AN INVESTIGATION OF THE GENUS *PHYLLOTA* (DC.) BENTH. (LEGUMINOSAE)

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(Plates xxix–xxx)

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Synopsis

The generic status of *Phyllota* has been retained, pending a more extensive examination of the taxonomic relationships of *Pultenaea* with *Phyllota*, *Dillwynia*, *Aotus*, and possibly other related members of the Podalyrieae. At the moment the generic distinction between *Phyllota* and *Pultenaea* rests almost wholly on the differing form and texture of the bracts, a distinction of comparable magnitude existing between east coast species of *Phyllota* with leafy bracteoles and persistent petals, and the remaining species, in which the bracteoles are predominantly small, linear, and in some species scarious or coriaceous. A detailed study, using quantitative techniques, demonstrated a number of phenotypically differentiated groups within *P. phylicoides*. As a result of this, specific rank has been restored to *P. grandiflora*, *P. squarrosa*, and *P. humifusa*. A number of other groups retain the identity of *P. phylicoides*. The need for an investigation of the breeding behaviour of these groups is shown, also the need for an investigation of the ecological factors connected with their distribution, in particular an investigation of possible variation in the mineral composition of the sandstones of the Sydney district. Lectotypes are named for *Phyllota luehmannii* and *Phyllota pleurandroides*.

INTRODUCTION

The genus *Phyllota*, which is endemic to Australia, was first described by A. P. de Candolle in his Prodromus Regni Vegetabilis, as a section of the genus *Pultenaea*. It was established as a genus in its own right by Bentham in 1838.

In the present study, the genus was investigated from several viewpoints, firstly an evaluation of its taxonomic relationships with other genera, in particular with the genus *Pultenaea*, an association first recognized by de Candolle, but also with the genera *Aotus* Sm. and *Dillwynia* Sm. Secondly, an investigation of the taxonomic relationships within the genus, particularly in the Sydney region, where considerable variation occurs in a relatively small area, and finally an attempt to correlate the variation in the Sydney district with environmental factors.

The distribution of the genus (see Fig. 1) extends around the southern part of Australia from Bundaberg on the Queensland coast, through New South Wales, Victoria, Tasmania, South Australia and the south-west of Western Australia. Figure 1 is based on herbarium records and, particularly in the case of Western Australia, the distribution shown may be incomplete.

The genus is confined largely to a sandy substrate, either in the form of fixed sand dunes or of sandstone, depending on the species. With the exception of two Western Australian species, the genus is also confined to temperate regions with a rainfall in excess of 20 inches per annum (Burbidge, 1960).

Since it appeared that infraspecific variation in the Sydney region was much greater than elsewhere, it was decided to devote particular attention to this area, where, in recent years, all variations have generally been included

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within the species *Phyllota phylicoides* (Sieber ex DC.) Benth. (e.g. Thompson, 1961). In the past these variants have been recognized as being of specific rank, there being eight specific epithets presently included as synonyms of *P. phylicoides*. It is proposed to deal with the investigation carried out in the Sydney region in a first section, and to consider later the taxonomy of the genus as a whole.

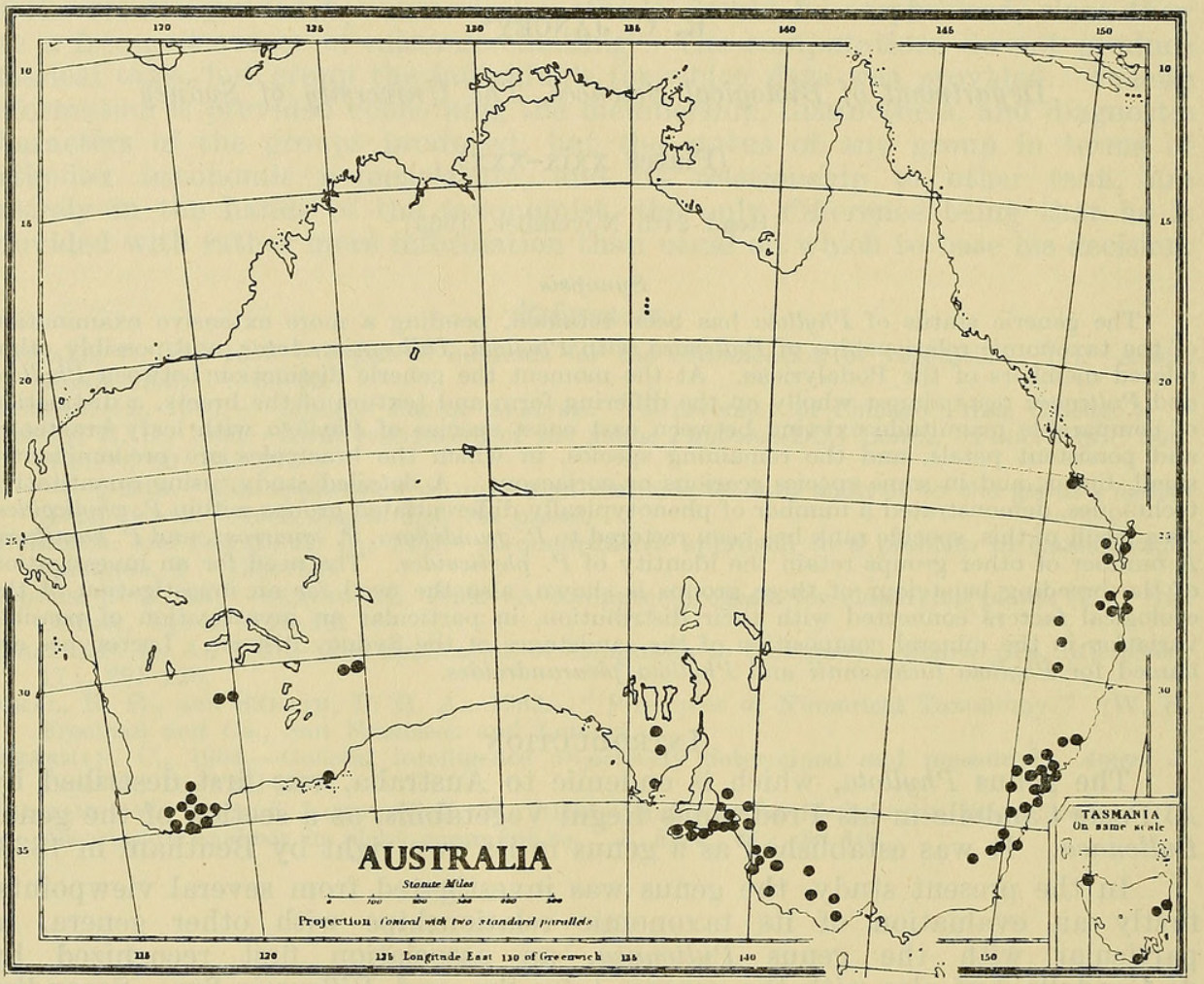


Fig. 1. Distribution map of the genus *Phyllota*

Variation in the Sydney Region

Introduction

This section of the study formed the basis of an investigation using numerical taxonomic methods. The numerical aspects of the investigation have been reported elsewhere (Jancey, 1966). In the course of this investigation a number of groups were established on the basis of phenotypic similarity. In the present account it is proposed to describe the relationships of these groups in terms of geographic distribution, breeding behaviour, and cytology, in addition to phenotypic characters, and, in the light of the total information available, establish the taxonomic rank, if any, to which they may be entitled. While it is not proposed to introduce any discussion of numerical techniques into this account, for convenience of reference the variants in the Sydney region will be referred to by the group numbers used in the investigation previously referred to.

Methods

Collection of specimens

All the specimens of *P. phylicoides* from the National Herbarium of New South Wales and the Queensland Herbarium were examined in detail, and a

series of measurements on soaked material were also made on all the specimens from the National Herbarium of New South Wales with the object of selecting an area for investigation which would include all the sites of major variation within the species. A further object of this examination was the selection of phenotypic characters to be recorded on living material.

As a result of these preliminary investigations coupled with observations in the field, the area selected for study was one bounded by Lake Macquarie in the north, Jervis Bay in the south, and Lithgow in the west. It was felt desirable to collect specimens as evenly as possible from the area under investigation, since this would yield additional information concerning the geographic and ecological range of the variants, apart from the location of any possibly transitional forms. The method chosen was to take specimens at one-mile intervals along roads and fire trails in the area, with the precaution of making the collection 100 yards or more from the road to avoid plants distributed by passing traffic. Detailed measurements were made on 313 specimens, and additional field trips made and specimens examined to establish more precisely the distributional limits of the groups.

Recording of data

Data recorded at the time of collection included height of specimens, the formation in which they were growing (heath, dry sclerophyll forest, etc.), soil type, amount of shading, exposure to wind, and the presence of other plants where it was felt that these were indicative of a change of habitat.

On returning to the laboratory, a number of records of characteristics were made on the fresh material, and are listed below. Use was made of a number of subjective scales for recording characters not amenable to objective measurement; illustrations of scale values are included where applicable. All measurements of floral parts were made on flowers which had just opened, and could hence be considered to be in a comparable state of development.

Data recorded in the laboratory may be summarized as follows:

Inflorescence length

The longest inflorescence of any specimen was stripped of its flowers, and the length of the inflorescence axis measured in millimetres. While there was considerable variation within individuals, there appeared to be some constancy in the maximum inflorescence length which an individual could attain.

Number of flowers per inflorescence

As could be expected, this character was correlated with inflorescence length. The correlation was not a necessary one, however, since independent variation of these characters occurred. It served, in conjunction with the other two inflorescence characters, to demonstrate affinities which could otherwise be described only in extremely subjective terms.

Number of flowers per millimetre

A character derived from the two previous inflorescence observations. It showed a high correlation with both, but demonstrated differences which would have otherwise been difficult to describe, and was hence treated as an independent variable.

Bracteole length and breadth

Both these two characters were measured to the nearest half millimetre. Since all floral measurements were made on flowers which had just opened, the characteristic enlargement of bracteoles after the death of the petals did not constitute a source of variation between specimens.

Calyx and bracteole indumentum

For flowers of the same age on the same plant this character was quite constant. The epidermal hairs responsible were similar to those associated with the bullae on the leaves. In flowers of the age examined, the hairs were still present, obviously so in the case of the calyx, but the relationship between bracteole and calyx indumentum was always the same. A subjective assessment of this indumentum was made on a 1–4 scale of abundance (see Pl. xxix).

Bracteole colour

Bracteole colour appeared from preliminary observations to be far less dependent on environmental factors than stem colour, and considerably more constant within individuals. It was preferred consequently as a character. It was difficult to assess, and may, like calyx colour, have represented the outcome of a number of contributing forces. It was recorded on a subjective scale, with green represented by 1, and varying through yellow to almost wholly red at 4.

Calyx colour

This was recorded in a similar way to bracteole colour. The colour of the calyx and bracteoles was frequently similar but not always so. For this reason both characters were retained.

Calyx length

This character was measured by dissecting out the calyx tube at its point of attachment to the receptacle, and measuring the length of the tube plus one of the posterior calyx lobes to the nearest half millimetre.

Standard length

It was found that within the species *P. phylicoides*, the petals did not vary in relative lengths, consequently standard length was taken as representative of corolla length. After dissecting the flower, the total length of the standard was measured, including the claw. The length of the standard was extremely constant within individuals, such variation as occurred, some 0·5 mm. within individuals, was almost certainly due to the difficulty experienced in flattening reflexed standards prior to measurement.

Standard pigmentation

Three separate patterns were found on the standards of living specimens. The three pigmented areas were recorded on subjective 1–4 scales, the four values being illustrated in Figure 2.

Leaf spacing

The number of leaves produced within the 10 mm. of axis immediately behind an inflorescence was counted. This character was somewhat susceptible to environmental factors.

