filaments small beads of honey are secreted. The object of the hairs is probably to prevent any insects reaching the honey except those which are furnished with a proboscis. The pollen is very coherent, and not easily shaken from the anthers. The flowers have no perceptible fragrance.

P. eugenoides, according to Hooker, is more or less diœcious, though the numerous specimens I have examined were invariably hermaphrodite. The flowers are produced in large corymbs, which are very conspicuous, and they are extremely fragrant, and secrete a quantity of honey between the bases of the ovary and filaments. In many cases, when opening, the anthers are found dehiscing almost on the viscid stigma, to which some of the pollen-grains adhere. In this way probably the flowers are often fertilized, while their attractions to insects are so numerous as almost to ensure cross-fertilization.

Nat. Ord. CARYOPHYLLÆ.

The order is represented by four genera—*Gypsophila*, *Stellaria*, *Colobanthus*, and *Spergularia*. Our species are probably all self-fertilized, the only doubtful one being *Stellaria roughii*, a mountain form with large green flowers. The others have small, and, in some cases (*Colobanthus*), perfectly inconspicuous flowers, destitute of colour, scent, or honey.

Nat. Ord. PORTULACÆ.

Claytonia australasica has small, white flowers, which are, however, relatively very large when compared with the size of the whole plant. They are tolerably conspicuous, have a little honey at their base, and are distinctly proterandrous, the divisions of the style being stigmatic on their inner faces only, and these remaining closed until the pollen is scattered.

Nat. Ord. HYPERICINÆ.

Two species of *Hypericum* are found in New Zealand, and both occur in Otago.

H. gramineum has very bright, golden-yellow flowers, which are, however, destitute of smell, and also, I believe, of honey. The numerous stamens do not dehisce all at once, but one after another, and they produce a great quantity of pollen. *H. japonicum* has its fully-formed flowers very similar to the other species, but much smaller. It is remarkable, however, for producing besides a set of flowers in which the capacity for self-fertilization is so complete that they have almost become cleistogamic. There is no true abortion, but only great diminution of the corolla and stamens, and the flowers produce seed without having ever opened. It appears to me that we have here a case of variation going on. Probably the examination of a large series of specimens would show that some had acquired complete cleistogamy. I think both species of *Hypericum* are self-fertilized by the withering and curling-in of the petals, which thus smear the stigmas with pollen, if they have not previously been crossed by insects.

Nat. Ord. MALVACEÆ.

This order is represented by three genera—*Plagianthus*, *Hoheria*, and *Hibiscus*, but only the first two occur in Otago.

Plagianthus divaricatus is a low shrub, occurring abundantly on the muddy shores at the head of Otago harbour. It is strictly dioecious, the male flowers having no trace of a pistil, and the female being furnished with rudimentary stamens, which produce no pollen. The former are much more numerously produced, and are, therefore, more conspicuous than the latter. They produce little or no honey, but to make up for their small size they are extremely fragrant.

P. betulinus is also strictly dioecious. The male flowers are produced in dense panicles, which are whitish-yellow in colour, and are thus very conspicuous; they have no trace of a pistil. The pistillate flowers are in lax panicles, are much more sparingly produced, and, from their greenish colour, are rather inconspicuous. The style is surrounded at its base by a ring of abortive stamens, and the stigma is a wide flattened expansion, proportionally large to the rest of the flower. Both kinds of flowers are very fragrant, and produce honey, the female in this latter respect being better provided than the male.

I have not had an opportunity for years of examining *P. lyallii*, the flowers of which are very large and white.

Hoheria populnea produces great masses of pure white flowers. These are quite hermaphrodite, and appear to depend for their crossing almost entirely on their conspicuousness. They have neither scent nor honey, nor do they appear to be at all dichogamous.

Nat. Ord. TILIACEÆ.

There are three genera of this order in New Zealand: viz., *Entelea* (not found in Otago), *Aristolelia* and *Elaeocarpus*.

Aristotelia racemosa is very abundant, and is interesting from the perfect gradation which it exhibits between true male flowers having no trace of a pistil and true female flowers quite destitute of even the rudiments of stamens, and between these and true hermaphrodite flowers having the full complement of both stamens and carpels. The flowers are produced in great numbers, the male particularly, so that the bushes are bright red with them. They have no perceptible fragrance, and no honey, and the pollen is of so light and friable a nature that I think they must be almost entirely anemophilous, though perhaps assisted in their fertilization by insects. They grow, also, on the edges, or in more open parts of the bush, where they are not shut off from access of wind.

Aristotelia fruticosa is one of those extremely variable species which I think are at the present time undergoing rapid modification into distinct forms. Sir J. D. Hooker states, in the "Handbook of the New Zealand Flora," that he has made four varieties, "but they seem to be states determined by age and exposure, rather than hereditary races." I have, however, gathered three very distinct forms growing all together, which makes me consider them as incipient species. As in *A. racemosa*, the flowers of this species are polygamous, but being much smaller and more sparingly produced it is difficult to say how they are fertilized. I could detect neither scent nor honey. At the same time the flowers have not the loosely-hung anthers, nor the very prominent stigmas, which characterize the majority of wind-fertilized plants.

Elæocarpus hookerianus seems to be fitted for insect-fertilization. The flowers are greenish-white and drooping, but very conspicuous by their abundance. They appear to be strictly hermaphrodite, but are proterandrous. Though destitute of fragrance they produce a great deal of honey, which is probably secreted by the circle of glands surrounding the base of the stamens.

Nat. Ord. LINACEÆ.

Linum monogynum is the commonest representative, and is a very variable plant as to the size of its leaves and flowers. I have not been able, however, to detect distinct dimorphism, which is so characteristic of some European forms, nor have I seen the minute honey-glands, such as occur in *L. usitatissimum*. The flowers are pure white, scentless, but, as far as I can make out, sterile with their own pollen. Examination of more specimens, and cultivation, would throw more light on this plant. I have not been able to examine *L. marginale*, which occurs sparingly in the neighbourhood of Dunedin.

Nat. Ord. GERANIACEÆ.

Of the genus *Geranium*, four species are common, but I have only examined two, viz., *G. microphyllum*, and *G. molle*. The latter has been

described in Lubbock's work already quoted, and the former agrees well with it in its fertilization. The outer anthers commence to open first while the stigmas are still immature and closely pressed together. But before the pollen is all discharged the stigmatic surfaces expand, though they only reach maturity after the anthers are emptied.

Pelargonium I have not examined.

Oxalis is represented by two common species, which differ very much in their habitat, *O. magellanica* being found in damp woods, and mountain bogs and streams, while *O. corniculata* affects dry, sunny localities. *O. magellanica* has white scentless flowers. Of its ten stamens, five are long, equalling the style in height, and five are considerably shorter. The anthers of the latter dehisce first, usually a couple of days before those of the long stamens. The flowers when first open stand nearly erect, but the peduncle gradually bends down, until by the time the petals are withering they are completely pendulous. By this time the petals gradually cohere together and close into a kind of cylinder, which in falling off smears the stigmas with pollen. I was at first of opinion that the flowers were thus self-fertilized, in the event of their not being crossed, but having cultivated a large number of plants under glass, I found that *all the flowers produced* were sterile, not a single capsule having set.

The closely allied European wood-sorrel (*O. acetosella*) produces cleistogamic flowers, but I have never found any on our New Zealand species.

O. corniculata. The brilliant little yellow flowers of this species contain a good deal of honey, and only display themselves on sunny days, which makes me conclude that they are dependent on insects for fertilization, but I have not been able to examine them minutely.

Nat. Ord. *RUTACEÆ*.

Melicope simplex, the only representative of the order in Otago, is an abundant shrub. Its flowers are more or less unisexual, the male having no pistil, and the females having a full complement of stamens, but with abortive anthers. The flowers have little or no honey, but are sweet-scented. They are not, however, individually conspicuous, nor are they produced in large masses, and are therefore, I think, entirely dependent for fertilization upon the numerous small *Diptera* which so commonly frequent the edge of the bush.

Nat. Ord. *OLACINÆÆ*.

Pennantia corymbosa is entirely dependent on insects for fertilization. The flowers are usually dioecious in function though hermaphrodite in structure; but in the male flowers the ovary is only represented by a rudiment, while in the female the anthers are abortive. They are pure white, produced in great quantity, and are very fragrant; I have seen no honey.

Nat. Ord. RHAMNÆ.

Our only local representative is the abundant *Discaria toumatou*. The flowers of this plant are small, green, and hermaphrodite, and produced in considerable numbers along the under-side of the branches. Though inconspicuous, I believe they are chiefly or altogether insect-fertilized. Their fragrance is overpoweringly strong, and they produce a very large quantity of honey, besides which the stamens mature a little before the stigma.

Nat. Ord. CORIARIÆ.

All three species of *Coriaria* are common in the neighbourhood of Dunedin (*C. angustissima* at elevations of about 2,000 feet), and their mode of fertilization is extremely interesting. According to the "Handbook of the N.Z. Flora," the flowers of the genus are hermaphrodite, but in at least two of our species they are polygamous. They are all anemophilous.

C. ruscifolia appears always to be hermaphrodite. The flowers are very markedly protogynous, the stigmas withering completely before the anthers dehisce. The flowers are produced in great abundance, but are green, small, and destitute of honey or scent. (The green colour is to a considerable extent relieved by red in the first stage of flowering, when the stigmas are expanded). The stigmas are relatively large and very papillose, and protrude to a considerable extent. When the stamens are mature, the anthers dangle out at the end of very slender filaments, while the pollen is very light and incoherent.

C. thymifolia and *C. angustissima* agree almost exactly in their flowers. These are sometimes hermaphrodite in structure as in *C. ruscifolia*, in which case they are as distinctly protogynous. But more frequently the parts are more or less wanting, so that we find truly male and truly female flowers, with every intermediate stage to complete hermaphroditism.

Altogether it seems unlikely that they are visited by insects, but everything points to their being fertilized by the wind.

Nat. Ord. LEGUMINOSÆ.

Out of the nine species of *Carmichaelia*, described in the "Handbook of the N.Z. Flora," I have only examined *C. flagelliformis*. The flowers are very distinctly marked, but, being small and isolated, are not conspicuous. They are, however, very fragrant, and contain quite a considerable amount of honey. The anthers dehisce as soon as the flowers open.

Clianthus puniceus. This beautiful flower is only found in cultivation in the South Island, and seems to be chiefly fertilized by birds (*tuis*, *kori-makos*, etc.) The extremity of the style generally protrudes from the flower before it fully expands; only the tip of it is stigmatic, and it is furnished on its lower (outer) side with a brush of hairs. The anthers dehisce before the flowers open, and, as the latter are pendulous, the pollen falls down

towards the apex of the carina, and lodges on the hairs of the style. As soon as the vexillum opens, it curves completely backwards; an arrangement which tends to make the flower more prominent and conspicuous than it would otherwise be. The carina opens about the middle, the two petals diverging slightly at that part, opposite to the anthers of the shorter stamens; in their upper part they remain in contact with each other, their edges slightly folded together, so as to hold the style and enclosed pollen firmly. The flowers are scentless, but the cup-like calyx contains a large drop of honey. It is this delicacy which attracts the honey-birds, which search the flowers with great diligence. In inserting their heads into the flowers, they push back the carina with considerable force; this retains its hold of the style for a time, until the pressure is too great, when the latter is jerked forward by its own elasticity, and throws out the accumulated pollen on the intruder's head. The filaments of the stamens are normally so long as to exceed the carina, but many of them are bent completely back for part of their length. I am not aware what is the use or object of such an arrangement.

Sophora tetraptera. This is another species chiefly visited by honey-birds. It usually flowers very early with us—from July to September—at which time of year there are very few insects about. Like the last-named species, this has very conspicuous pendulous flowers, which are hardly papilionaceous however; they are not sweet-scented, but contain a quantity of honey in the cup of the calyx. The style projects a considerable distance beyond the stamens, and rather out of their line, while only the extreme point is stigmatic. I have no idea whether this species and *Olianthus puniceus* are self-fertile or not, but they are certainly well-fitted for cross-fertilization by the numerous birds which visit them.

Nat. Ord. ROSACEÆ.

This order, like the last, is very poorly represented in these islands, being represented by only four genera and ten species, of which latter two are cosmopolitan. Some of its species, however, are remarkable for the contrivances which enable them to wage a very successful warfare with their neighbours,—the *Rubus* with its powerful recurved spines, and some species of *Acæna* with their singular barbed bristles developed from the calyx-lobes, being pre-eminent in this respect.

Rubus australis is invariably diœcious, a fact which Hooker, in the "Handbook of the N.Z. Flora," appears not to have noticed, or to have overlooked. I have examined great numbers of flowers for several years past, and have never found even a trace of hermaphroditism. I do not know whether this character holds throughout New Zealand; I have occasionally found that certain species of plants which produce hermaphro-

dite flowers in one locality, produce dioecious flowers in another part, where the conditions are different.

In the species under consideration the flowers are produced in great conspicuous panicles, and are not only powerfully sweet-scented, but also contain a quantity of honey. As in almost all such cases, the male flowers are much larger and whiter than the female, which have a greenish hue, and are more sparingly produced. They have also a much wider and flatter disc, so that insects lighting on them turn round and round, smearing the under surfaces of their bodies with pollen. In lighting on the female flowers the same process is repeated, the stigmas of the carpels being brushed over by the under-surfaces of their bodies. The stamens expand from without inwards, the outer anthers being often empty before the inner ones have commenced to dehisce, so that the supply of pollen is kept up for some days.

These flowers seem to be chiefly visited by hairy Diptera of the size and form of a common house-fly, but of which I do not know the species.

Potentilla anserina has very conspicuous bright yellow flowers, which, however, only expand fully in sunshine. Sir J. Lubbock states that the species of this genus have the stigma arriving at maturity before the stamens, so that cross-fertilization generally takes place. I have never been able to detect any difference of such a nature. The honey, as he further states, is secreted in a thin layer, not in drops. The flowers are faintly sweet-scented.

Geum urbanum is stated by Sir J. Lubbock to be melliferous. I have not examined it.

Acæna sanguisorba has its flowers clustered into small heads. They are distinctly protogynous, and, when the stamens expand, they do so one after another. From their inconspicuousness, want of scent, and large papillose stigmas, I am inclined to think that they are wind-fertilized.

Nat. Ord. SAXIFRAGÆÆ.

Carpodetus serratus, belonging to the tribe Escalloniæ, is apparently dependent altogether on insects. The flowers are conspicuous and very fragrant; they produce a large amount of honey, and are distinctly proterandrous.

Weinmannia racemosa, belonging to the tribe Cunoniæ, has also very conspicuous sweet-scented and melliferous flowers. I have not noticed whether they are also proterandrous.

Both these species are hermaphrodite.

Nat. Ord. CRASSULACEÆ.

This order is only represented in New Zealand by five species of *Tillæa*, three of which occur in this neighbourhood. Of these *T. sinclairii* and *T. verticillaris* have extremely minute flowers. *T. moschata* has also very

small flowers, but they are apparently strongly sweet-scented, and secrete honey. The stamens dehisce before the stigma is matured, so that their fertilization is probably aided by insects.

Nat. Ord. DROSERACEÆ.

The extremely interesting genus *Drosera* is represented by six species in New Zealand, all of which occur in this island, and of which I have gathered four. I regret having been unable to get them in sufficiently good flower to notice their mode of fertilization. They do not seem to open their flowers very freely, which fact alone has often led me to think that they are chiefly self-fertilized.

All our species catch and digest insects, and in fact are known in some districts by the name of "Fly-catchers."

D. stenopetala, which I have gathered at Port Pegasus, Stewart Island, where it is abundant, seems to be remarkably well fitted for this work, the hairs on its spathulate leaves being unusually long, and bearing very large glands.

D. arcturi, which grows in bogs on the summit of Maungatua, seems in its native habitat seldom to catch insects, but this is attributed by me to the fact of its being often submerged in wet weather. The leaves are from one to three inches long, and rather narrow-spathulate; the marginal glands are on pedicels about .05 inch long, those on the surface of the blade being much shorter, and interspersed with glandular papillæ. These glands all showed the aggregation of the protoplasm as mentioned in Darwin's "Carnivorous Plants," when acted on by dilute ammoniacal solutions.

I experimented on various leaves by supplying them with small fragments of raw meat and insects. I did not weigh the portions of meat, as I was not particular as to the exact results, but selected them of various sizes, from the size of a pin's-head to pieces as large as a full-sized grain of wheat. In each case the meat was seized by the tentacles (or marginal hairs) in from two to twenty-four hours, those nearest bending first towards it, and by the latter time the colour was generally bleached out of it. The process of absorption lasted from four days to as much as eight for the larger pieces, the meat all the time having a pearly-white appearance, and being bathed in clear liquid, which sometimes accumulated to such an extent as to run down the blade and petiole. In experimenting with insects I placed four full-sized rose *Aphides* on each leaf, and found that on an average they were completely disposed of in about three days, usually not a trace of them remaining. Only those glands in the immediate vicinity of the insects appeared to be concerned in the process. These results were obtained on strong, healthy leaves. Very young leaves seemed easily

sickened by an overdose of meat, while older ones sometimes did not begin to act for two or three days.

Drosera spathulata, like the last, is a very low-growing plant, and in wet weather is frequently submerged. In dry weather, however, it is often seen to have insects adhering to its leaves, the bright red colour probably attracting them. The leaves are very small, and have not such powerful tentacles as *D. arcturi*, but the blades are broader, and when bent form a more perfect cup than the trough-like shape assumed by those of the other species. These gave similar results to the last recorded, being of course supplied with proportionally small supplies of food.

D. binata, as well as the last-mentioned species, is referred to in Darwin's work already alluded to. Its leaves are quite different in form to the spathulate-leaved species, but they are equally active in their power of absorbing nitrogenous materials. In the native state this plant almost always has insects, seeds, etc., etc., adhering to its tentacles, and this may be chiefly due to its erect habit and bright-red colour.

Nat. Ord. HALORAGACEÆ.

My observations on the genus *Haloragis* are very imperfect. The flowers are mostly unisexual, and from their inconspicuous appearance and want of scent are apparently anemophilous. In the smaller species, *H. depressa* and *H. micrantha*, the relatively large plumose stigmas point to the same conclusion.

Myriophyllum is also apparently anemophilous. The plants are usually monœcious, having female flowers in the axils of the lower leaves, and male flowers higher up. This is the case in all the specimens of *M. variæfolium* and *M. pedunculatum* examined by me.

Gunnera monoica and *G. densiflora* are certainly anemophilous. The male flowers are produced on erect peduncles which stand usually well up from the leaves; the female flowers on the contrary, which are very inconspicuous, are in almost sessile clusters and are greatly buried by the leaves.

Callitriche verna also has monœcious (or dicecious) very imperfect flowers, and is probably similarly fertilized. All the species named of this order have powdery pollen.

Nat. Ord. MYRTACEÆ.

This order is fairly well represented in New Zealand, which possesses four genera, including some seventeen species; of these only a few occur in Otago.

Leptospermum scoparium is remarkable for the polygamous character of the flowers, and is the only plant, as far as I know, which departs from the normal hermaphroditism of the order. It would be of interest to ascertain whether it is truly hermaphrodite in Australia. The flowers are sweet-scented and secrete a quantity of honey. They are also very conspicuous,

those which are only staminate in structure being both larger and whiter than hermaphrodite or female flowers. The most singular fact about the plants is that the same branch will produce different kinds of flowers, and that frequently the lower part of a branch will bear the previous year's capsules while the upper part is covered with male flowers only. All stages of hermaphroditism and polygamy occur in this species, which seems absolutely dependent on insect aid for its fertilization.

L. ericoides bears smaller flowers than the preceding, and all that I have observed were hermaphrodite. They are also fragrant and melliferous, and are probably aided in their fertilization by insects.