Leaf weight per millimetre of length

The character was measured by determining the air-dried weight of 20 leaves immediately below an inflorescence, and dividing this weight by 20 times the average leaf length as found in the previous character, thus giving a value for leaf weight per millimetre of length. Given the assumption that all leaves of all individuals were of equal density, this character would have provided a comparable measure of the cross sectional area of the leaves, a character which was seen in the preliminary investigation to have a marked constancy within individuals, and an equally marked variation within individuals. No attempt

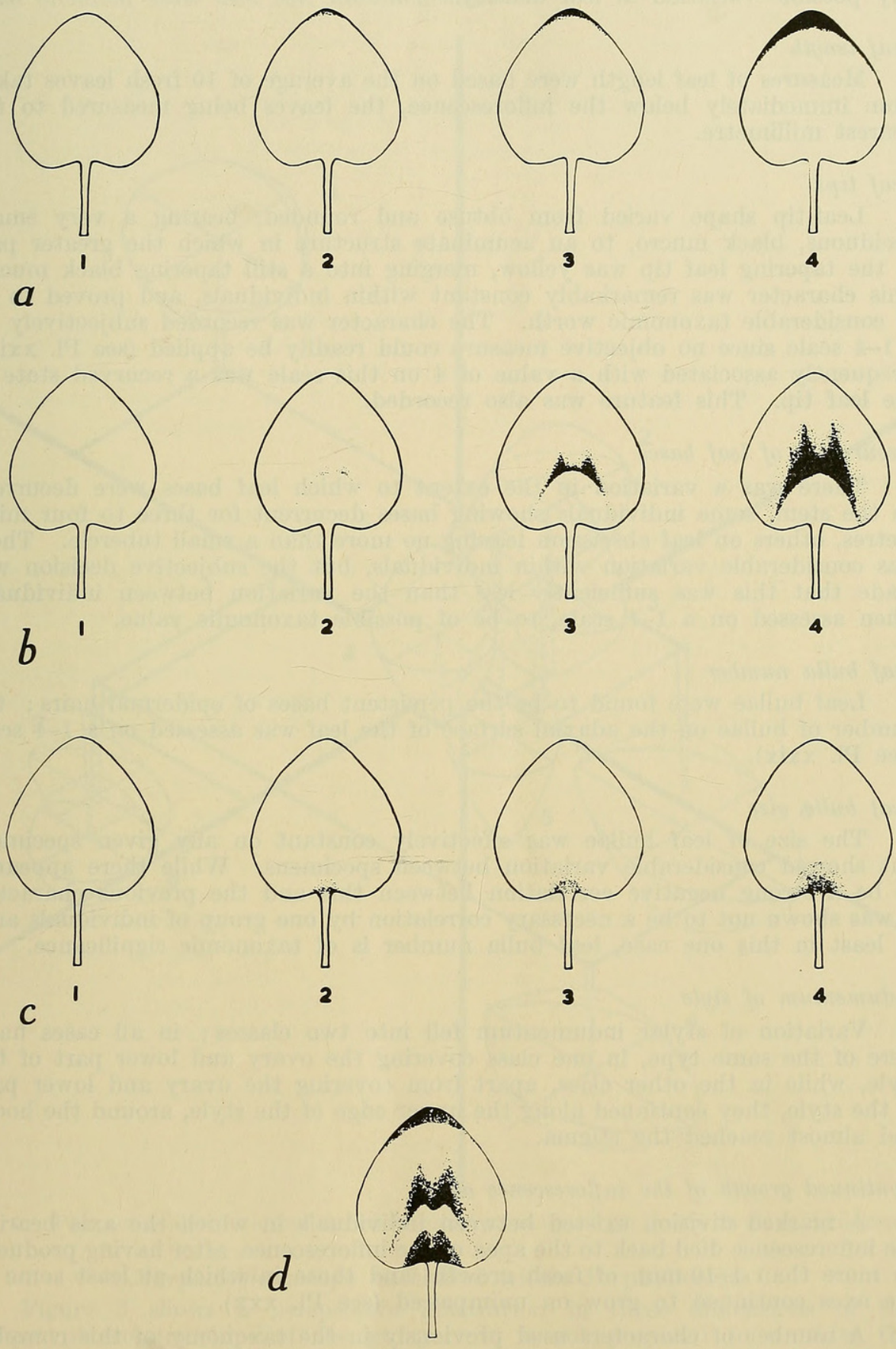


Fig. 2. Illustrating the values from 1 to 4 on the subjective scale for pigmentation of the standard. Upper, middle and lower zones are shown in *a*, *b*, *c* respectively. The composite form is shown in *d*, which also illustrates the alternative form taken by the lower edge of the middle zone.

was made to confirm the assumption of equal density, since the differences in cross sectional area were so large and so consistent as to be quite distinct despite any possible variation in leaf density.

Leaf length

Measures of leaf length were based on the average of 10 fresh leaves taken from immediately below the inflorescence, the leaves being measured to the nearest millimetre.

Leaf tips

Leaf-tip shape varied from obtuse and rounded, bearing a very small, deciduous, black mucro, to an acuminate structure in which the greater part of the tapering leaf tip was yellow, merging into a still tapering black mucro. This character was remarkably constant within individuals, and proved to be of considerable taxonomic worth. The character was recorded subjectively on a 1–4 scale since no objective measure could readily be applied (see Pl. xxix). Frequently associated with a value of 4 on this scale was a recurved state of the leaf tip. This feature was also recorded.

Decurrence of leaf bases

There was a variation in the extent to which leaf bases were decurrent on the stem, some individuals showing bases decurrent for three to four millimetres, others on leaf abscission leaving no more than a small tubercle. There was considerable variation within individuals, but the subjective decision was made that this was sufficiently less than the variation between individuals, when assessed on a 1–4 scale, to be of possible taxonomic value.

Leaf bulla number

Leaf bullae were found to be the persistent bases of epidermal hairs ; the number of bullae on the adaxial surface of the leaf was assessed on a 1–4 scale (see Pl. xxix).

Leaf bulla size

The size of leaf bullae was effectively constant on any given specimen, but showed considerable variation between specimens. While there appeared to be a strong negative correlation between this and the previous character, it was shown not to be a necessary correlation by one group of individuals and, at least in this one case, leaf bulla number is of taxonomic significance.

Indumentum of style

Variation of stylar indumentum fell into two classes ; in all cases hairs were of the same type, in one class covering the ovary and lower part of the style, while in the other class, apart from covering the ovary and lower part of the style, they continued along the upper edge of the style, around the hook, and almost reached the stigma.

Continued growth of the inflorescence axis

A marked division existed between individuals in which the axis bearing the inflorescence died back to the apex of the inflorescence, after having produced no more than 1–10 mm. of fresh growth, and those in which at least some of the axes continued to grow on unimpaired (see Pl. xxx).

A number of characters used previously in the taxonomy of this complex were rejected after a preliminary survey of living material, on the grounds that the character concerned was essentially constant within the species under investigation. Characters coming within this category were the shape of calyx lobes, their length relative to that of the calyx tube, the relative length of the

petals and their shapes, and also the shape of the style. Other characters were rejected because of excessive susceptibility to environmental factors; these included stem and leaf indumentum.

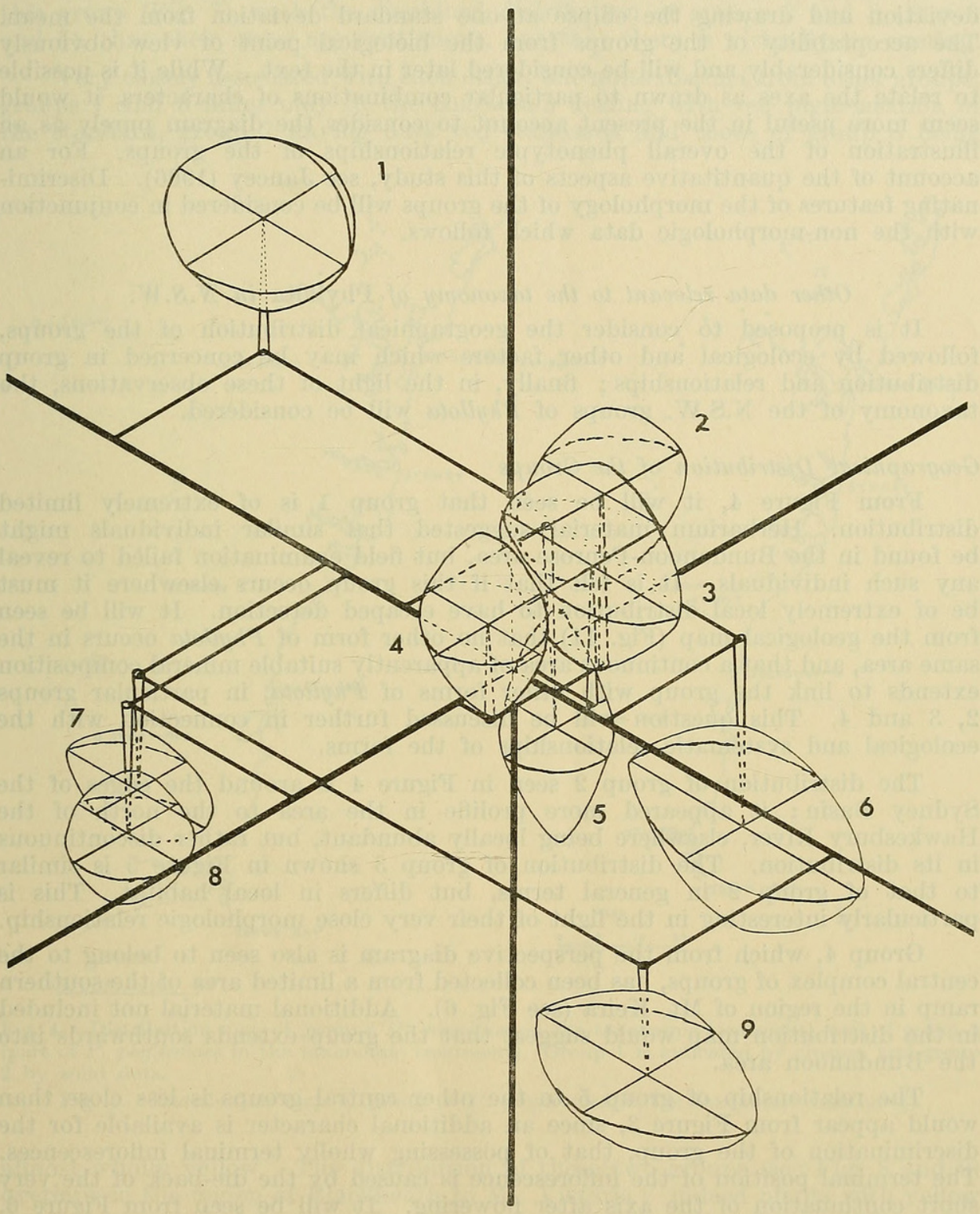


Fig. 3. Perspective illustration of the relationships of morphologic groups in three dimensions

Morphologic groups established within P. phylicoides

Figure 3 shows a perspective illustration in three dimensions of the phenotypic relationships of the groups. It is not proposed to consider the numerical techniques by which the groups were delimited in this taxonomic account, but it may be said briefly that the three axes represent the first three axes of a principal axes factor analysis of the correlation matrix of characters. Thus each axis is composed of varying contributions from the characters used

in the study. The groups have been discriminated by another multidimensional analytical technique, but for clarity of expression have been represented in terms of factor scores of their members. This was achieved by calculating the mean on each axis for the members of a group, calculating the standard deviation and drawing the ellipse at one standard deviation from the mean. The acceptability of the groups from the biological point of view obviously differs considerably and will be considered later in the text. While it is possible to relate the axes as drawn to particular combinations of characters, it would seem more useful in the present account to consider the diagram purely as an illustration of the overall phenotypic relationships of the groups. For an account of the quantitative aspects of this study, see Jancey (1966). Discriminating features of the morphology of the groups will be considered in conjunction with the non-morphologic data which follows.

Other data relevant to the taxonomy of Phyllota *in N.S.W.*

It is proposed to consider the geographical distribution of the groups, followed by ecological and other factors which may be concerned in group distribution and relationships; finally, in the light of these observations, the taxonomy of the N.S.W. groups of *Phyllota* will be considered.

Geographical Distribution of the Groups

From Figure 4, it will be seen that group 1 is of extremely limited distribution. Herbarium material suggested that similar individuals might be found in the Bundanoon-Penrose area, but field examination failed to reveal any such individuals. It is felt that if this group occurs elsewhere it must be of extremely local distribution to have escaped detection. It will be seen from the geological map (Fig. 11) that no other form of *Phyllota* occurs in the same area, and that a continuous area of apparently suitable mineral composition extends to link the group with other forms of *Phyllota*, in particular groups 2, 3 and 4. This question will be discussed further in connection with the ecological and systematic relationships of the forms.

The distribution of group 2 seen in Figure 4 is around the edges of the Sydney Basin; it appeared more prolific in the area to the north of the Hawkesbury River, elsewhere being locally abundant, but rather discontinuous in its distribution. The distribution of group 3 shown in Figure 5 is similar to that of group 2 in general terms, but differs in local habitat. This is particularly interesting in the light of their very close morphologic relationship.

Group 4, which from the perspective diagram is also seen to belong to the central complex of groups, has been collected from a limited area of the southern ramp in the region of Mt. Keira (see Fig. 6). Additional material not included in the distribution map would suggest that the group extends southwards into the Bundanoon area.

The relationship of group 5 to the other central groups is less close than would appear from Figure 3, since an additional character is available for the discrimination of the group, that of possessing wholly terminal inflorescences. The terminal position of the inflorescence is caused by the die-back of the very short continuation of the axis after flowering. It will be seen from Figure 6, that the group is largely confined to the region south of Botany Bay, having its centre in the Royal National Park; a small number of individuals from other areas have been assigned to the group. Of these, one individual from the near north shore of Sydney, and the two from the Blue Mountains, are similar to those found in the main distribution area of group 5, their isolated position possibly being due to distribution by man. The remaining isolated individuals do not show the terminal inflorescences characteristic of group 5, and may now be better assigned to groups 2 or 3, an assignment which would be more in keeping with their distribution.

Group 6 is confined to the north shore of Sydney Harbour (see Fig. 7). The two individuals from the Royal National Park could be assigned subjectively with greater confidence to group 5 in the light of data concerning terminalization of the inflorescence. It will be seen from a comparison of the distribution of this group (Fig. 7), with the combined distribution of groups 2 and 3 (Figs 4 and 5), that their areas are contiguous, but that there is virtually no overlap.

Very closely associated with each other, but quite distinct from other groups, groups 7 and 8 differ only in the characters dealing with red pigmentation of the standard, group 7 having dark red standards and those of group 8 being

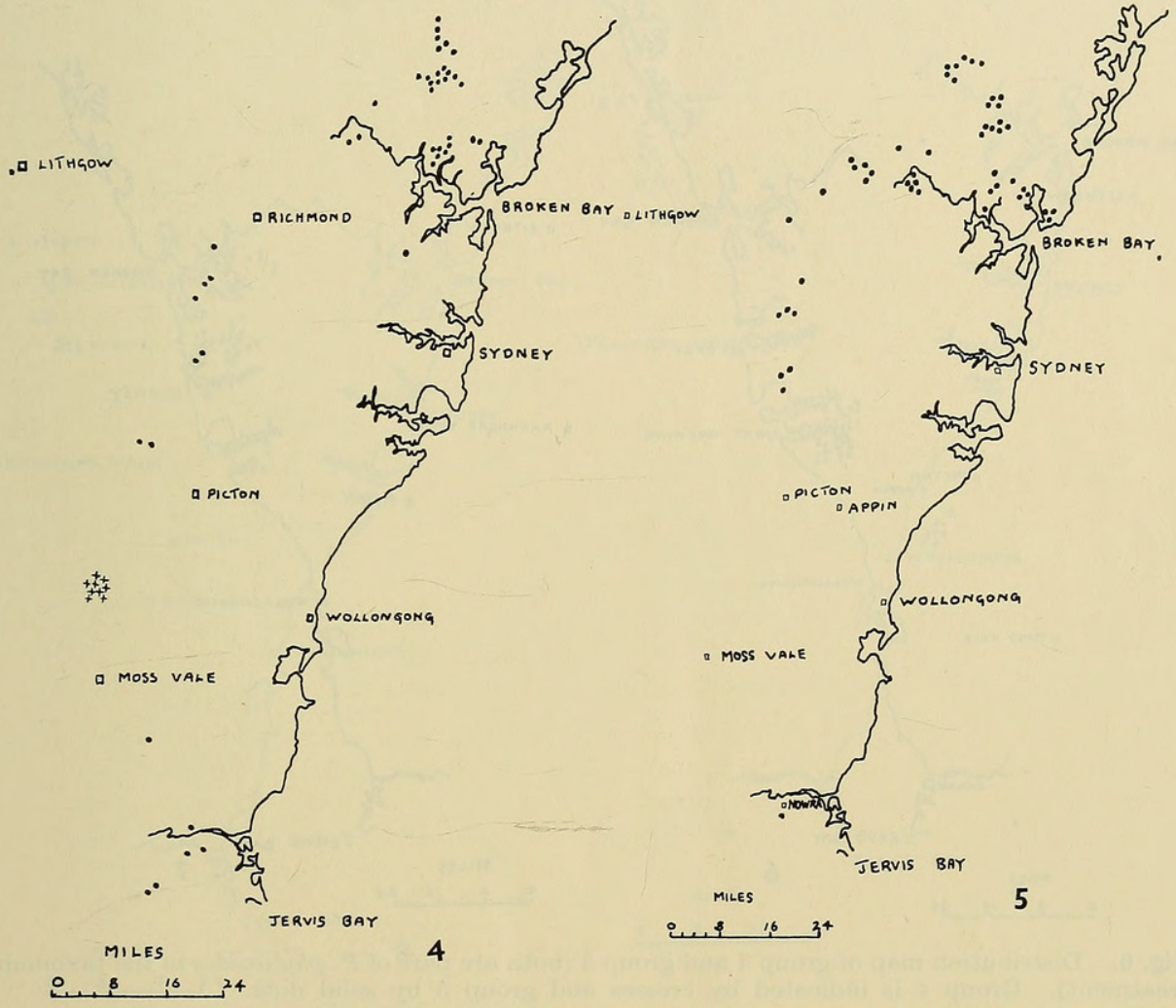
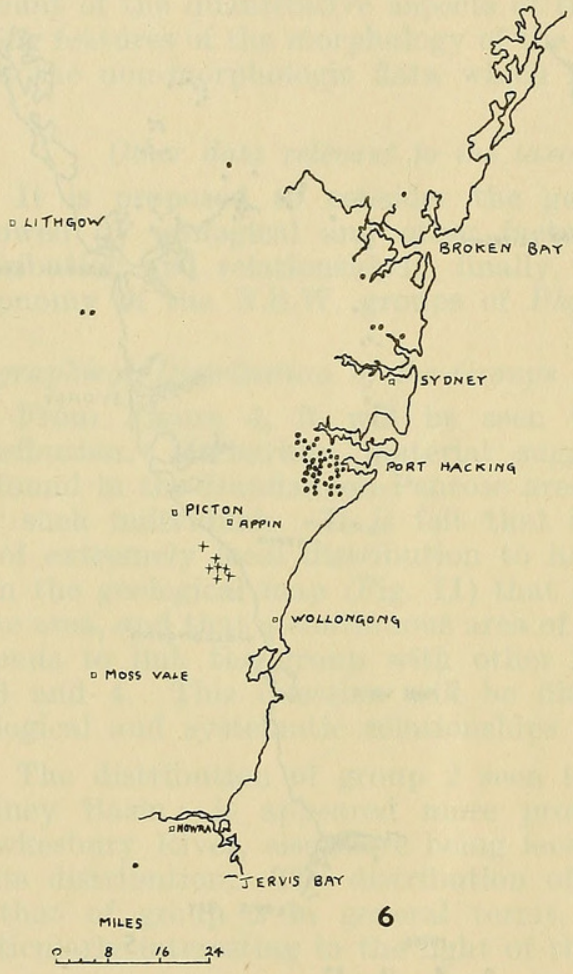


Fig. 4. Distribution map of group 1 (*P. humifusa* in the taxonomic treatment), and of group 2 (part of *P. phylicoides* in the taxonomic treatment). Group 1 is indicated by crosses, and group 2 by solid dots.

Fig. 5. Distribution map of group 3 (*P. phylicoides* in the taxonomic treatment).

almost wholly yellow. The distribution of these two groups (see Figs 8 and 9) overlaps in the region of Blackheath to Mt. Victoria ; indeed plants with yellow and red standards have been found growing next to each other in this region. Group 7 contains two individuals isolated geographically from the rest of the group, one at Mt. Keira, and the other south of Nowra. Group 8 contains one individual from the Nowra region, but is otherwise confined to the Upper Blue Mountains. Examination of these three specimens confirmed that their assignment to groups 7 and 8, like the assignment of two individuals from the same region to group 5, was almost certainly a misclassification as a consequence of the small number of individuals from the region. It will be seen from the combined distribution of groups 7 and 8, that the groups are confined to the

higher parts of the Blue Mountains. Comparison with Figures 4 and 5 would suggest that the groups are geographically isolated from groups 2 and 3. However, the anomalous records for group 5 individuals at Wentworth Falls and also two Herbarium records for plants of the group 2, 3 type in the same area would suggest that the geographic isolation may not be complete. The ease with which plants of the group 2, 3 type can be found in the foothills of the Blue Mountains, and their absence despite careful searching higher in the ranges would suggest that their distribution in the latter area must be very discontinuous and limited. The north-south distribution of groups 7 and 8 is less easy to establish than their east-west distribution. Figures 8 and 9



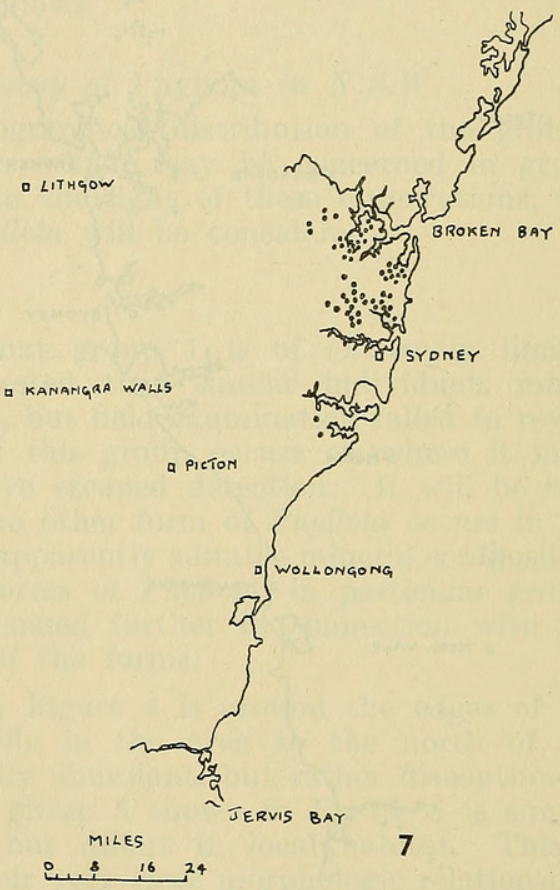


Fig. 6. Distribution map of group 4 and group 5 (both are part of *P. phylicoides* in the taxonomic treatment). Group 4 is indicated by crosses and group 5 by solid dots.

Fig. 7. Distribution map of group 6 (part of *P. phylicoides* in the taxonomic treatment).

show the distribution to be confined to the highest parts of the Blue Mountains, and from further observations it may be said that the northerly distribution extends at least as far as the inner end of the Wolgan Valley, north of Clarence, but has ceased before the Capertee Beds east of Rylstone are reached. This absence of *Phyllota* is paralleled to the east by the absence of groups 2 and 3 going north along the Colo-Putty-Singleton road (see Figs 4 and 5). The southerly extension of groups 7 and 8 appears to be limited by the available high ground of suitable mineral composition. South of the Blackheath-Katoomba area there is little continuous high sandstone ground, apart from the neck running out to Mt. Solitary. This area has not been examined for the presence of *Phyllota*, but individuals of group 8 have been collected from Kanangra Walls, where they were found growing on Permian sandstones. Their presence in this area would imply either great age to the discreteness of group 8, followed by no evolutionary change, or alternatively, that even

assuming a route via Mt. Solitary, colonization and genetic interchange over considerable distances of unsuitable country were possible. No *Phyllota* has been found on the non-sandstone rocks surrounding Kanangra Walls. To the east of the walls, groups 2, 3 have been found at Oakdale, though at a very much lower altitude. South of Kanangra, the first sandstone examined lies south of the Wollondilly River, to the east of Mt. Bullio, where the altitude is also much lower. Here no *Phyllota* is found at all, though some 10 miles to the east lies the limited area containing group 1.