Metrosideros lucida, the rata or iron-wood of Otago, is one of the most gorgeous plants in New Zealand. Like most of the very conspicuous plants of the genus, it owes its brilliancy to the long tassels of crimson stamens in each flower. The flowers are destitute of scent, but secrete a quantity of honey. They are invariably hermaphrodite, but are probably aided in their fertilization by the numerous tuis and honey-birds which frequent them for the sake of their honey.

M. hypericifolia, a smaller species which climbs on the trunks of trees, is much less inconspicuous than the former. Its flowers are smaller, white, pink or crimson, with much shorter and less conspicuous stamens, but these disadvantages are counterbalanced by the abundance of honey produced, and its fragrance. It is sometimes visited by birds, but more probably by large Diptera.

Myrtus obcordata and *M. pedunculata* have nearly similar flowers, and are apparently dependent chiefly on insect-aid. Though not produced in great quantity, they are white and tolerably conspicuous, very fragrant, and distinctly proterandrous. I have not observed any honey in them.

Nat. Ord. ONAGRARIÆ.

The genus *Fuchsia* is usually considered to have three representative species in New Zealand, viz., *F. excorticata*, *F. colensoi*, and *F. procumbens*, but I should really consider them as two widely different forms, with a great many intermediate gradations. They all agree, however, in the peculiarity of their flowers which I am about to describe, and which I am rather astonished has not been noticed before. Each of these kinds is dimorphic, possessing two very distinct forms of flowers.

The larger form of flower is green and purple, an inch to an inch and a half long, stout, and with exserted anthers. These produce abundance of brilliant blue pollen, which is tied together in a remarkable manner by slender threads. These flowers are hermaphrodite in function as well as in structure, but the stigma matures before the anthers, so that cross-fertilization must often take place.

The other form of flower is much smaller, seldom exceeding five-eighths of an inch in length, pale green and pink in colour, and with very short stamens furnished with abortive anthers, which contain no pollen. These flowers, though hermaphrodite in structure, are pistillate in function, and may often be seen with their stigmas smeared with the blue pollen of the larger form.

In the "Handbook of the N.Z. Flora," p. 728, the length of the stamens has been taken as a character separating *F. procumbens* from the other two, the latter having the stamens as long as or longer than the calyx-lobes, and *F. procumbens* having them shorter. I have, however, repeatedly found true *F. excorticata* with both forms of flowers, and *F. procumbens* also with both, and this is one of my chief objections to admitting the validity of the three species.

Both forms of flowers are scentless, but produce a large quantity of honey within the calyx-tube. They appear to be fertilized only by tuis and honey-birds. As in the case of the other plants frequented by these birds, viz., *Clianthus*, *Sophora*, and *Metrosideros lucida*, the *Fuchsia* flowers are pendulous, affording no resting place for insects, while the great quantity of honey secreted would drown any but a large form furnished with a long trunk.

I believe that the dimorphism manifested by our *Fuchsias* is a modification tending in the direction of separation of the sexes, and which would ultimately lead to the production of dicecious plants. This is remarkable, as occurring in an order characterized among other marks by the hermaphroditism of its flowers. Probably the polygamy already noticed as occurring in *Leptospermum scoparium* among the Myrtaceæ is a further development of the same tendency.

The genus *Epilobium* is credited in the "Handbook of the N.Z. Flora" with seventeen species (or, as they might more correctly be called, varieties of about ten or twelve tolerably distinct forms). It is one of those remarkable genera probably undergoing rapid modification and development at the present time, in which the variety of form is so great that it becomes impossible to define the species with any accuracy. The various forms range from minute-flowered like *E. nummularifolium* var. *brevipes* to the large handsome-flowered *E. pallidiflorum*. All are strictly hermaphrodite, and I have not been able to notice any very appreciable difference in time between the maturing of the stamens and pistil. They all seem to be self-fertilized, though the finer-flowered forms are probably largely aided and crossed by insects. I have grown *E. nummularifolium* and *E. pubens*, and carefully isolated them under glasses when about to flower, so that all access of insects or of wind was prevented, and they have produced a vast number of

capsules and seeds. From the great variety of intermediate forms which occur so commonly, I am inclined to think that hybridization goes on freely among the various so-called species.

Nat. Ord. FICOIDEÆ.

The flowers of *Mesembryanthemum australe* are stated to be unisexual, in which case they are probably entomophilous. All the specimens I have examined have been hermaphrodite however, and apparently self-fertilized. The flowers are very conspicuous, but destitute of scent or honey.

Tetragonia expansa has comparatively inconspicuous and solitary flowers, which are always hermaphrodite. It is probable, therefore, that they are self-fertile, but they are also rendered attractive to insects by the thin layer of honey they contain, while cross-fertilization must often be insured by the fact of their being slightly proterogynous. The stigma is always expanded some time before the anthers dehisce.

Nat. Ord. UMBELLIFERÆ.

This large order, which is nearly always represented in other parts by hermaphrodite flowers, has unisexual forms in three of its New Zealand genera.

In the genera *Hydrocotyle*, *Pozoa*, and *Crantzia*, the flowers are very small and inconspicuous, and the plants themselves are small and low-growing. *Oreomyrrhis* has also small flowers, though more conspicuously placed, while the same remark applies to the smaller forms of *Ligusticum*. *Daucus brachiatus* has minute red flowers, which are somewhat conspicuous when abundantly produced. I am not aware whether the flowers of these different plants are visited by insects or not.

Apium, like the foregoing, has hermaphrodite flowers, which are conspicuous in *A. australe*, but much reduced in *A. filiforme*. The former secrete honey and are slightly fragrant. I have not noticed either peculiarity in the flowers of the latter.

Aciphylla squarrosa and *A. colensoi* have dicecious flowers, the male being furnished with an imperfect pistil. They produce abundance of honey, are very fragrant, and are produced in such mass (forming elongated panicles two to four feet long) as to be extremely conspicuous objects. They are entomophilous, and are frequently seen to be covered with various species of Coleoptera and Diptera. Professor Hutton informs me that *Lyperobius huttoni* and *Inophlæus innus*, two large weevils, are only found on plants of this genus, and that *Cyttalia griseipila* is much more abundant on them than anywhere else. He is of opinion, however, that *Lyperobius huttoni* lives on the juices of the leaves.

The larger species of *Ligusticum* which I have examined—namely, *L. intermedium* and *L. lyalli*, are also usually dicecious. The flowers are sweet-

scented and produce honey, while the umbels are of large size, much flattened on the top, and very conspicuous.

Angelica gingidium produces very conspicuous umbels of white, sweet-scented, polygamous flowers, which contain honey. Some are hermaphrodite, some pistillate, and others only staminate.

Angelica geniculata, though a much less conspicuous species, and having its flowers in very small umbels, is also polygamous. Most of the flowers in each umbel are hermaphrodite, but a few of the outside ones have stamens only, and these are generally much the most prominent. All have honey on their disc, and are very fragrant. The hermaphrodite flowers of both species are also proterandrous, a character which is rather prevalent throughout the order. I believe that most of our flat-flowered, hermaphrodite Umbelliferae are fertilized by Diptera (and perhaps minute Coleoptera). Sir J. Lubbock has pointed out that flowers which have their honey produced on a flat disc are rarely visited by Lepidoptera, whose long trunks are more suited to flowers with tubes.

Nat. Ord. ARALIACEÆ.

Stilbocarpa polaris, or a closely-allied species, occurs in Stewart Island, usually within or at the edge of the bush, but at no distance from the sea. The flowers are produced in very large loose umbels, and are tolerably conspicuous, but have no scent, and little or no honey. They are either hermaphrodite or unisexual. In the latter case, they can only—to judge from their habitat—be fertilized by insects. The Auckland and Campbell Islands plant appears to be somewhat different, growing in the open, “covering large tracts of ground with huge orbicular masses, very conspicuous from the yellowish-waxy flowers, and black shining fruit.”

The genus *Panax* is represented by ten species, of which I have only examined three—*P. simplex*, *P. edgerleyi*, and *P. colensoi*. All have green flowers, which are only conspicuous by their umbellate arrangement. All are dioecious or hermaphrodite, but, when the latter, distinctly proterandrous. They are also fragrant, and produce a considerable amount of honey. I have frequently seen large, hairy, brown Diptera on the flowers of *P. colensoi*, and think that all the species are entomophilous.

In like manner *Schefflera digitata* produces great umbels of small green flowers, but these are fragrant, and secrete a quantity of honey, and are frequently visited by flies.

Nat. Ord. CORNÆÆ.

This order contains two New Zealand genera, each with two species, but only one of each occurs in Otago.

Griselinia littoralis, the common broadleaf, has perfectly dioecious flowers, the male and female flowers showing no trace of the organs appertaining to

the other sex. I judge from the following considerations that they are wind-fertilized:—viz., because they are produced in enormous numbers by each tree, they are very small, green and inconspicuous, and are destitute of either scent or honey.

Corokia cotoneaster produces numbers of golden yellow, very conspicuous flowers, which are all hermaphrodite. They are also very sweet-scented, and the bright orange-coloured pistil is covered with a scale or fringe of glandular hairs, which secrete a little honey. They are thus rendered very attractive to insects, which must aid in their fertilization.

Nat. Ord. LORANTHACEÆ.

The genus *Loranthus* has five species in New Zealand, which exhibit a steady gradation in size and conspicuousness. Thus *L. colensoi*, which occurs abundantly in the West Taieri bush, where it is chiefly parasitic on *Fagus menziesii*, has bunches of handsome scarlet flowers which are nearly two inches long. These are pendulous, have no scent, and apparently no honey. It is probable that this is developed at some time of their growth however, and that it attracts tuis and honey-birds.

L. tetrapetalus (which I have not seen), and *L. tenuiflorus* which occurs at Queenstown and other localities in the Lake district, have flowers about one inch long.

In *L. flavidus*, which is a common parasite on *Fagus solandri*, the flowers are tolerably conspicuous, yellow-coloured, and about half an inch long. Lastly, in *L. micranthus* they are minute and green. Though so inconspicuous in this last species, they are fairly sweet-scented, and are probably visited by small Diptera. All the flowers of this genus are hermaphrodite, and probably more or less self-fertile; the largest forms being most dependent on external aid.