Group 9 follows the distribution of group 6 (see Figs 10 and 7). The small group of individuals from group 9 in the region of Appin, are rather different from the bulk of the group found north of Sydney Harbour, being rather less

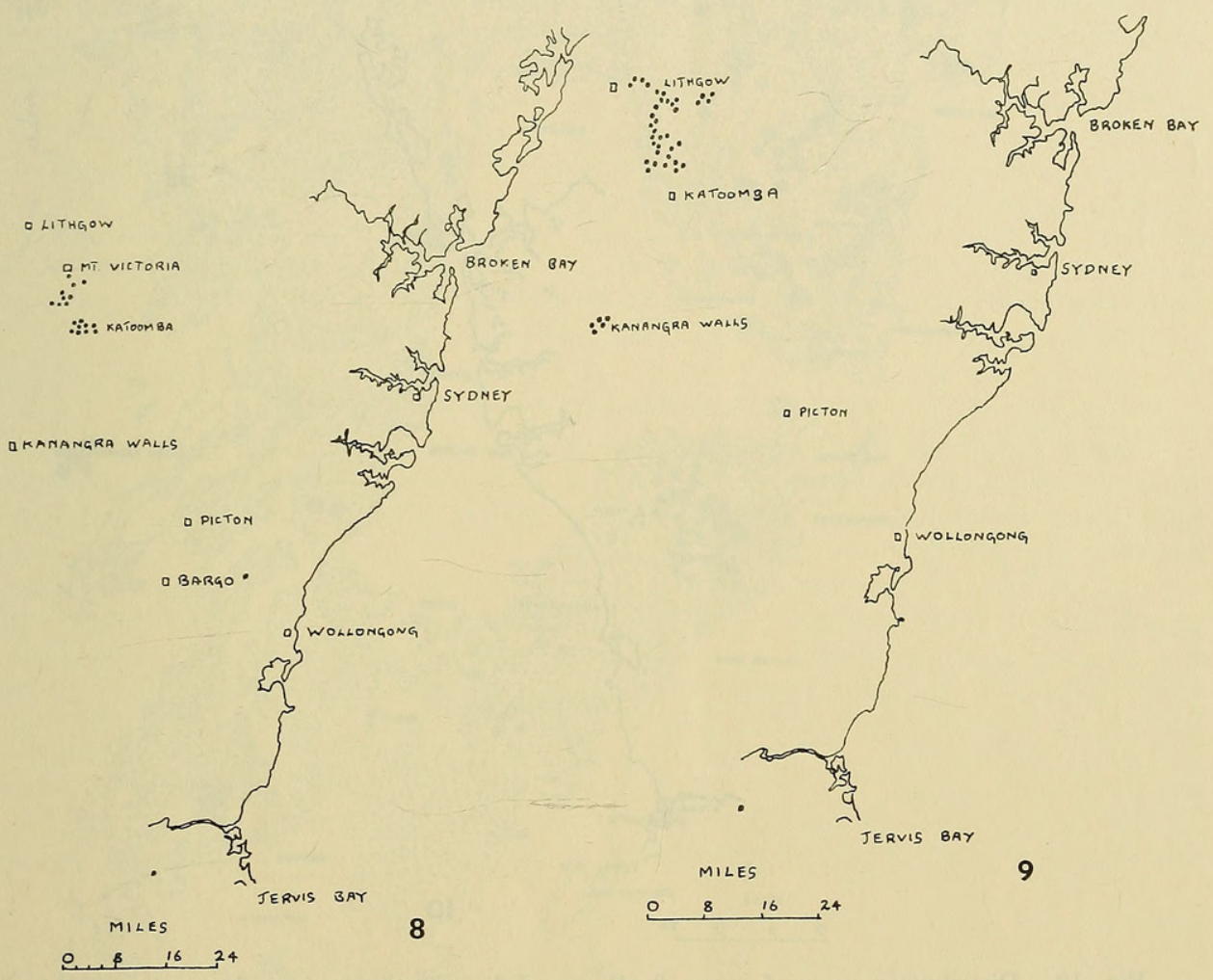


Fig. 8. Distribution map of group 7 (part of *P. squarrosa* in the taxonomic treatment).
Fig. 9. Distribution map of group 8 (part of *P. squarrosa* in the taxonomic treatment).

robust, and possessing rather fewer flowers per inflorescence. However, these distinctions will be considered in more detail in the section dealing with the taxonomy of the New South Wales forms of *Phyllota*. The two individuals found on the Hume Highway south of Bargo correspond very well to the character values for group 9. Their presence in this area could possibly have been the result of human distribution, but if so, the distribution must have taken place in early colonial days or before, as a specimen of the group 9 type was collected by MacArthur from Bargo, and is at present in the Kew Herbarium. Failure of the plants to spread may have been due to unsuitable substrate. Herbarium records show specimens of the group 9 type to be growing immediately south of Botany Bay in the region of Como. Careful searching has failed to reveal any living examples in this area, an absence which may be due to urban development.

Factors affecting Distribution and Variation

Geological and Ecological

Figure 11 shows the distribution of all the individuals used in the analysis, superimposed on the areas of sandstone in the region. It will be seen that, while no records fall outside the sandstone areas shown on the map, there are large areas of sandstone in which no *Phyllota* of any group is found. While no quantitative study has been made of this problem, it may be said that the presence or absence of *Phyllota* is to some extent associated with small changes in altitude. In view of the small changes in altitude involved, this would suggest stratigraphic changes, and hence possible changes of a mineralogical nature. Changes in iron content of the Hawkesbury Sandstone certainly occur

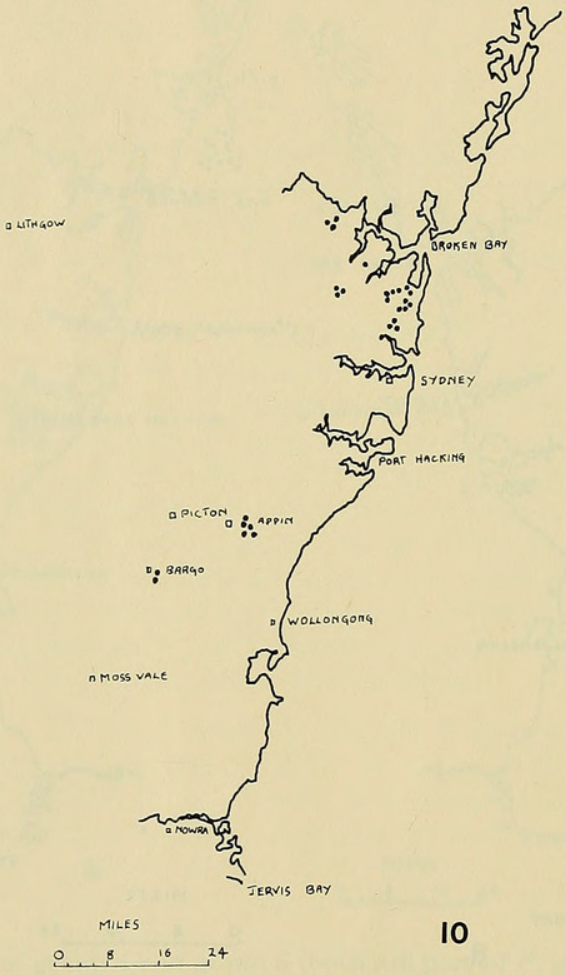


Fig. 10. Distribution map of group 9 (*P. grandiflora* in the taxonomic treatment).

(David, 1950), and it would seem reasonable to suppose that other metals at least would be present in varying abundance. Cases where discontinuities of *Phyllota* occur without changes in altitude would not necessarily refute this basis for variation since, in the case of dipping strata, movement over the surface would bring about the same changes as changes of altitude in the case of horizontally bedded strata. A particularly clear case of the correlation of strata with distribution is found in the region north of Wiseman's Ferry, where, although *Phyllota* is apparently absent from the slopes of the sandstone plateau, it may be found at the top of the plateau. Equally flat, although slightly lower, areas of the plateau are however once again devoid of *Phyllota*. Similarly, individuals of group 5 disappear from the Princes Hghway just south of the Woronora Dam turnoff as the highway climbs up towards the Bulli Pass, and, although not included in Figure 6, the distribution of group 5 continues around the lower contour as far as the western limit of the exposed sandstone to the north-east of Appin.

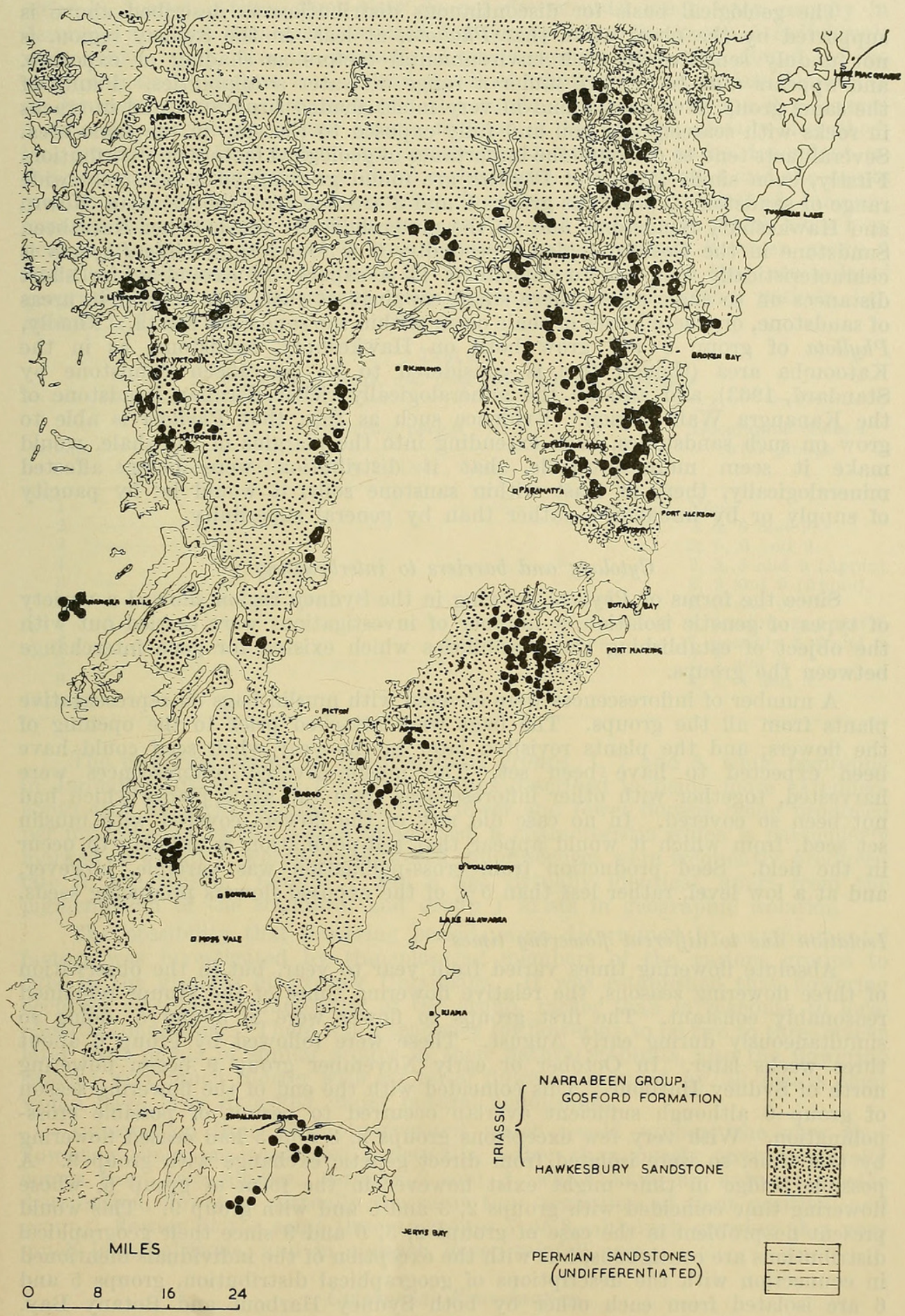


Fig. 11. Map of total distribution relative to areas of sandstone. The westernmost areas shown as Hawkesbury Sandstone are, according to Standard (1963), Narrabeen Sandstone but are mineralogically different from that in the Gosford area.

The geological basis for discontinuous distribution as described above is supported by the observation that *Phyllota*, at least in the Sydney region, is not unduly sensitive to such environmental factors as shading or exposure, and appears able to survive under a range of water availabilities. Plants of the same group have been found in very moist shaded situations, and in cracks in rocks with scarcely any soil and fully exposed to the sun, in the same area. Several facts tend to discount the importance of geological factors on distribution. Firstly, even single groups of *Phyllota* are found growing on a relatively wide range of sandstone types, thus groups 2 and 3 are found on the Permian, Nowra and Hawkesbury Sandstone, and on the mineralogically much richer Narrabeen Sandstone in the Gosford region. Secondly, it is found that while *Phyllota* is characteristically confined to sandstone, it is capable of extending for short distances on to shale soils, where small cappings of such soils remain in areas of sandstone, or where lenses of shale occur within the sandstone strata. Finally, *Phyllota* of group 8 will grow both on Hawkesbury Sandstone, as in the Katoomba area (though this is considered to be Narrabeen Sandstone by Standard, 1963), and also on the mineralogically richer Permian Sandstone of the Kanangra Walls region. Evidence such as this, that *Phyllota* is able to grow on such sandstones, even extending into the margins of the shale, would make it seem more probable that if distribution were being affected mineralogically, then, at least within sanstone soils, it would be by paucity of supply or by imbalance, rather than by general superfluity.

Cytology and barriers to interbreeding

Since the forms of *Phyllota* growing in the Sydney region showed a variety of types of genetic isolation, a number of investigations were carried out with the object of establishing the possibilities which existed for gene interchange between the groups.

A number of inflorescences were covered with muslin bags on representative plants from all the groups. The bags were attached prior to the opening of the flowers, and the plants revisited later in the year when seed could have been expected to have been set. The muslin-covered inflorescences were harvested, together with other inflorescences from the same plants which had not been so covered. In no case did any of the flowers covered with muslin set seed, from which it would appear that self-pollination is unlikely to occur in the field. Seed production from cross-pollination was variable, however, and at a low level, rather less than 5% of the exposed flowers producing seeds.

Isolation due to different flowering times

Absolute flowering times varied from year to year, but in the observation of three flowering seasons, the relative flowering times of the groups remained reasonably constant. The first groups to flower were 2, 3 and 5, doing so simultaneously during early August. These were followed by group 6 about three weeks later. In October or early November group 9 began flowering north of Sydney Harbour. This coincided with the end of the flowering season of group 6 although sufficient overlap occurred to permit of possible cross-pollination. With very few exceptions groups 2, 3 and 5 had ceased flowering by this time, so were isolated from direct genetic exchange with group 9. A possible bridge in time might exist however in the form of group 6, whose flowering time coincided with groups 2, 3 and 5 and with group 9. This would present no problem in the case of groups 2, 3, 6 and 9 since their geographical distributions are contiguous, but with the exception of the individuals mentioned in connection with the descriptions of geographical distribution, groups 5 and 6 are isolated from each other by both Sydney Harbour and Botany Bay. The members of group 9 occurring in the Appin region are in geographic contact with group 5. However, the members of group 9 in the Appin region, apart from the slight differences from the rest of group 9 already mentioned, also

differ in flowering time, since they do not flower until much later, usually in January, and are thus quite isolated temporally from the group 5 individuals with which they are in contact. Late flowering was also found to be characteristic of groups 1, 4, 7 and 8, all of which flowered in late December or January onwards. Group 4 and the Appin members of group 9 possessed a flowering period of similar length to that of the groups already described, i.e., groups 2, 3, 5, 6 and 9, the precise length appearing to be dependent on the season, but extending over about eight weeks. Thus group 4 and the Appin members of group 9, by commencing flowering in the beginning of January, experienced a temporal isolation from groups 2, 3 and 5 with which they may possess geographic contact (as was found to exist certainly between group 5 and the Appin members of group 9), while at the same time they are isolated geographically from the groups with contemporaneous flowering periods, i.e., groups 1, 7 and 8.

TABLE 1

Flowering periods, and geographic contacts of groups

Group	Flowering period								Geographic contact with groups
	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mch.	
1						———	———	→	None.
2	———	———							3 5, 6 and 9.
3	———	———							2, 5, 6 and 9.
4						———	———		2, 3, 5 and 9 (Appin).
5	———	———							2, 3 and 9 (Appin).
6		———	———						2, 3 and 9.
7						———	———	→	8, possibly 2, 3 and 5.
8						———	———	→	7, possibly 2, 3 and 5.
9				———	———	———			2, 3 and 6.
9 (Appin)						———	———		2, 3, 4 and 5.

The flowering period of the remaining groups, 1, 7 and 8, while beginning in January, differed from the other groups described in being more extended, continuing until the autumn, but with fewer and fewer flowers being produced per inflorescence as the season progressed, a characteristic which is particularly marked in group 1, where one-flowered inflorescences were frequently produced late in the season. Groups 7 and 8 are virtually identical, apart from the pigmentation of the standard, and group 1 exists in geographic isolation.

The possibility that flowering periods were determined by environmental factors was investigated by transplanting members of the various groups to sites in the grounds of Sydney University. It was established that flowering occurred at times characteristic of the group, rather than in response to local climatic conditions. There was a tendency for flowering to be two to three weeks later than plants of similar groups in their natural habitats, also the flowering seasons were much shorter with far fewer flowers produced by all plants than would have been expected under natural conditions.

Information from field observations which would support the view that flowering times are controlled genetically rather than purely environmentally comes from two sources. Groups 2 and 3, which have an extremely wide distribution, flower at virtually the same time regardless of their position, and group 1 flowers at the same time as groups 7 or 8, although growing at a very much lower altitude, and in a much lower rainfall area.

Cytological Examination

All cells examined were found to have a chromosome number of $2n=14$. No differences were observed in the morphology of the chromosomes. The need for artificial breeding experiments is clear but, owing to the time required

to produce flowering progeny, and the difficulties experienced in raising seedlings, no attempts at artificial crossing were made. Voucher specimens were placed in the herbarium of Sydney University, and are listed in the formal taxonomic section of this work.

Growth Habit

Apart from the differing propensities for terminalization of the inflorescence as mentioned earlier, a number of further habit differences exist between the groups which for various reasons it was not possible to utilize in the construction of the model of phenotypic groups.

Branching pattern

The extent to which plants branched was characteristic of the different groups, and appeared to be related in some way to the tendency towards inflorescence terminalization. Groups 2, 3 and 5 branched most profusely, the branches emerging and remaining at an angle of about 45 degrees to the parent axis. Such branching tended to be, but was not invariably, associated with the formation of inflorescences. The resulting appearance tended to be of a rather compact bushy shrub. Groups 4, 6 and 9 showed less tendency towards branching and, associated with this, a more vigorous growth of existing stems, and a greater mean plant height, at least in the case of groups 6 and 9. Groups 7 and 8, although showing virtually no tendency towards inflorescence terminalization, and branching relatively infrequently, nevertheless showed a distinct limitation in the height to which they would grow, even in sheltered situations. Joined with them in the matter of height limitation was group 4, though to a rather lesser extent. The most extreme case of height limitation was found in group 1, in which the production of the characteristically few flowered inflorescences appeared in no way to interfere with the continued growth of the stem. Plant height seldom exceeded three to six inches, however.

Rooting system

Some explanation of plant height variations not apparently relatable to branching characteristics may be found in the form of the plant at and below ground level. In setting up the transplant experiments described previously, stolon-like structures were discovered while digging up plants in the field. Since the presence of runners had been used as a diagnostic character in the case of a South Australian species of *Phyllota* (Willis, 1957), their occurrence among the groups under discussion was investigated. Horizontal underground structures linking two or more aerial stem systems were found in groups 2, 3, 4, 7, 8 and 9. Microscopic examination showed that these possessed the anatomical structure of a root. The extent to which the root system developed suckers varied considerably among the groups, being most marked in groups 7 and 8, considerably less extensive in groups 4 and 9, but with the suckering roots much thicker in the latter though occurring rather less frequently. Suckering was very infrequent among groups 2 and 3, though short horizontal roots, about six inches long and rather thicker than the normal rooting system, were encountered frequently, even in seedlings about 12 months old. No examples of suckering were found in groups 5 or 6, though group 6 showed occasional examples of short horizontal roots similar to those found in groups 2, 3. No such roots were found in group 5, nor were any other indications of a tendency to produce suckers. Group 1, while showing no tendency to produce root suckers, achieved a similar, though lower, growth habit to groups 7 and 8 through an extensive prostrate stem system, from which arose short erect branches, bearing in turn a few even shorter lateral branches (see Pl. xxx). Continued growth of some aerial shoots caused them to become procumbent, finally forming part of the prostrate stem system. Apart from the presence of leaf bases, anatomical investigation confirmed the distinction of group 1 in

possessing a prostrate stem system, as opposed to the suckering root system of some other groups. The free and extensive suckering of groups 7 and 8, and to a lesser extent of group 4 (see Pl. xxx, *c* and *a*), would appear to be related in some way to the limited height achieved by their aerial parts, a situation paralleled in some degree by group 1. The stimulation of suckering by burning off the aerial parts during bush fires is a possibility, but since bush fires are prevalent throughout the areas of Hawkesbury Sandstone, it is not felt that this would account for the observed differences. The plant shown in Plate xxx was collected from an area believed not to have been burnt for some years, yet numerous young suckers were emerging. Examination of group 5 plants from areas known to have been burnt showed no trace of suckering, while among plants of groups 6 and 9 growing within a few feet of each other, plants of group 9 bearing suckers were easily found, while none were found on plants of group 6.

The Taxonomy of Phyllota *in New South Wales*

As was stated previously, the forms of *Phyllota*, presently referred to *P. phylicoides*, which occur outside the area covered by the investigation are remarkably uniform, and correspond in fact to groups 2, 3 in Figure 3. Some herbarium material from sites in Queensland might be referable to group 5 but, in the absence of non-terminal inflorescences, the distinction between the groups rests mainly on inflorescence characters which can be established only by destruction of the inflorescence. In any case, at least in the light of present knowledge, the entities recognized on the basis of information from the area under investigation include the whole range of variation found within what has been recognized hitherto as the species *P. phylicoides*.

Taxonomic status of the groups

The groups which have been described are, for the most part, easily recognizable in the field by a trained observer. A considerable amount of additional data exists supporting the status of the groups, but in many of the groups there is a lack of suitable discriminatory characters on which the confident allocation of some herbarium material might be made.

The difficulty described above presents the problem of purpose in erecting formal taxa. Barriers to gene interchange appear to exist between all groups with the exception of groups 2, 3 and 7, 8. The barriers, as described in an earlier section, apparently being distance, differing flowering times or, at least in the case of groups 6 and 9, genetic incompatibility. In this latter case, the two groups are found within six feet of each other, and the flowering periods overlap sufficiently to permit the possibility of frequent cross pollination. The absence of intermediate forms is so complete that no difficulty was experienced in distinguishing flowering individuals of the two groups at a glance; it was scarcely more difficult in the vegetative condition. Clearly information of this sort is not a satisfactory basis for decisions concerning barriers to gene interchange, and should be substantiated by controlled breeding experiments. The length of time involved, however, placed such a programme beyond the scope of this investigation. The probability of partial or complete barriers to gene flow between the groups is relevant to their taxonomic status but, even were complete genetic isolation demonstrated, the utility of erecting taxa not readily discriminated on morphologic grounds seems doubtful. A more appropriate vehicle for describing a number of the morphologically similar groups would appear to be the deme system of terminology (Gilmour and Heslop-Harrison, 1954), in which groups of plants characterized, for example, by geographic distribution or potentialities for gene interchange are described in such terms, without any implication of orthodox taxonomic rank.

Considering the group relationships in the light of all the available information, it is clear that the distinction least capable of substantiation is

that between 2 and 3. Their separation was the result of small consistent differences on a number of characters. The distinction was so slight as to be undetectable by subjective means, and even now cannot be confidently discriminated at sight. Such a distinction is clearly of little utility for taxonomic purposes, particularly in view of the common flowering time and distribution of the two groups. Consequently their distinction will not be maintained.

The combined groups 2 and 3 have, as their closest related form, group 5. Discrimination between these two groups in morphologic terms rests on the number of flowers per inflorescence, number of flowers per mm. and the number of leaves per 10 mm. respectively. A further distinction is given by the invariable inflorescence terminalization in 5 as opposed to the continued growth of the stem in 2, 3. Other distinctions lie in the production of occasional root suckers in 2, 3 and, rather less infrequently, short, thickened horizontal roots resembling abortive attempts at sucker production, as compared with the complete absence of anything approaching sucker formation in 5. Finally, the group distributions may be considered; apart from a small number of herbarium specimens from Queensland whose identity with 5 was doubtful, the group is confined to an area south of Sydney Harbour and, as far as can be determined, is isolated geographically from the possibility of gene interchange with 2, 3. Whether any incompatibility barriers also exist is not known, but the effective isolation might well be sufficient to account for the observed morphologic differences. While the magnitude of these differences is not sufficient to make a formal taxonomic distinction either necessary or practicable, recognition may nevertheless be given to 5 by describing it as a phenogamodeme. This term indicates at one time the spatial, temporal, and genetic possibility of interbreeding within the group and also the existence of phenotypic distinction from other groups.

The status of 4 is to some extent analogous to that of the members of 9 occurring in the Appin area. Both are represented by small numbers of individuals, and occur in a limited geographical area. In both cases the large flowers occurring in lax inflorescences suggest affinities with 7, 8 and 9. However, the inflorescences of Appin individuals are both shorter and contain fewer flowers than other members of 9. Those of 4 are quite typical of 7 and 8. Despite the similarity of inflorescence with 7 and 8, in almost all other characters, 4 shows greatest affinity with the central complex of groups as may be seen in Figure 3. As a consequence of this, it has been decided to unite 4 with 2, 3 and hence with 5 for taxonomic purposes. Individuals at Appin can best be left as members of 9 since, although differences exist, they are associated most closely with this group and, in the absence of further information concerning their origin, cannot be separated reasonably from it. Both group 4 and the Appin members of 9 may be given some recognition in the deme terminology as phenotopodemes, though absence of sufficient evidence precludes the use of the distinction gamodeme.