Tupeia antarctica. This species, though like the last bearing inconspicuous flowers, is dioecious and entomophilous. The separation of the sexes is complete. Both kinds of flower are very fragrant, and secrete a relatively large amount of honey. They are much frequented by numerous midge-like Diptera, which in sucking the nectar from the flat discs bring the lower part of their bodies into contact with the stamens or stigmas.

The mode of fertilization in both our species of *Viscum* has not been made out by me. In *V. lindsayi*, the flowers are whorled on minute peduncles, while in *V. salicornioides* they are solitary on the tips of the joints of the branches. In both plants they are unisexual, and from the fact of their being so inconspicuous I suppose they are wind-fertilized. I have found them on a variety of shrubs, but always in comparatively open parts, or on the outside edges of the bush.

Nat. Ord. RUBIACEÆ.

The chief genus of this very large order in New Zealand is *Coprosma*, of which over twenty-five species have been described in these islands. As is remarked in the "Handbook of the N.Z. Flora," "the species are most difficult of discrimination, owing to their extreme variability, their being dioecious, and their very small flowers." These latter points constitute, to my mind, a much greater difficulty than the former, for I think it will be found, after examination of a large series of specimens, that most of the forms are tolerably distinct and well-defined. The genus may be divided into two sections, in one of which the female flowers are collected into clusters, and in the other they are solitary. In the former they are, of course, more conspicuous than in the latter, but there seems no doubt that in both forms they are solely dependent on the wind for fertilization. They are dingy-green in colour, small, and quite destitute of scent or of honey. The male flowers have four stamens, the anthers of which dangle at the extremity of very slender, easily shaken, long filaments. The pollen is also extremely light and powdery, and the whole of it escapes on the dehiscing of the anther. The female flowers have a much smaller calyx and corolla than the male, these parts being reduced to the minimum size consistent with their function of covering the pistil while it is still immature. The ovaries are very small, but the styles are proportionally of immense size, and stigmatic over their whole length. Some idea of this may be gained from the drawings in Plate I., where figure 1 represents the female flower of *C. propinqua*, and figure 2 that of *C. rotundifolia* (both magnified). I have examined the flowers of fourteen species growing in this neighbourhood, and find that all possess the same character. The brightly-coloured drupes of these plants must aid greatly in their dispersion, as they are eaten and passed by birds. It would be interesting to ascertain what advantage is gained by the possession of the intensely foetid odour which is so characteristic of some species.

The genus *Nertera* differs from *Coprosma* not only in its herbaceous habit, but—in the New Zealand species at least—in having hermaphrodite flowers. These are, however, perfectly dioecious in function. I have examined the flowers of three out of the four New Zealand species, viz., *N. depressa*, *N. dichondraefolia* and *N. setulosa*. All are very decidedly protogynous, the stigmas being expanded fully while the stamens lie in the flower, and withering completely before the anthers dehisce. They must, therefore, be always cross-fertilized, and as the flowers agree in all respects (but that already mentioned) with those of *Coprosma*, they are also probably anemophilous.

The flowers of *Galium umbrosum* and *Asperula perpusilla* are very small,

but they are white and secrete a minute trace of honey, and are therefore probably visited by insects. The latter plant, which is one of the smallest flowering plants we have, is remarkable for exhibiting distinct dimorphism. In one form the stigma is almost sessile on the ovary, in the other there is a well-developed style. I have not observed a corresponding difference in the stamens, which made me think at first that the difference was due solely to the varying age of the flowers examined. This, however, is not the case, as in young and old flowers alike the two forms are to be found.

Nat. Ord. COMPOSITÆ.

This very large and important order is represented in this part of New Zealand by about sixteen genera, out of the twenty-four occurring in the colony. The advantages possessed by flowers of this order by having their florets crowded together, have often been insisted on, the chief of these being the prominent appearance of the flowers when massed together, the facility with which honey is obtained rendering them attractive to insects, and the greater chance of cross-fertilization enjoyed by them, seeing that an insect lighting on a flower-head is likely to come into contact with several flowers at each visit. A further chance in favour of cross-fertilization arises from the polygamous nature of the florets in each head, those on the outside being usually pistillate only, while those within are hermaphrodite. In most of the sub-order Ligulifloræ, the ray-florets are pistillate, and it is worthy of notice that this is the reverse of what usually occurs in diœcious or polygamous plants, for it is usually the staminate or male flowers which are the most conspicuous. This will be found to be the case in almost all the genera mentioned in the earlier part of this paper in which separation of the sexes occurs. In those Composites which are frequented by insects—and possibly in others—*autogamy*,* or fertilization of a flower by the pollen from the stamens of the same flower, is usually avoided by a simple form of proterandry. The anthers, which cohere to form a tube round the style, dehisce a little before the flower expands; the pollen, however, is retained in the tube, where it has no access to the stigmatic surfaces of the style, as these are in close contact. The style gradually lengthens up, however, through the staminal tube, which it bursts open at the top, and scatters the pollen out. After a time the stigmatic arms at its summit separate, and gradually recurve, in which position they protrude to some distance from the mouth of the floret. This peculiarity of Composites and

* "Flowers and their Unbidden Guests," by Dr. Kerner, (C. Kegan Paul & Co.) This author also proposes to use the terms *geitonogamy*, for the fertilization of a flower by pollen from other flowers on the same plant, and *xenogamy*, for the fertilization of a flower by pollen from other plants. Both terms to be classed under the name *allogamy*. He objects to the indefiniteness of the term "self-fertilization."

some other plants, is illustrated in Sir J. Lubbock's work already referred to, at p. 114, to which the reader is referred for details. I have observed it in the following New Zealand Composites: *Olearia ilicifolia* and *O. nitida*, *Celmisia longifolia*, *Lagenophora forsteri*, *Cotula coronopifolia* (though not so decidedly as in the other species named), *Cassinia fulvida*, *Senecio lantus* and *S. rotundifolius*, and in *Microseris forsteri*. It is probably the rule in all the bright-flowered species.

Of the genus *Olearia*, probably all are very attractive to insects—*O. nitida*, *O. dentata*, and *O. ilicifolia*, have their flowers arranged in large conspicuous corymbs, and are sweet-scented. I have not seen honey in them.

O. virgata has small sweet-scented heads, which are much less conspicuous than the preceding, while *O. hectori* has its flowers most deliciously scented, like ripe peaches.

Of the genus *Celmisia*, the larger flowered species examined—namely, *C. coriacea* and *C. hectori*, though very conspicuous, have no fragrance and very little honey. The same remark applies to *C. sessiliflora*, in which the individual heads, though small, are produced in such immense numbers as to render the cushion-like masses in which the plant grows extremely conspicuous. In *C. longifolia* the flower-heads are solitary, but are slightly fragrant, and the tubes of the disc-florets contain a little honey.

In *Vittadinia australis* the flower-heads are also produced singly. They are not so conspicuous as the last-named, and, though slightly fragrant, are probably more commonly autogamous. The protrusion of the stigmas from the hermaphrodite florets of the disc is very slight, and they are frequently found smeared with the pollen of the same floret. The ray-florets, however, being pistillate only, require the visits of insects to bring pollen to them from other flowers.

Lagenophora forsteri and its small variety *L. petiolata* have small but conspicuous scentless flowers.

The genus *Cotula* I have hardly looked into. *C. coronopifolia* has very conspicuous yellow flower-heads, which are destitute of fragrance and produce little or no honey. The minuter flowered forms, as *C. dioica*, *C. minor*, etc., do not seem to possess any attractions for insects. The absolutely unisexual species are probably anemophilous.

The flower-heads of *Cassinia fulvida* are very conspicuous by association, and are sweet-scented.

Ozothamnus glomeratus has also sweet-scented florets, which are much less conspicuous than the last.

Gnaphalium bellidioides and *G. trinerve* are very conspicuous, owing to the large pure white involucral leaves which surround the flower-heads. These perform the function of the ray-florets in other Composites, acting as lures

or flags of invitation to honey-loving insects. These flowers are also sweet-scented.

The genus *Erechtites* has inconspicuous greenish flower-heads, which never expand much. They have no scent, and no honey, and are probably self-fertilized.

The genus *Senecio* exhibits a great diversity in its flowers. *S. lautus* has yellowish, but by no means conspicuous flowers. These are scentless, but contain a little honey, and, as has been already remarked, are proterandrous.

S. lagopus and *S. bellidioides* (probably two extreme forms of the same variable species), and the beautiful *S. lyalli*, have very conspicuous flowers, which are also scentless, and produce very little honey. *S. rotundifolius*, which grows so abundantly round the coasts and in the bush of Stewart Island and the West Coast Sounds, has comparatively inconspicuous flowers, but these are of an overpowering fragrance, and the tubes of the florets almost overflow with honey.

Lastly, *Microseris forsteri* has solitary flower-heads destitute of scent, and with very little honey, but they are bright yellow, very conspicuous, and proterandrous.

Nat. Ord. STYLIDIEÆ.

The flowers of this order are characterized *inter alia* by being gynandrous, *i.e.* having their style and stamens united into a column. Instead of aiding in self-fertilization, as might at first be supposed, this arrangement more commonly prevents it. The order is represented by three genera in New Zealand.

Phyllachne (Forstera) sedifolia has extremely variable flowers as to size, those which grow on the hills near Dunedin being seldom more than a fourth of an inch in diameter, while some gathered by me on Frazer Peaks, Stewart Island, were over three-fourths of an inch, and furnished with a very beautiful dark-purple eye. All I have gathered have been hermaphrodite, but according to Hooker they are sometimes unisexual. These flowers are scentless, but so strongly proterandrous as to be practically dicecious. The two stamens shed all their pollen, and wither completely, before the stigmas commence to expand and recurve. The flowers are furnished with two epigynous glands, whose function I have not made out; it may be to secrete honey, of which the flowers contain a little. They are manifestly entomophilous.