Groups 6 and 9 show greater morphologic distinction from each other and from group 2, 3 than other groups described so far. They differ also in having superposed distributions, though that of group 9 is more restricted in area. Both groups 6 and 9 tend to be characterized by taller growing plants than group 2, 3, though this may be obscured by the age of the plants. As in the groups described already, flower and inflorescence characters are of particular discriminatory value. Inflorescence length is least in group 2, 3, followed by group 6, and finally group 9 has the longest inflorescence. Inflorescence density serves to distinguish groups 2, 3 and 9 with lax inflorescences, from group 6 in which the number of flowers per millimetre is much greater, though not equal to that found in group 5. A suspected connection between inflorescence density and tendency towards inflorescence terminalization was not borne out by group 6, since, although possessing denser inflorescences than group 2, 3, it shows a considerably greater tendency towards vigorous continued growth

of the stem after inflorescence production. Above average length of inflorescence, coupled with great density, results in group 6 having the highest value of any group for the number of flowers per inflorescence. Apart from the characters already described, group 9 is distinguished from group 2, 3 and from group 6 by high values for weight per millimetre of leaf length ; indeed, this character distinguishes group 9 from all groups other than groups 7 and 8, where other distinctions apply. The absence of root suckers in group 6 provides a further link with group 5, while at the same time distinguishing it from group 9 in which such suckers are frequently found, and group 2, 3 in which they are occasionally present.

TABLE 2

Summary of major discriminating characters

Presence of	Characteristic of groups
Procumbent stems	1.
Consistent and prolific production of root suckers	7, 8.
Consistent terminalization of inflorescence	5.
Large flowers	4, 7, 8, 9.
Lax inflorescence	4, 7, 8, 9.
Long inflorescence	6, 9.
Recurved leaf tips	7, 8.
Numerous flowers in inflorescence	5, 6.
Massive leaves	9.

This qualitative table is by no means exhaustive, and should be interpreted in conjunction with the text. Quantitative values have been omitted in the interests of simplicity, but may be found in the formal taxonomic descriptions.

Information concerning breeding behaviour on the north shore of Sydney Harbour may be summarized as follows : Temporal isolation precludes direct gene flow between group 2, 3 and group 9, though group 6 represents a possible temporal bridge. In the absence of direct experimental evidence, no final conclusions on gene flow can be reached ; it may be said, however, that in view of the distributions and flowering times of the groups, the absence of intermediate forms, particularly between groups 6 and 9, would suggest inter-group sterility.

In the light of the above considerations, group 9 will be restored to specific rank. The status of 6 is less clear ; while this group shows sufficient differentiation from groups 2 to 5, when these are considered as individual groups, to merit infra-specific distinction, the increase in range of character variation resulting from the combination of 2 to 5 is such that confident discrimination between this combined group and 6 can no longer be achieved. Group 6 will be merged, therefore, with these groups for formal taxonomic purposes, though it undoubtedly represents a phenotopodeme of rather greater distinction. In the absence of spatial or temporal breeding isolation, a decision regarding its status as a gamodeme must be reserved until direct experimental evidence is available.

The two groups occurring in the Upper Blue Mountains, 7 and 8, show little morphologic differentiation from each other, except in pigmentation of the standard. Geographic distributions are not identical, but show considerable overlap. Since flowering times are identical, little can be said concerning the breeding behaviour of the two groups other than that there is no obvious barrier to interbreeding. The contrary evidence provided by the absence of intermediate forms is of rather less weight than in other groups, since the phenotypic distinction is confined to characters which might have a very similar genetic origin. While the differences in pigmentation enable the two groups to be recognized as separate phenodemes, it is not felt to be a distinction meriting formal taxonomic status. Consequently, these two groups will be considered together ; in this combined form ready discrimination from other groups is

still possible. In qualitative terms it may be said that the group differs from the ' central complex ' of Figure 3 in possessing lax inflorescences of larger flowers (though see previous remarks concerning group 4), and the much greater leaf weight per mm. It is distinct from group 9 in its lesser plant height, number of flowers per inflorescence, rather smaller flowers and narrower bracteoles. Characters separating 7 and 8 from all other groups are the consistently recurved and acuminate leaf tips, and the abundance of root suckers produced by unspecialized roots. With the exception of two apparently anomalously located individuals from other groups, geographic isolation would appear to be complete from all other groups and, even if the two individuals mentioned should be representative of others as yet undetected, breeding isolation would still be maintained by virtue of the differing flowering times. In the light of the above considerations, the combined groups 7 and 8 will be restored to specific rank.

The remaining group, group 1, shows considerable morphologic differentiation from other groups. It differs from the combined groups 7 and 8 in its smaller flowers, absence of acuminate recurved leaf tips, and in having a lower value for leaf weight per mm. It can be distinguished from 9 by size of floral parts, pigmentation of standard, inflorescence length and flower number, length and weight per mm. of leaves, plant height and number of leaf tubercles. From the ' central complex ' of groups, group 1 differs in respect of plant height, inflorescence length, bracteole breadth, pigmentation of standard, and leaf length. Group 1 differs from all other groups in its low creeping habit and prostrate stem, and also in geographical distribution. In view of the degree of differentiation indicated above, it is felt that group 1 should be restored to specific rank.

Thus in this area, specific rank is given to the following four assemblages : 1 ; 9 ; 7, 8 ; 2, 3, 4, 5, 6.

The Relationship of Specific Epithets previously applied to Phyllota *in New South Wales, to the Groups described*

In view of the considerable synonymy of the New South Wales species of *Phyllota* it is proposed to consider the specific epithets available, the groups to which they refer, and hence the synonymies of the species, prior to the formal descriptions of the species occurring in New South Wales as determined by this investigation.

PHYLLOTA HUMIFUSA A. Cunn. ex Benth. in *Ann. Wien. Mus.*, II : 77 (1838).

Features of the holotype of this species which are of importance in relating the type specimen to the groups described in the preceding section are as follows : Stems prostrate, thin and wiry. Leaves 6 mm. long, 0·5 mm. wide, apex recurved with a small mucro. Inflorescence few–flowered (*ca.* 3), loose, not terminal. Bracteoles linear-lanceolate, 3 mm. long, 1 mm. wide. Calyx hirsute with appressed hairs, *ca.* 4 mm. long (lobes 2 mm.). Ovary villous, style glabrous.

Holotype : Wombat Brush, Argyle County, N.S.W. A. Cunningham No. 8 (K).

These characters, combined with the locality of the type specimen, leave no doubt as to the identity of *P. humifusa* with group 1.

PHYLLOTA SQUARROSA (Sieber ex DC.) Benth. in *Ann. Wien. Mus.*, II : 77 (1838).

Basionym : *Pultenaea squarrosa* Sieber ex DC. *Prod.*, II : 113 (1825).

Leaves divergent, recurved, with distinct recurved, acuminate yellow tips, leaves *ca.* 1·3 mm. long. Flowers few in spike, axis growing on while still in flower. Standard *ca.* 9·5 mm. long.

Holotype: Sieber No. 406 (GEN). The isotype at Kew bears Sieber's original label, and is localized as Blue Mountains; there are also two sheets bearing this number at MEL. This specific epithet will be applied to the combined groups 7 and 8.

Two names are available for the species represented by group 9: *Phyllota pilosa* Benth. and *Phyllota grandiflora* Benth. Both species were erected by Bentham in *Ann. Wien. Mus.*, II: 77 (1838), but included by him in *Phyllota phylicoides* in *Fl. Austr.*, II: 95 (1864). The latter epithet will be adopted, since it describes the more striking and constant feature of the species.

PHYLLOTA PILOSA Benth.

There are three sheets of Huegel's collection at Vienna, two of which correspond to group 9; the remaining sheet differs in a number of respects from both the two preceding sheets and Bentham's description of the species, corresponding more closely to the type of *P. comosa*. In particular this last sheet possesses rather more slender, erect leaves, the hairs over the whole plant being more appressed. The flowers are smaller and the calyx much less pilose. It corresponds most closely to NSW 7226, Gordon West, M. Tindale, except for slightly longer, yellowish hairs.

P. GRANDIFLORA Benth.

Only one sheet bearing this name exists at Vienna, and none at Kew. The specimen corresponds to Bentham's diagnosis of *P. grandiflora*, but this does not differ sufficiently from that of *P. pilosa* to differentiate the two species; thus for *P. grandiflora*, '. . . foliis supra tuberculoso-scabris subtus pubescentibus . . .', and '. . . bracteolisque pilosis flore brevioribus . . .', while for *P. pilosa*, '. . . foliis tuberculoso-scabris muticis, novellis calicibusque pilosis, floralibus flores aequantibus . . .'; the type specimens, with the exception referred to in the case of *P. pilosa*, all being referable to group 9.

P. COMOSA (Sieber ex DC.) Benth. in *Ann. Wien. Mus.*, II: 77 (1838).

Basionym: *Pultenaea comosa* Sieber ex DC. *Prod.*, II: 113 (1825).

Holotype: Sieber No. 407. Locality, Nov. Holl. Two sheets of this material are at Vienna, and one at Kew, all bearing Sieber's original label, and also two at MEL. The Kew isotype is similar to the specimen NSW 7226 Gordon West, M. Tindale. The vigorous continued growth of the axis is characteristic of groups 6 and 9, while the size of the floral parts satisfactorily establish *P. comosa* as a binomial associated with group 6. This is also in accord with the isotypes at MEL.

P. ASPERA (Sieber ex DC.) Benth. in *Ann. Wien. Mus.*, II: 77 (1838).

Basionym: *Pultenaea aspera* Sieber ex DC. *Prod.*, II: 113 (1825).

Holotype: Sieber No. 408. Locality, Nov. Holl. There are two sheets of this material at Vienna, one of which was acquired via Reichenbach fil., possibly in 1889. Since Bentham described the species while in Vienna, it would seem possible that his diagnosis of *P. aspera* was derived from the other sheet, previously at Vienna; this deduction would be in accord with the fact that Bentham's description '. . . bracteis glabris . . . . calycibus vix pubescentibus . . .' fits the specimen at Vienna. The sheet at Kew bearing Sieber's number 408 is also labelled Wm. Mac Arthur, No. 13, *Pultenaea asperata* (sic); no precise location is given, but another specimen of this is labelled Bargo Brush, Mac Arthur. It does not agree with Bentham's diagnosis with respect to the bracteoles and calyx quoted above, but resembles the specimen W. F. Blakely, The Valley, Hornsby, NSW 36368. These observations would place the Kew sheet in group 9, in contrast to the specimen seen by Bentham in Vienna, and the three sheets at MEL, which have been identified with group 6.

P. BILLARDIERI Benth. in *Ann. Wien. Mus.*, II : 77 (1838).

The holotype of this binomial is at Vienna, having been collected by Labillardière, with no record of the locality. The predominantly glabrous nature of the plant ' . . . ramulis vix puberulis, foliis glabris . . . . bracteolis glabris . . . . calycibus glabrisculis . . . ' would all seem to prohibit reference of the name to group 9, all the members of which tend to be moderately to markedly hirsute, at least in the calyx, and never wholly glabrous. The size of the leaves, 10·0 mm. long, 1·5 mm. broad, pedicels 1 mm. long, bracteoles nearly ovate, with a breadth of 3 mm., and an overall flower length of 9 mm., which would correspond to a standard length of 8·5–9·0 mm., all tend to exclude the possibility of reference to group 9. A photograph of the holotype excluded the possibility of groups 1 and 7, 8, though group 1 was in any case excluded on the basis of the measurements. The diagnosis ' Spica oblonga subterminali ' excludes group 5 from consideration, thus leaving the conclusion that this epithet properly belongs with group 2, 3 or group 6, though insufficient data are available to differentiate between these two groups.

P. PHYLICOIDES (Sieber ex DC.) Benth. in *Ann. Wien. Mus.*, II : 77 (1838).

Basionym : *Pultenaea phylicoides* Sieber ex DC. *Prod.*, II : 113 (1825).

Holotype : Sieber No. 405. Locality, Nov. Holl. There are three sheets of this collection, all bearing Sieber's original number, two at Vienna (one via Reichenbach fil.) and one at Kew. There are three sheets at MEL and a second sheet at Kew, which does not bear Sieber's original label, but is marked ' ex Herb. Mus. Vind.'. It bears no flowers, but is mounted with a specimen labelled ' 14, Pultenaea, Sydney, Hooker 1845 ', which corresponds to group 5. The Kew isotype possesses leaves of length 13 mm., which are not mucronate. This feature is characteristic of members of group 5, the leaves being obtuse and with an extremely small black mucro which is very deciduous ; this characteristic appears in Bentham's diagnosis as ' . . . foliis obtusis '. The diagnosis also states ' spicis brevibus terminalibus ', a distinctive characteristic of group 5 since any growth of the axis following production of an inflorescence rapidly dies back, leaving the inflorescence effectively in a terminal position. Finally, the numerous and small flowers (length overall 6 mm.) are both characteristic of group 5, which is in accord with the MEL isotypes.