Stylidium subulatum is a very doubtful member of this genus. Its column is short and straight, and in no way irritable, whereas one of the characteristics of the genus is a bent, irritable column which springs up with considerable force on a touch, and throws the pollen out of the

anthers. In this species the only contrivances for preventing self-fertilization appear to be the position of the transverse anthers under the stigmatic disc, their proterandry—which, however, is not very decided, and the rigidity of the short, erect column. They are probably, also, entomophilous as in the preceding species.

Donatia novæ-zealandiæ occurs tolerably abundantly on the summit of Maungatua (3000 feet), and in similar swampy country near sea-level in Stewart Island. The flowers are solitary, white, and quite sessile at the end of rigid branches, which are covered with very short, rigid leaves. They are destitute of scent and, as far as I have observed, of honey, but owing to the plants being aggregated into large tufts they are very conspicuous. The bases of the filaments and styles are connate, but the anthers diverge from the stigmas and dehisce outwards. I hardly think the flowers are self-fertilizable, but have not sufficiently definite information on the subject.

Nat. Ord. CAMPANULACEÆ.

Two species of *Wahlenbergia* are abundant in this part of New Zealand, *W. gracilis* being found in dry spots at all elevations from the sea-level to 3000 feet (Maungatua), while *W. saxicola* is more commonly a hill-growing species. I have, however, found it at sea-level in some parts of Otago and in Stewart Island. The former is a branched plant, sometimes two feet high, and producing a solitary flower at the end of each branch. These are small but brightly coloured, white, lilac, or blue. *W. saxicola* is a much smaller plant, producing one much-larger bell, on a slender, erect peduncle, seldom more than six inches high, and conspicuous from its pure white or pale blue colour. Both species are hermaphrodite in structure, but diœcious in function, as they are very distinctly proterandrous. The anthers dehisce before the flowers open, and discharge all their pollen on to the outside of the style, which is furnished with hairs to which the grains adhere. The style, which bears two stigmatic branches at its upper part, lengthens upwards, carrying the pollen with it, in which state it is accessible to any insect visiting the flower. It cannot, however, get on the stigma, for the two faces of the style are in close contact. These ultimately open, displaying two convex surfaces thickly clothed with glandular papillæ, and finally curving back from one another stand right in the path of any insect entering the flower. The ovary is covered by the expanded and fringed bases of the filaments, and between these may be seen small beads of honey. Both species are evidently quite dependent on insect-aid for their fertilization.

Nat. Ord. LOBELIACEÆ.

The only plant belonging to this order which I have been able to examine is *Prutia angulata*. It is almost universally admitted among

botanists that irregular flowers are specially fitted for the visits of insects, and if this view is correct all the plants which belong to this order are more or less entomophilous.

The flowers of *Pratia* (with which those of *Lobelia* and *Colensoa* agree pretty closely), are extremely irregular. The corolla tube is split to the base at the back, while in front it stands somewhat horizontal, and affords a convenient landing stage for small insects. It is usually white in colour, with very bright blue or purple guiding lines converging to its base, where a considerable amount of honey is secreted. The style, which is two-lobed above, is surrounded by the connate anthers when the flower newly opens, and the column is thus bent forward at its summit, so as to slightly arch over the horizontal corolla-tube. The stamens are proterandrous, as in *Wahlenbergia*, and just as in those flowers, the style lengthens out of the staminal tube, carrying out the pollen with it, and then the two stigmatic faces, which up to this time have been in close contact, expand widely and expose a large papillose surface. These flowers are quite incapable of self-fertilization.

Nat. Ord. GOODENIACEÆ.

The fertilization of *Selliera radicans* has been already fully and clearly described by Mr. T. F. Cheeseman.* This species is exclusively insect-fertilized.

Nat. Ord. ERICEÆ.

There are really only two genera (*Gaultheria* and *Pernettya*) of this large order in New Zealand.

Gaultheria antipoda is remarkable for the tendency towards separation of the sexes which it exhibits; standing alone in this respect—as far as I am aware—in the order.

In some of its forms truly hermaphrodite flowers are found, and in these the stamens mature considerably before the stigmas. In others, the stamens occur in a more or less aborted form, until a stage is reached where the anthers are represented by small bent portions on the summit of a diminished filament. I have never found a purely pistillate form with no trace of anthers, nor have I found a male form showing a diminished pistil. In all those of course in which abortion of the stamens has taken place, cross-fertilization must take place to secure the production of seed, and from the nature of the flower this can only be accomplished by insect-agency. In the hermaphrodite flowers, even if not absolutely essential, it must frequently take place. The corolla always contains honey at its base.

Gaultheria rupestris, which is a much more conspicuously flowered plant

* "Trans. N. Z. Inst." Vol. IX. p. 542.

than the preceding, though probably connected with it by a complete gradation of intermediate forms, shows the same tendency to abortion and separation of the reproductive organs. Hermaphrodite and pistillate forms are both found, honey is also found in the flowers, and these are usually produced in such quantity as to be very readily seen.

Nat. Ord. EPACRIDÆ.

Six genera of this typically Australian order occur in New Zealand, and four of these grow in this neighbourhood.

Cyathodes acerosa has extremely minute, solitary flowers, difficult of detection by sight, and destitute of smell. They contain honey however, and are distinctly proterandrous, so that they must probably be visited by small insects.

Leucopogon frazeri is a most abundant plant on dry ground, and is apparently solely entomophilous. I have found its flowers invariably hermaphrodite, but yet so contrived as to require insect-aid to ensure fertilization. The corolla, which always stands quite erect, is in the form of a long cylindrical tube contracted at the throat; its lobes and most of the inner surface of the tube are thickly clothed with hairs. The style is very long and slender and bears a rounded stigmatic head, which projects a little above the throat of the corolla and is very viscid. Immediately below it are the five anthers, nearly filling up the whole of the tube. These are nearly sessile, and one-celled, and their pollen, after escaping from them, lies exposed on their inner side, and almost in contact with the top of the style. The pollen-grains are comparatively large and circular, and cohere readily together. The flowers are very sweet-scented, and the base of the corolla contains a large secretion of honey. It seems almost impossible that self-fertilization can take place, while the manifest attractions for insects lead us to the conclusion that their agency is necessary for the production of seed. The only insects which could reach the honey, however, are those furnished with a long slender proboscis, such as the Lepidoptera, for not only is the corolla-tube lined thickly with hairs, but the style itself is also furnished with these impediments. Between the walls of the corolla, however, and the style, are five minute apertures through which a moth's proboscis might be inserted to reach the honey, but, as these apertures lie right over the anthers, it would be almost impossible for the insect to reach the coveted sweets at the bottom of the flower without touching and removing some of the pollen. The position of the capitate stigma also, guarding the entrance of the flower, with its drop of viscid secretion is such that contact with anything adhering to the proboscis of an insect would almost certainly take place. I do not think insects with short trunks could reach the honey. I, on one occasion, found a minute beetle in the tube, but it was drowned in the honey at the bottom.

Pentachondra pumila is somewhat similarly furnished with a densely-bearded corolla-tube, and is probably fertilized in the same manner. In the summer of 1876 I had a plant of this in flower under glass, and, though it produced numerous blossoms, no fruit resulted. In each case, after the gradual withering of the corolla, it was found that the ovary had shrivelled also.

Dracophyllum longifolium has very conspicuous fragrant clusters of flowers. These contain a great deal of honey, and are therefore no doubt visited by insects. They are hermaphrodite, but I have not seen any special contrivance to render self-fertilization impossible. Birds occasionally visit the flowers.

Nat. Ord. MYRSINÆ.

The only New Zealand genus is *Myrsine*, of which two species—*M. urvillei* and *M. divaricata*—are common in the neighbourhood of Dunedin. I have examined the flowers of the former, and find them mostly dioecious. The male flowers have an imperfect ovary, while the female flowers have stamens with small anthers, which, however, contain no pollen. This is morphologically so slight a remove from hermaphroditism that I think the latter must frequently occur. In all cases I have noticed they have, however, been functionally dioecious. The flowers are produced in great numbers, are small and rather inconspicuous, have no scent and no honey, while their pollen is light and very incoherent, all of which considerations lead me to consider them as always anemophilous.

Nat. Ord. APOCYNÆ.

The only plant of this order found here—*Parsonia albiflora*—has puzzled me a good deal. It is a straggling climber producing panicles of pendulous white flowers. These have a funnel-shaped corolla, the lobes of which bend back. The stamens are syngenesious—that is, their anthers are united together. These anthers are arrow-shaped, with very acute apices, and when joined together they form a sharply-pointed conical cap (not unlike some forms of metal drills) which fits closely on the summit of the stigma. Of each anther, one cell only produces pollen, which seems to me to be always applied directly on the stigma. In fact, this introrse dehiscence of the anther, and the application of the pollen on the stigma, is given by Le Maout and Decaisne* as a characteristic of the order. At first sight this would make us at once conclude that the flowers were self-fertile, in which case insect-aid would not be absolutely necessary. But what appears a still greater difficulty is that the pollen is all contained inside a cap, from which I have not seen it shed, and which does not readily open from any side. Yet the flowers are usually fragrant, and contain a large quantity of honey. I am inclined to think that, had I examined the flower at different stages of

* "Descriptive and Analytical Botany," by Le Maout and Decaisne, p. 550. Edited by Sir J. D. Hooker. (Longmans and Co.)

its maturity, I should have found a clue to this apparently contradictory arrangement. Meanwhile, I commend the case to other working botanists as one that will repay investigation.

Nat. Ord. GENTIANEÆ.

Of the five species of *Gentiana* described in the "Handbook of the N.Z. Flora," I have only examined the commonest form, viz., *G. montana*. The flowers are white and scentless, and produce very little honey. They are, however, very distinctly proterandrous, and can only be fertilized by pollen from another flower. The style is two-lobed above, and only the inner faces of these are stigmatic, as in *Wahlenbergia*. The anthers dehisce as soon as the flowers open, but the stigmas do not expand for two or three days after, when they separate pretty widely. Any adhering pollen is then on the outside of the style, but not on the stigmatic arms.

Nat. Ord. CONVULVULACEÆ.

Convolvulus tuguriorum and *C. soldanella* are both plants with very prominent and beautiful flowers; the former with large white blossoms, which often cover the shrubs over which the plant climbs; the latter growing only on the sand at the sea-shore, which it ornaments with its rose-coloured, purple-striped flowers.

C. tuguriorum remains open all night if the sky is bright, and often in wet weather too, and yet though thus flaunting its attraction before diurnal and nocturnal insects alike it does not seem to be much visited by them. Both the species named are self-fertilized; they are scentless also, and produce apparently no honey.

Dichondra repens is a very low-growing, humble plant, producing small, greenish-white or yellowish flowers, which are, however, extremely variable both in size and conspicuousness. The larger and brighter forms are perhaps visited by insects, but the smallest forms show a tendency towards cleistogamy. In some localities I have found them with large calyces (which hardly opened at all), greatly reduced corollas, and stunted anthers, and yet producing full round capsules.

Nat. Ord. SCROPHULARINEÆ.

This large order is represented in New Zealand by ten genera, the most characteristic and important of which is *Veronica*. All the flowers of the order are irregular, and we find numberless contrivances for the attraction of insects, and the consequent cross-fertilization which ensues. I have not, however, had opportunities of studying many flowers of this interesting class.

The fertilization of *Glossostigma elatinoides* has been remarkably well described by Mr. T. F. Cheeseman.* In this flower the flattened spoon-shaped stigma is sensitive to a touch, and lies over the top of the anthers,

* "Trans. N.Z. Inst.," Vol. X., p. 353.

ready to spring up when touched. I do not know whether similarly-sensitive stigmas are found in the two species of *Mimulus* which occur in this colony. In both our naturalized forms, *M. luteus* and *M. moschatus* (the common musk-plant), self-fertilization is prevented by such a contrivance. I have not seen any description of the fertilization of these flowers (though I believe they have been described), and therefore will record here my own observations on the former species, as they may be suggestive to anyone observing our indigenous species. I may mention that very beautiful hybrid forms of this species have gone wild in Ross Creek, in the neighbourhood of Dunedin. In their new habitat they have attained immense growth, forming thick succulent stems an inch and more in diameter and frequently three feet long. It was on the flowers of these plants that my observations were made. The style is a good deal longer than the longer pair of stamens, and ends in a two-lobed stigma, formed of two flat plates, which are viscid on their inner faces (fig. 3, pl. X.). The upper of these lobes stands against the corolla-tube, the lower hangs over, and is in the way of any large insect entering the flower. This lower lobe is sensitive to a touch, not springing up rapidly however, but taking from five to fifteen seconds to close against the upper plate. In the course of half an hour or less, if no pollen is placed on it, it opens again. If, however, pollen from another flower be placed on it, it closes firmly against the upper plate, with which it remains in contact for many hours. On opening again it is no longer sensitive, and the corolla soon after withers. It is quite evident that if a bee or other large insect enter the flower without pollen on its head, it is almost certain to come into contact with the lower stigmatic lobe, which will then close up, but only to open again in a short time. In order to get at the honey in the bottom of the flower however, the insect pushes past the anthers, which would probably dust its head with pollen. On visiting a second flower, it again comes in contact with the stigma, but this time leaves some pollen on it, and thus secures fertilization.

M. moschatus, the common musk plant, shows the same irritable stigma.

Veronica. The species of this genus, though hermaphrodite, and not nearly so irregular as other flowers of the order, are probably all unfitted for self-fertilization. From this statement I must except some of the small herbaceous European species. In our species the anthers are more or less proterandrous, and their filaments diverge widely as they dehisce, while the style projects forward quite out of the flower.

V. traversii—which I have only seen in cultivation—produces immense numbers of white, very conspicuous flowers, which have a little honey but no scent. On bright days they are visited by great numbers of insects, chiefly Hymenoptera and Diptera.

V. buxifolia is similarly very white, melliferous and scentless. It is an extremely common plant at elevations of 2,000 feet and upwards. *V. lyalli* and *V. cataractæ* (an abundant West Coast plant) are similarly characterized.

V. salicifolia produces conspicuous racemes of white, lilac, or purple flowers which are very fragrant and produce a little honey. They attract great numbers of insects, chiefly species of Diptera and moths, besides one or two butterflies.

V. elliptica, which is especially a sea-side plant, has large and conspicuous flowers, which are very fragrant, and secrete a very considerable amount of honey.

Nat. Ord. LENTIBULARIÆ.

This order contains only two genera, *Utricularia* and *Pinguicula*, of which the former is represented by four species in New Zealand. These are rather rare, or what is more probable are very readily overlooked, except, however, at flowering time, when they are conspicuous enough, though small.

Utricularia monanthos occurs abundantly in the bogs at the head of Paterson's Inlet, Stewart Island. The plant is very minute, bearing one or two bright purple flowers at the summit of a slender scape, a half to four inches high. (Pl. X. fig. 4a). The few leaves are very small and narrow, and almost always submerged, while the creeping rhizome or root bears two or more of the small compressed bladders from which the genus takes its name. The flowers are evidently adapted for cross-fertilization. The corolla is bilabiate, the lower lip being flattened and expanded at its distal end into a broad landing stage. This is purple in colour, and furnished with a bright yellow glandular line—the honey guide—down the centre. The upper lip (fig. 4b) stands nearly erect, while the base of the corolla is produced downwards into a spur or nectary (though I found no honey in it). The two stamens lie under the upper lip; the filaments diverge somewhat widely below, but are curved inwards in their upper part, bringing the anthers close together under the stigma. This latter is a flap or plate opening downwards, so as to project somewhat over the entrance to the nectary, and partly covering the anthers. If an insect alighted on the lower lip of the flower, and advanced to suck honey from out the nectary (for, though I did not find any, there can be little doubt that at suitable times the spur does contain honey), its head would probably come first into contact with this flap. This would bend down, exposing the middle or stigmatic portion, to which any pollen on the insect's head would adhere. The lower side of the flap, which is not stigmatic, would meanwhile completely cover the anthers. On withdrawing its head the insect would rub it against the anthers first, and then push up the

lower side of the flap, which would not, however, receive any pollen during the withdrawal. I think it quite impossible that this species can be self-fertilized. From its habitat, standing, as the flowers do, right out of the water, it is probably visited by small species of Diptera.

As already mentioned, the name of this genus is derived from the bladders (Lat. *utriculus*) attached to the leaves or rhizomes. The primary function of these bladders would appear to be that of floating the plant during the flowering season to the top of the water in which it grows. The following quotation from De Candolle's "Vegetable Physiology" is extracted from Le Maout and Decaisne's "System of Botany," p. 591 :—"These bladders are rounded and furnished with a kind of moveable operculum. In the young plant they are filled with a mucus heavier than water, and the plant, submerged by this ballast, remains at the bottom. Towards the flowering season the leaves secrete a gas which enters the utricles, raises the operculum, and drives out the mucus, when the plant, now furnished with aerial bladders, rises slowly and floats on the surface, and there flowers. This accomplished, the leaves again secrete mucus, which replaces the air in the utricles, and the plant re-descends to the bottom, and ripens its seeds in the place where they are to be sown."

This view of the function of the bladders may apply in the case of such species as *U. neglecta* (of Europe), which bears them on the leaves, and is quite destitute of roots; but in the case of the species under consideration, and all others which bear them on the subterranean rhizomes or creeping stems, some other explanation must be sought. It is probable that the view advanced by Darwin in his "Insectivorous Plants," p. 395, is the correct one—that the bladders have now become adapted (whatever may have been their original function) for the capture of small aquatic animals, and their subsequent absorption. In the work named Darwin details very minutely the structure of the bladders of *U. neglecta*. These are remarkably well adapted for the capture of prey, their aperture being furnished with bristles directed into the interior of the cavity, like a rat-trap. Entrance into the bladder is easily accomplished, but, once in, escape is almost impossible. The interior of the bladder is lined with what are termed "quadrifid processes," which are four elongated cells borne almost crosswise from the summit of a minute projection or foot-stalk. Besides these there are "bifid processes," similarly placed on stalks, and various forms of glands. All these bodies are found to have the power of absorbing decaying animal matter, as well as weak solutions of salts of ammonia and urea. As the older bladders are found to contain animal remains always more or less disintegrated, there seems little doubt that their presence must be beneficial to the plant. As to what entices the animals entrapped to enter the bladders

no satisfactory explanation has been given as yet. The transparency of the bladder membrane, and the presence of long bristles or antennæ, may induce small aquatic animals to attempt the passage. Darwin suggests that "perhaps small aquatic animals habitually try to enter every small crevice, like that between the valve and collar, in search of food or protection.* I can myself vouch for the inquisitiveness of many of the small Entomostraca, those species particularly which, like *Cypris*, are secure in a two-valved shell, being the boldest in this respect. The bladders do not seem to digest their prey, there being no glands for secretion; and fragments of meat, etc., placed in bladders, were found unacted on at the end of three days. It is probable that the animals which force an entrance into the bladders become asphyxiated, owing to the contained oxygen being all used up, and that, as their bodies decay, the products thus resulting are absorbed by the various processes on the walls.

The bladders on our Stewart Island species—*Utricularia monanthos*—are somewhat different from any of the species described in Darwin's book. They are almost circular in outline, and laterally compressed, and vary in diameter from $\frac{1}{20}$ to $\frac{1}{8}$ of an inch. Running almost completely round them is a well-defined vascular bundle (fig. 5a & b) the inner end of which forms the thickened collar or neck, against which the valve closes, while the outer and upper end is sometimes continued into a horn-like antenna, or is abruptly truncated. On each side of the entrance are the so-called "antennæ," which in this species are narrow at the base, and expand outwards in a palmate manner, ending in numerous unicellular hair-like processes. That portion of the bladder between the entrance and stalk by which it is attached, is bordered by a flange or expansion of the cellular tissue of the walls on each side. This, together with the overlapping antennæ, forms a sort of covered way to the entrance. There are no spines directed into the interior of the cavity, as in *U. neglecta*, nor could I detect any glands, other than the numerous quadrifid processes (fig. 6) with which the whole inner surface is lined. The arms of these processes are nearly equal in length. The outside of the bladders is covered with rounded pit-like cells, at the junctions of many of the hexagonal cells of the parenchyma.