P. BAUERI Benth. in *Ann. Wien. Mus.*, II : 77 (1838).

Now at Kew and ex Herb. Mus. Vind., the holotype is mounted on the same sheet as another specimen collected by the U.S. Exploring Expedition, under Wilkes, at Sydney, this second specimen also being labelled *P. baueri.* The small leaves with minute mucro, and the small flowers in a subterminal inflorescence, identify this name with group 2, 3. It consequently becomes synonymous with *P. phylicoides.*

P. STURTII Benth. in *Fl. Austr.*, II : 95 (1864).

Holotype : C. Sturt, South Australia (K). Personal examination of the holotype of this species identified it with groups 2, 3 although it is described by Bentham as being between *P. phylicoides* and *P. barbata.* It is surprising that no similar collections have been made in South Australia subsequent to that of Sturt ; possibly the location refers in fact to southern New South Wales, though it is unlikely that Sturt collected in this region. There is, however, no doubt as to the identity of the specimen with groups 2, 3, and hence synonymous with *P. phylicoides.*

TAXONOMIC DISCUSSION

Intrageneric relationships of Phyllota *Benth.*

The species of *Phyllota* occurring on the east coast of Australia are distinguished from the remaining species of the genus in a number of respects.

Adnation of the petals and stamens is well marked in the New South Wales species, usually all 10 stamens being firmly united to the petals along the length of the claws. In addition, the claws of one or both wings are not uncommonly fused to that of the standard. In the remaining species, adnation is much less common, being confined to 5 or fewer of the stamens attached to the base of the petal claws, connation of the petal claws not occurring at all.

A distinction which may bear some relation to adnation of stamens is seen in the persistence of petals and stamens after flowering in the east coast species. This persistence was such that the remains were still present at maturity of the legume, while in other species petals and stamens were deciduous soon after enlargement of the legume began.

Final distinguishing features of the east coast species are seen in the shape and texture of the bracteoles. The lanceolate, herbaceous bracteoles, common to all these species with the exception of *P. humifusa*, are not found in the remaining species. Many possess scarious or coriaceous bracteoles, e.g. *P. diffusa*, *P. remota*, and *P. pleurandroides*, while those of the Western Australian species are very similar to foliage leaves, except in *P. luehmannii*, the bracteoles of which were found to approach the expanded leafy form found in the east.

P. barbata and *P. gracilis* in Western Australia represent another distinct group of species, being distinguished by barbulate styles, and acute, narrowly lunate keels. The relationship of these species is obscure, due to the lack of material of *P. gracilis*, a species represented solely by the type collection.

Apart from the larger discontinuities in the genus described above, interspecific distinctions within the genus appear, at least from a subjective approach, to be at approximately the same level of significance, with size, shape and texture of the bracteole being most useful in taxonomic discrimination, followed by size and shape of the standard.

The relationship of Phyllota *to the genera* Pultenaea, Dillwynia, *and* Aotus

Discriminating characters

Leaves : A satisfactory distinction exists between *Phyllota* and *Dillwynia* in that the leaves of *Dillwynia*, while being narrow-linear, are, without exception, involute as opposed to revolute. The leaves of *Aotus* and of some species of *Pultenaea* are similar to those of *Phyllota*.

Stipules : The presence or absence of stipules is not a reliable distinguishing character between the genera quoted, though it has been used as such in the past. All species of *Phyllota* have been found to possess minute stipules, stipules of the same size being found in at least some species of *Dillwynia* and *Aotus*. While *Pultenaea* has been characterized frequently as having more or less obvious stipules, in many species they are minute, and in others quite absent.

Bracts : Clear intergeneric distinctions are afforded by the form and texture of the bracts, these being small, brown and scarious in *Pultenaea*, *Dillwynia* and *Aotus*, also deciduous in the latter two genera. In *Phyllota*, however, the foliage leaves subtending the flower are unaltered, except in two instances : *P. pleurandroides* shows what may be an approach to the formation of differentiated bracts in the virgate clusters of leaves with altered bases which surround the flower ; on the specimen of *P. georgii*, now referred to *P. luehmannii*, the floral leaves, and those immediately below the inflorescence, no longer show the characteristic revolute form, but are nearly flat, with recurved margins.

Bracteoles : The range of bracteole form in the genus *Phyllota* has already been discussed. The presence, in at least some of the species, of minute scarious bracteoles removes this character as a source of intergeneric distinction, at least from *Pultenaea*, since such bracteoles are also characteristic of the latter genus. *Dillwynia* possesses similar bracteoles, but they are remote from the calyx and deciduous, while *Aotus* is without bracteoles.

Petals : No satisfactory distinctions may be made on the basis of petal shapes or relative sizes, due to the variation within genera, the biggest distinction existing between *Phyllota* and *Dillwynia*, where the orbicular to almost reniform standard of *Dillwynia* is only approached by some species of *Phyllota*.

Stamens : Adnation of stamens to the petals is confined to the genus *Phyllota*, though it has not been possible to establish the complete absence of this phenomenon in the other three genera. It has been possible to show, however, that there is considerable variation in the extent to which adnation occurs within the genus *Phyllota*, varying from fusion of stamens to petals and also of the petal bases themselves in *P. phylicoides* and the other New South Wales species, to the situation found in *P. diffusa* where the adnation is so slight as to be virtually undetectable, and certainly comparable with the situation occurring in at least some members of the genus *Pultenaea*.

Style : As a result of the intrageneric variation associated with stylar characteristics, and also the range of intraspecific variation associated with this character, little discriminatory value attaches to it, except in the case of *Dillwynia* which differs from the other genera in possessing a thicker, more truncate style, and *Aotus* in which the style is generally filiform.

Seed : All the genera under discussion possess two ovules per ovary, of which characteristically only one develops into a mature seed. The genera are also united in possessing reniform seeds of similar size ranges. The strophiole is a distinguishing character of limited value, being wholly absent from *Phyllota*, wholly present as far as is known in *Dillwynia* and, with some exceptions, present in *Pultenaea* and absent in *Aotus*.

The intergeneric relationships described above may be summarized as follows :

The genus *Pultenaea*, by virtue of its greater size and more diverse nature, appears to act as a central link joining the other three genera considered. Thus, in the form of its bracteoles, *Phyllota* appears to be linked to *Dillwynia* and *Aotus* via *Pultenaea*. A similar series may be seen in the form of the bracts, though there is much greater discontinuity in this case, in which no species of *Phyllota* shows any leaf modification comparable with that found in *Pultenaea*.

In leaf form *Phyllota* and *Aotus* appear to be alike, and linked to *Dillwynia* via *Pultenaea*. The small size or absence of stipules in *Phyllota*, *Dillwynia* and *Aotus* would unite them with relation to the greater part of the genus *Pultenaea*, though without creating any discontinuity, since similar forms are also found in the latter genus. Since stamens are free in all the genera except *Phyllota*, the positions of *Phyllota* and *Pultenaea* are the reverse of those obtaining in the case of stipules.

Leaves.

Phyllota ——— *Pultenaea* ——— *Dillwynia*

Aotus ———

Stipules.

Phyllota ———

Aotus ——— *Pultenaea*

Dillwynia ———

Bracts.

——— *Aotus*

Phyllota ——— *Pultenaea*

——— *Dillwynia*

Bracteoles.

Phyllota ——— *Pultenaea* ——— *Dillwynia* ——— *Aotus*

Stamens.

——— *Dillwynia*

Phyllota ——— *Pultenaea*

——— *Aotus*

Status of the genus Phyllota

The relationships of the genus have been considered in the previous section ; whether these relationships are sufficiently distant to warrant generic rank is debatable. It will be seen that the association is particularly close between *Phyllota*, *Aotus* and *Pultenaea*. The distinction between *Phyllota* and *Aotus* is acceptable at the generic level in that the two genera differ quite clearly in the form of their bracts and of their bracteoles. These structures bear a relationship to each other which leaves these two distinguishing characteristics with rather less weight than might have been carried by a more dissimilar pair of characters, but when considered in conjunction with a number of correlated but less constant characteristics, for example, those concerned with the shape of the standard and of the style, there is a dissimilarity which is of satisfactory generic rank. The distinction between *Phyllota* and *Pultenaea* is less satisfactory ; founded originally on differences in stipules, bracts, bracteoles, stamens and seeds, discrimination can now be based only on the bracts. It would seem doubtful if generic distinction could properly be based on one such character, without support from a number of other, more or less constant character differences. That the distinction is narrow is emphasized by some Western Australian species of *Pultenaea*, e.g. *P. dasyphylla* (Turcz.) C. A. Gardn., *P. lycopodioides* (S. Moore) and *P. capitata* (Turcz.) C. A. Gardn., none of which possess strophioles, and whose only apparent common difference from *Phyllota luehmannii* rests in the recurved rather than revolute form of the leaves, a distinction which, it will be recalled, was largely bridged by the specimen of *P. luehmannii* originally attributed to *P. georgii*.

While there is no doubt that such doubtful generic limitations are unsatisfactory, the generic status of *Phyllota* has been maintained in this study, since it is felt that an evaluation of the generic status of *Phyllota* should form part of an overall review of the Podalyrieae, or at least those members of the tribe already mentioned and known to be allied to *Pultenaea*.

Formal Descriptions of Taxa

Characters used in formal descriptions have been largely confined to those of value in intrageneric discrimination, those of generic distinction being considered in the section dealing with the status of the genus.

Of the specimens examined, only those belonging to collections known to have been lodged in European herbaria, or which are readily identifiable by accession numbers to Australian herbaria, have been included in the citations of specimens following the formal descriptions.

Taxonomy

Phyllota (DC.) Benth.

Fl. Austr., II : 93 (1864) ; Engler et Prantl, *Nat. Pflanz. Fam.*, III, 3 : 210 (1894) ; Benth. et Hook., *Gen. Pl.*, I : 470 (1865) ; Moore et Betche, *Handb. Fl. N.S.W.*, 135 (1893) ; Ewart, *Fl. Vic.*, 640 (1931) ; Black, *Fl. S. Aust.*, II : 442 (1948) ; Thompson in *Contrib. N.S.W. Nat. Herb., Fl. N.S.W.*, No. 101 : 45 (1961).

As *Pultenaea* sect. *Phyllota* DC., *Prod.*, II : 113 (1825) ; Curtis, *Stud. Fl. Tasm.*, I : 132 (1956).

Shrubs, with stems terete, pubescent at least in the upper parts, echinate with decurrent leaf bases. Leaves alternate, simple entire, linear, the margins revolute ; stipules minute or absent. Flowers axillary, solitary or crowded towards the ends of the branches, sometimes appearing terminal by death of the distal axis ; pedicels 1–5 mm. long ; bracts identical with, or scarcely differing from, foliage leaves ; bracteoles 1–15 mm. in length, scarious, coriaceous or frequently herbaceous, inserted at the base of the calyx. Calyx with the two upper lobes broader than the lower, and connate higher up.

Corolla: petals all clawed, the standard ovate to orbicular, equal to or somewhat exceeding the others. Stamens adnate to petals or scarcely so in some species. Ovary sessile, pubescent to villous, ovules 2, on short funicles, the style dilated or thickened at the base, incurved and subulate above, the stigma small and terminal. Legume inflated, twice as long as the calyx at maturity, containing 1–2 seeds. Seed reniform, not strophiolate.

A genus of 10 species, endemic in Australia.

Key to the Species of Phyllota

A. Style bearded upwards on inner edge
  B. Flower 12 mm. long, pedicel less than 1·5 mm. long .. .. .. *P. barbata*
  B′. Flower 5 mm. long, pedicel 4 mm. long, exceeding the calyx .. *P. gracilis*
A′. Style not bearded on inner edge
  C. Bracteoles herbaceous, linear or lanceolate
    D. Stem, bracteoles and calyx yellow tomentose, flowers in dense heads, keel purple, petals and stamens deciduous after flowering .. .. *P. luehmannii*
    D′. Stem glabrous to pubescent, bracteoles and calyx glabrous to villous, if flowers in dense heads then keel not purple, petals and stamens persisting until maturity of legume
      E. Flowers in lax spikes towards the ends of the branches, leaf tips acuminate and recurved, numerous root suckers formed .. .. *P. squarrosa*
      E′. Flowers scattered, in lax spikes or dense terminal heads, leaf tips never acuminate and recurved, root suckers absent or few from a thickened root-stock
        F. Procumbent shrub with purple-red corolla; flowers solitary or few together, bracteoles linear .. .. *P. humifusa*
        F′. Erect shrub with flowers in dense spikes at or towards the ends of the branches
          G. Leaves massive, 1·25–2·25 mm. broad, standard 10–15 mm. long, calyx densely villous .. .. *P. grandiflora*
          G′. Leaves slender, 0·75–1·25 mm. broad, standard 5–11·5 mm. long, calyx glabrous or pubescent .. .. *P. phylicoides*
  C′. Bracteoles scarious or coriaceous, not green
    H. Bracteoles oblong-ovate, as long as the calyx, keeled, mucronate .. *P. remota*
    H′. Bracteoles ovate, less than 2 mm. long, not keeled
      I. Flowers solitary or in pairs, in virgate clusters of leaves along the stem; leaves recurved and acuminate.. .. .. *P. pleurandroides*
      I′. Flowers in spikes towards the ends of the branches; leaf tips not recurved, obtuse .. .. *P. diffusa*

Phyllota phylicoides (Sieber ex DC.) Benth.