The smaller bladders were usually semi-transparent and empty, but the larger ones were mostly filled with dark brown or blackish material. This seemed to consist of disintegrated animal and vegetable remains, most of it destitute of recognizable structure, but containing Diatoms, Algæ, etc., and in many cases Entomostraca. All the larger bladders had from one to as many as ten specimens of the common Entomostracan, *Cyclops novæ-zealandiæ*, sometimes quite entire, and at other times in fragments. A good-

* *Loc. cit.*, p. 409.

sized *Daphnia* was also obtained in one; the body was reduced to a brownish mass, but the bivalve shell and portions of the limbs were intact. The Diatoms and other minute organisms are probably present not as prey, but as commensalists or messmates, taking advantage of the rich food obtainable in the bladders to take up their residence in them.

Of the four species of *Utricularia* described in the Handbook Fl. N. Z., three have their bladders borne on the rhizome, while *U. protrusa* has floating stems and capillary leaves like the English species. A fifth species has been mentioned by Mr. Kirk,* but apparently not described, as occurring in Rotomahana, and having the same arrangement of the bladders on the leaves.

Nat. Ord. VERBENACEÆ.

Teucriidium parvifolium occurs plentifully enough near Dunedin, but I have not examined its flowers.

Myoporum lætum, the only other representative of the order in this part of the island, is also extremely common. This plant produces its flowers chiefly from November to January, but it continues to put out blossoms sparingly for a considerable part of the year. These unseasonable flowers are commonly defective, their anther-cells being destitute of pollen and their pistil also being more or less aborted. I cannot conceive of what use they are to the plant. The ordinary flowers are white and conspicuous, and produce a little honey. They have little or no scent, and I cannot say whether they are self-fertile or not. The lining of hairs on the lobes of the corolla probably serves to impede small and unsuitable insects from obtaining the honey.

Nat. Ord. LABIATÆ.

This large order—the flowers of which present such a variety of contrivance to ensure cross-fertilization—is represented by two very small plants in New Zealand, belonging to the genera *Mentha* and *Scutellaria*. The latter I have not seen.

Mentha cunninghamii belongs to a genus in which the corolla does not show the extreme irregularity of typical Labiates. There is a tendency also to dimorphism, which this species among others exhibits, one of the characters given in the “Handbook of the N.Z. Flora,” p. 226, being “Stamens included in the corolla-tube of some flowers, exserted in others.” I have not, however, noticed this difference. Nor have I noticed any tendency towards production of female as well as hermaphrodite flowers, which prevails in some species. The flowers of our species are only slightly irregular; they are, however, proterandrous, strongly sweet-scented, and produce a great amount of honey, and are consequently much visited by insects.

* “Trans. N. Z. Inst.” Vol. V., p. 343.

Nat. Ord. PLANTAGINÆ.

Plantago raoulii is the only common plant of this order. Though its flowers are hermaphrodite, they seem to be exclusively cross-fertilized, and to depend on the wind for the performance of this necessary occurrence. They are very inconspicuous, scentless and destitute of honey. As soon as the flowers open, the long papillose stigmas protrude, while the stamens remain undeveloped. The flowers lowest down the spike open first and those at the top last, and the withering of the stigmas takes place in the same order. As the stigmas wither, the filaments commence to lengthen, bearing at their extremity the versatile anthers full of light friable pollen. Even then of course some of the upper flowers are only in the pistillate stage, and may get pollen from flowers lower down the same spike, but in most cases it must be blown from flowers either on different plants or different spikes.

Nat. Ord. CHENOPODIACEÆ.

The plants of this order bear very inconspicuous flowers, which are sometimes hermaphrodite, but more commonly polygamous. *Chenopodium triandrum* is the only one I have examined with care. When hermaphrodite, its flowers are very distinctly proterogynous, the stigmas withering completely before the anthers dehisce, so that in this, as in diœcious forms, self-fertilization is impossible. It is an anemophilous plant, and this will probably be found to be a character of all the New Zealand species of the order.

Nat. Ord. POLYGONÆ.

Polygonum aviculare is apparently self-fertilized, the flowers being small and destitute of honey or scent.

The species of the genus *Muhlenbeckia* are anemophilous. They are almost always diœcious, though sometimes imperfectly hermaphrodite. They are very inconspicuous in colour, destitute of scent and honey, and furnished with large plumose or papillose stigmas. I have not noticed any insects visiting them.

Rumex flexuosus and *R. neglectus* are hermaphrodite. The flowers are distinctly proterandrous however, and dependent for fertilization on the wind.

Nat. Ord. THYMELEÆ.

The only plant of the genus *Pimelea* which I have looked into is the common but very variable *P. prostrata*. Though hermaphrodite in structure, this species is diœcious in function, and will probably tend rapidly to become so in structure as well. In those forms of it which are truly hermaphrodite there is a simple contrivance to prevent self-fertilization. Just before the flowers expand, the style (which is placed to one side of the

perianth) is shorter than the stamens, but, as they open, it lengthens rapidly, and carries the stigma up one side and past the expanding anther-cells.

Of those which are dioecious in function there are two forms, which, though growing usually side-by-side, are distinct enough to be taken for two varieties. The male or staminate form is considerably larger and more conspicuous than the other. When fully open the two stamens are quite exerted from the perianth-tube. At this stage the slender style, with its minute, *almost glabrous*, stigma, is only about half the length of the perianth-tube, but, after the anthers have dihisced, it lengthens very much and protrudes between the lobes of the perianth, as if to ensure fertilization. Having reached this stage further development ceases, the small ovary with its contained ovules, which never become fertilized, commences to shrivel, and ultimately the whole flower withers and falls off.

The smaller pistillate flowers have a long style, bearing at its summit a capitate stigma, which is so crowded with glandular or papillose hairs as to be almost globose, and which projects at the mouth of the perianth. Nearly half way down the tube are the two minute stamens, with shrivelled anthers containing no pollen. Probably between these two forms, and truly hermaphrodite ones which are proterandrous, there are intermediates. I have not yet found any forms absolutely dioecious in structure, though the species seems tending towards this. I think that in the gradation from the proterandrous hermaphrodite form to the staminate form, in which the first part of the proterandry is carried out but the second fails to be carried out, we see the step by which the dicecism (to coin a word) of this plant is attained.

In all its forms the flowers of this plant are small, but conspicuous by their association into terminal corymbs; they are sweet-scented and their tubes invariably contain honey, so that they must be very attractive to insects.

Drapetes dieffenbachii has extremely small and rather inconspicuous flowers, which are not crowded into masses as in the preceding species. I could not detect any smell or honey, yet I am inclined to think that this plant is tending in the same direction as *Pimelea prostrata*. There seem to be two forms, in one of which the pistil is very much smaller than the other. I did not make out, however, whether there was a difference of function in the two kinds. They are probably visited by minute Lepidoptera, which swarm in immense numbers among low-growing plants during the summer months.

In the lower orders of Dicotyledonous plants wind-fertilization is the rule, and, as if effectually to prevent self-fertilization, most of the plants belong-

ing to them have the sexes separate. Thus *Fagus menziesii* (Nat. Ord. Cupuliferæ) has inconspicuous monœcious flowers; *Epicarpurus microphyllus*, *Urtica incisa*, and *U. ferox* have diœcious flowers; while *Australina pusilla* and *Parietaria debilis* are monœcious or polygamous. All these five belong to Nat. Ord. Urticæ. The only exception to this general rule is in *Euphorbia glauca*, which appears occasionally to be visited by insects, and the involucre of which, though not very conspicuous, are yet of a bright purple colour, and enclose more or less honey. The introduced *E. pepylus*, which is a common weed in this part of New Zealand, though producing very small flowers, is evidently dependent on insect-aid for fertilization. The anthers ripen after the pistil, and the four horned glands glisten with a plentiful secretion of honey. The stamens are not visible within the involucre bracts until the female flower is hanging quite out of reach.

All the Coniferæ, I believe, are anemophilous, our New Zealand species being no exception to the rule. Their flowers are either monœcious or diœcious, and the male flowers are produced in such mass as to scatter their pollen in clouds.

MONOCOTYLEDONS.

In this class, as has been pointed out by Sir J. Lubbock in his work already quoted, the contrivances and means of adaptation to secure the visits of insects are not so numerous nor so complicated as in Dicotyledons, if we except the remarkable order of Orchidæ. Still we have some interesting modes of fertilization, even outside of this order, as perfect as any yet detailed.

Nat. Ord. ORCHIDÆ.

The modes of fertilization of many of the species of this order have been described already by Mr. T. F. Cheeseman and myself.*

Earina mucronata, though differing considerably in appearance from *E. autumnalis*, is similar in structure, and only fitted for cross-fertilization. The flowers are very fragrant and produce a large amount of honey.

Dendrobium cunninghamii. The mode of fertilization I have already described.† This last summer, 1879–80, I found it in great quantity and flowering in magnificent profusion in Stewart Island. In nearly every plant examined the flowers contained a large amount of honey. In one lot of eighty examined ten had their pollinia removed.

Sarcochilus adversus. I obtained a few flowers of this rare little species from dry rocks close to the edge of the harbour near Port Chalmers. Though one of the smallest and most inconspicuous Orchids in New Zealand it is absolutely incapable of self-fertilization, but is dependent on insects,

* "Trans. N.Z. Inst.," Vol. V., p. 352; Vol. VII., p. 349; and Vol. XI., p. 418.

† "Trans. N. Z. Inst.," Vol. XI., p. 419.

and the mechanism by which cross-fertilization is effected is the most perfect of its kind. The flowers are produced in few-flowered racemes seldom exceeding an inch in length, and more or less hidden by the leaves. They are much more regular than the majority of Orchid flowers, are greenish in colour, with a few purple lines on the labellum, and do not exceed one-tenth of an inch in diameter.

At first sight I thought that owing to their inconspicuous appearance they must certainly be self-fertilized, but besides being slightly fragrant, I noticed that they secreted a considerable amount of honey between the base of the column and the fleshy, ridged labellum, and this caused me to look more narrowly into their structure. The four pollinia are united into two almost globular masses, which are attached by a caudicle to a broad flat disc fixed to the rostellum. If this be removed from the anther, which is at the top of the column, it at once commences to contract, and thus causes the pollinia to be depressed to a nearly horizontal position. This depression is almost identical with that which occurs in the British *Orchis mascula*, as described by Darwin,* but there is a somewhat different action in our species, in that the two masses of pollinia separate slightly at the same time. The time taken by this contraction and depression of the caudicles, was about ten seconds. If these were attached to the proboscis of a small insect, they would on their first withdrawal from the anther be in such a position as to strike the rostellum of the next flower they visited, but this is obviated by the depression of the caudicle, so that, in the short interval of time mentioned, they are so placed as to project into the deep and somewhat two-lobed stigmatic cavity under the rostellum.

In my former paper† I stated that *Chiloglottis cornuta* seemed exclusively adapted for self-fertilization. This I am now enabled to verify, for a number cultivated indoors, and covered by a hand-glass during the flowering season, produced a fine full capsule from each flower.

Of the *Thelymitras*, *T. longifolia* is very frequently self-fertile, but prominent forms are no doubt crossed by insects. *T. uniflora*, on the contrary, which produces very brilliant blue flowers, is chiefly dependent on insect aid, and is a great honey-producing species.

Nat. Ord. IRIDÆE.

This order is only represented in New Zealand by the genus *Libertia*, two species of which are found in Otago.

L. ixioides is an extremely common plant, particularly in dry, sandy situations. The white, hermaphrodite flowers have no scent, but in bright sunny weather secrete a considerable amount of honey, and are very conspicuous. I have not detected any difference in the time of ripening of the

* "Fertilization of Orchids," p. 6.

† "Trans. N.Z. Inst.," Vol. XI., p. 424.

anthers and stigma; but the styles diverge in a different direction from the stamens, and only their tip is stigmatic.

L. micrantha, which is a very abundant plant in the dense bush bordering the West Coast sounds, is also furnished with pure white, delicate, hermaphrodite flowers. These have no scent, nor have I been able to detect any honey, and they are probably self-fertile, though occasionally visited by insects.

Nat. Ord. NAIADEÆ.

The only species of the order which I have looked into is the ubiquitous *Potamogeton natans*. According to Delpino, quoted by Sir J. Lubbock,* this plant is proterogynous. I could not distinguish this peculiarity as being very well marked. The flowers are hermaphrodite, and probably can fertilize themselves; but they are also anemophilous, and produce a quantity of light powdery pollen, which is easily shaken out of the anthers.

Triglochin, which also has one species in New Zealand, *T. triandrum*, is stated by Axell† to be proterogynous. I have not observed this plant carefully.

Nat. Ord. LILIACEÆ.

Callixene parviflora, a beautiful little snowdrop-like plant, is common in the woods of the West Coast, the Bluff, and Stewart Island. I have not been able to notice any contrivance to secure cross-fertilization, and, with the exception of the prominent colour, the flowers have no great attractiveness to insects, being destitute of scent and honey.

Cordyline australis—the common cabbage-tree—produces great massive panicles containing thousands of whitish flowers. These are hermaphrodite, but are evidently greatly dependent on insects. They are powerfully fragrant, and secrete a good deal of honey. I have seen them surrounded by great numbers of insects, chiefly Diptera, which, on bright sunny days, swarmed on them in hundreds.

Astelia—which is usually separated into a distinct order, *Asteliæ*—is characterized among other things by its polygamo-dioecious flowers.

A. nervosa is the only common species in this part of Otago, and is unique in its fertilization, for its flowers are very inconspicuous owing to their colour and are produced quite among the large foliage leaves, while lastly the plants themselves grow in the bush. Its habitat debars it from being wind-fertilized, the plants usually occurring in sheltered parts of the bush, where even a strong wind is little felt. The flowers are completely dioecious in function, but hermaphrodite in structure, though always more or less imperfect. The panicles of male flowers are much more lax and prominent than those of the female flowers, and are lighter and more con-

* "British Wild Flowers," p. 153.

† Loc. cit., p. 161.

spicuous in colour. The perianth-lobes are somewhat chaffy and completely re-curved, so as to expose the wide disc, covered with its secretion of honey. The centre of this disc, within the stamens, has a conical stylopodium destitute however of a stigma. The ovary is fairly well-developed and contains numerous ovules, but these never seem to be fertilized, and always become aborted.

The female flowers are in a stout, rigid, and short panicle; which is very glossy and dark green in colour. The flowers have short, erect, perianth-lobes and no trace of stamens. The ovary is well-developed, and bears on its summit three clearly defined sessile stigmas.

Both kinds of flower are extremely fragrant, and attract considerable numbers of Diptera to them.

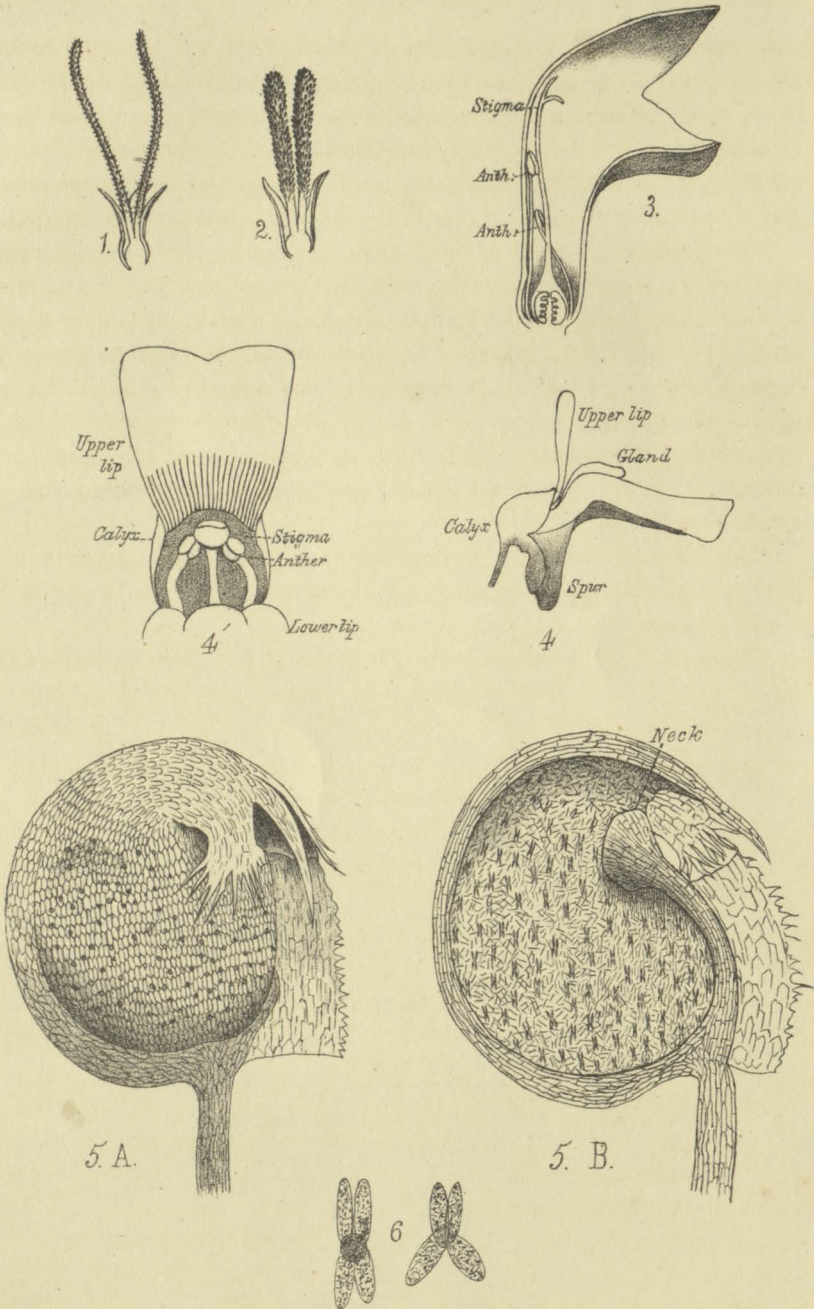
Anthericum hookeri is always hermaphrodite, while the much handsomer *A. rossii* found in the Auckland and Campbell Islands is always dioecious. Our species has bright yellow flowers, and is probably visited and greatly aided in its fertilization by insects, but it has neither honey nor scent. The stamens are somewhat proterandrous, the three opposite the outer perianth lobes always so.

On Frazer Peaks, Stewart Island, I found a very stunted form of this species, tending strongly towards cleistogamy. The flowers were crowded on short rigid scapes, and had their perianth-lobes so greatly reduced in size as to give the racemes a pale yellowish-green hue. The stamens also were greatly reduced, but the ovaries were well developed.

Phormium tenax is another of those large open-flowered species which are chiefly fertilized by birds. I have little doubt that large insects occasionally visit the flowers, but they depend chiefly on the tuis and honey-birds which visit them. Kakas and parakeets also aid sometimes, but the former are too heavy to be welcome visitants, and most probably do more damage than good.

The flowers secrete a large amount of honey, and are distinctly proterandrous. As only the extreme tip of the style is stigmatiferous, and does not become so until most of the pollen has been scattered, it is probable that the flowers are not capable of self-fertilization.

Into the modes of fertilization of the more inconspicuously-flowered orders of plants I have not gone, but there is little doubt that many interesting adaptations will be found to exist among them, and that their close examination will yield valuable results. It is a somewhat common remark that little remains to be done by an original worker among our flowering plants. Nothing could be more incorrect, however, than such a statement, for our knowledge is extremely limited and fragmentary. It is manifestly so in those respects which I have already pointed out in the earlier part of



G.M.T. del.

To illustrate Paper by G.M. Thomson.