In *Ann. Wien. Mus.*, II: 77 (1838); Benth., *Fl. Austr.*, II: 95 (1864); Moore et Betche, *Handb. Fl. N.S.W.*, 135 (1893); Thompson in *Contrib. N.S.W. Nat. Herb., Fl. N.S.W.*, No. 101: 45 (1961).

Nomenclatural synonym: Pultenaea phylicoides Sieber ex DC., *Prod.*, II: 113 (1825). BASIONYM.

Taxonomic synonyms: Phyllota baueri Benth. in *Ann. Wien. Mus.*, II: 77 (1838); *Phyllota billardieri* Benth. in *Ann. Wien. Mus.*, II: 77 (1838); *Phyllota comosa* (Sieber ex DC.) Benth. in *Ann. Wien. Mus.*, II: 77 (1838); *Phyllota aspera* (Sieber ex DC.) Benth. in *Ann. Wien. Mus.*, II: 77 (1838); *Phyllota sturtii* Benth. *Fl. Austr.*, II: 95 (1864).

A shrub 90 cm. (15–165 cm.) high, with stems terete, pubescent at least in the upper parts. Leaves linear, 10 mm. (5·5–19 mm.) long, 1 mm. (0·75–1·25 mm.) broad, bullate, obtuse to acute (1–3 on the subjective scale); stipules minute. Flowers 23 (11–83), crowded together into leafy spikes 13 mm. (8–45 mm.) long towards the ends of the branches. Pedicel 1 mm. (0·5–1·5 mm.) long. Bracts identical in appearance with foliage leaves; bracteoles lanceolate, 7·5 mm. (4·0–11·5 mm.) long, 1·7 mm. (0·5–3·5 mm.) broad, herbaceous with scattered or numerous short appressed silky hairs, borne on the base of the calyx. Calyx 5·3 mm. (3·5–9·0 mm.) long, almost glabrous

or with scattered to numerous short appressed silky hairs; lower lobes acuminate, longer than, or equal to, or shorter than the tube; upper lobes broader connate higher up and less acuminate. Corolla: keel equal in length to standard, broadly lunate to semi-circular, obtuse, yellow to yellow-green; wings equal in length to standard, oblong to semi-circular, laciniate at base, obtuse and rounded, sometimes almost acute, yellow; standard 8 mm. (5–11·5 mm.) long, ovate, obtuse and rounded, yellow or yellow with red markings. Stamens 10, some or all adnate to petals at base, both persistent after flowering. Ovary villous, style dilated or thickened at base, incurved or subulate above, pubescent with short appressed silky hairs below the curve. Legume 1–2 seeded, 1–2 times as long as the calyx. Seed reniform.

Distribution: Coast and tablelands of New South Wales and Queensland to Bundaberg.

Habitat: Sandstone heath and dry sclerophyll forest.

Chromosome number: 2n=14, voucher specimens R. C. Jancey No. 2; R. Carolin No. 3933; R. C. Jancey No. 3; V. Sands sine num.; R. C. Jancey No. 4; R. C. Jancey No. 5 (SYD).

Typification: Holotype: Sieber No. 405 GEN. Isotypes K, WIEN.

Selected specimens examined: New South Wales: Neutral Bay, J. B. Cleland, 9/1910, (AD 96311325); Port Jackson, R. Schomburgk, 8/1896, (AD 96311334); Shoalhaven, W. Bäuerlen, No. 396, 9/1883, (MEL); Kurrajong, Miss Atkinson, No. 13, —, (MEL); Richmond River, Mrs. Hodgkinson, 1874, (MEL); Long Bay, Miss C. Cowle, 1907, (MEL); Sandy Cape, R. Brown, —, (MEL); Fl. Nov. Holl., Sieber, No. 407, (MEL); Fl. Nov. Holl., Sieber, No. 408, (MEL); Mitchell's Expedition of 1836, Mitchell 291, 8/1836, (MEL); Nov. Holl., Lambert, —, (MEL); Nov. Holl., Sieber, No. 405, —, (MEL); Caloundra, L. J. Brass, 10/1934, (CANB 24244); French's Forest, G. H. Clarke, 9/1920, (CANB 4535); Middle Harbour, G. H. Clarke, 12/1920, (CANB 4534); Oxford Falls, K. Mair, 26/8/1953, (NSW 36444); Wahroonga, L. A. S. Johnson, 23/6/1945, (NSW 36445); Terrey Hills, M. Tindale, 12/8/1961, (NSW 55356); Dural, D. C. Cross, 5/9/1945, (NSW 15668); Cheltenham, N. C. Ford, 4/7/1945, (NSW 36421); Castlecrag, M. Tindale, 1/8/1948, (NSW 7227); Mount Colah, G. Chippendale, 18/8/1953, (NSW 36398); Berowra, R. H. Cambage, No. 499, 9/1901, (NSW 36429); Asquith, F. J. Thomas, 24/8/1951, (NSW 36434); Currockbilly, J. L. Boorman, 2/1910, (NSW 36393); Snowball, F. A. Rodway, No. 11734, 12/1940, (NSW 36395); Cooma, J. L. Boorman, 12/1915, (NSW 35391); Nerriga, F. A. Rodway, No. 13467, 3/1944, (NSW 36394); Como, J. L. Boorman, 9/1916, (NSW 36412); Gymea Bay, A. Cahill, 10/1938, (NSW 36409); National Park, Anderson and Boorman, 9/1921, (NSW 36413); Glenbrook, A. A. Hamilton, 10/1914, (NSW 36432); Blaxland, Blakely and Chisholm, 10/1929, (NSW 36426); Bundanoon, H. E. Ellen, 3/1917, (NSW 36448); Pigeon House Ra., Nerriga, E. F. Constable, 10/1957, (NSW 45273); Jervis Bay, F. A. Rodway, 10/1931, (NSW 36403); Wentworth Falls, W. F. Blakely, 11/1938, (NSW 36480); Box Point to Barber's Creek, J. H. Maiden, 10/1896, (NSW 36450); Appin, J. H. Maiden, —, (NSW 15662); Wiseman's Ferry, J. L. Boorman, 4/1908, (NSW 36433); Gosford, Blakely and Shiress, 1/1927, (NSW 15665); Woy Woy, Blakely and Buckingham, 10/1939, (NSW 15667); Somersby, G. Chippendale, 8/1953, (NSW 36418); Maroota, W. F. Blakely, 9/1929, (NSW 36439); Corindi, E. J. Constable, 11/1956, (NSW 4221); Bulladelah, J. Garden, 10/1951, (NSW 36379). *Queensland:* Sunnybank nr. Brisbane, C. T. White, No. 985, 9/1921, (NSW 36390); Sunnybank, L. A. S. Johnson, 6/1951, (NSW 36385); Mt. Gravatt, L. A. S. Johnson, 6/1951, (NSW 36386); Moreton Island, C. T. White, 9/1907, (NSW 36388); Stradbroke Island, H. S. McKee, No. 8725, 9/1961, (NSW 56450); Burrum, M. E. Watson, 10/1929, (BRI 036876); South Brisbane Cemetery, F. M. Bailey, 3/1875, (BRI 036889); Apsley, C. T. White, No. 6133, 7/1929, (BRI 036875); Coolum, Miss

M. S. Clemens, 4/1945, (BRI 036871); Mt. Gravatt, C. T. White, No. 7409, 3/1931, (BRI 036868); The Blunder, nr. Brisbane, C. E. Hubbard, No. 3584, 8/1930, (BRI 036863); Plunkett, C. E. Hubbard, No. 3784, 8/1930, (BRI 036862); Tingalpa, D. A. Goy, No. 134, 9/1936, (BRI 036860); Maryborough, Miss M. S. Clemens, 9/1948, (BRI 036857); Capalaba, L. Pedley, No. 426, 8/1959, (BRI 024332); Keppel Bay, C. T. White, No. 8032, 9/1931, (BRI 036882); Bundaberg, J. Keys, No. 336, —, (BRI 036887).

Phyllota grandiflora Benth.

In *Ann. Wien. Mus*,, II: 77 (1838).

Taxonomic synonym: Phyllota pilosa Benth. in *Ann. Wien. Mus.*, II: 77 (1838).

A shrub 90 cm. (60–150 cm.) high, stems pubescent at least in the upper parts. Leaves linear, 13 mm. (6–17·5 mm.) long, 1·25–2·25 mm. broad, densely minute-bullate, obtuse or acute (1–3 on the subjective scale); stipules minute. Flowers 23 (6–59) in lax leafy spikes towards the ends of the branches. Pedicel 1–2 mm. long. Bracts identical in appearance with foliage leaves; bracteoles lanceolate, 11 mm. (8·5–15·0 mm.) long, 2·7 mm. (2·0–4·0 mm.) broad, herbaceous, with scattered to numerous appressed silky hairs, borne on the base of the calyx. Calyx 8·2 mm. (6·0–10·0 mm.) long with numerous appressed silky hairs; lower lobes acuminate, equal to or shorter than the tube; upper lobes broader, connate higher up, acuminate. Corolla: keel equal in length to standard, broadly lunate to semi-circular, obtuse, yellow occasionally tinged with green; wings shorter than or equal to the standard, semi-circular, laciniate at the base, obtuse and rounded, yellow; standard 12·4 mm. (10·5–15·0 mm.) long, broadly ovate, obtuse and rounded, yellow or yellow with red marking. Stamens 10, some or all adnate to petals, both persistent after flowering. Ovary villous, style dilated and thickened at base, incurved or subulate above, pubescent with short silky appressed hairs, often extending along upper edge around the hook. Legume 1–2 seeded, 1–2 times as long as the calyx. Seed reniform.

Distribution: Between Sydney Harbour and the Hawkesbury River, also Appin and Bargo regions (see Fig. 10).

Habitat: Sandstone heath and dry sclerophyll forest.

Chromosome number: 2n=14, voucher specimen R. C. Jancey, No. 7 (SYD).

Typification: Holotype: Loc. non cit. F. Bauer, WIEN.

Specimens examined: New South Wales: Parramatta, W. Woolls, —, (MEL); Parramatta, W. Woolls, —, (MEL); Elanora Heights, V. May, 10/1934, (NSW 36366); Port Jackson, F. J. Sargood, 10/1911, (NSW 36362); Berowra, W. F. Blakely, 10/1940, (NSW 36369); Narrabeen, M. Mills, 10/1940, (NSW 36365); Narrabeen, J. J. Fletcher, 8/1887, (NSW 36364); The Valley, Hornsby, W. F. Blakely, 11/1939, (NSW 36368); Hornsby, E. Betche, 12/1886, (NSW 36436); "West Australia", Maxwell, —, (NSW 36359); St. Ives, Blakely and Anderson, 9/1936, (NSW 36357); Manly, E. Cheel, 10/1898, (NSW 36363); Hornsby, W. F. Blakely, 10/1914, (NSW 36371); Cheltenham, L. A. S. Johnson, 10/1945, (NSW 36370); Field of Mars, H. Deane, —, (NSW 36367); National Park, W. F. Blakely, 11/1938, (NSW 36361); Cataract Dam, J. H. Maiden, 11/1906, (NSW 36360).

Phyllota squarrosa (Sieber ex DC.) Benth.

In *Ann. Wien. Mus.*, II: 77 (1838).

Nomenclatural synonym: Pultenaea squarrosa Sieber ex DC., *Prod.*, II: 113 (1825). BASIONYM.

A shrub 30 cm. (15–60 cm.) high, suckering freely from the roots, stems pubescent at least in the upper parts. Leaves linear, 9 mm. (6·6–13·8 mm.)

long, 0·75–1·25 mm. broad, minutely bullate, acuminate and recurved (4 on the subjective scale), stipules minute. Flowers 8 (3–12) together towards the ends of the branches in lax leafy spikes 8 mm. (2–18 mm.) long. Pedicel 0·75–1·75 mm. long. Bracts identical in appearance with foliage leaves; bracteoles lanceolate, 8·25 mm. (5·5–13·0 mm.) long, 1·25 mm. (1·0–2·5 mm.) broad, herbaceous, glabrous or with scattered to numerous short appressed silky hairs, borne on the base of the calyx. Calyx 7·5 mm. (5·5–9·0 mm.) long, almost glabrous or with scattered to numerous short appressed silky hairs; lower lobes acuminate, equal to or longer than the tube; upper lobes broader, connate higher up, acuminate. Corolla: keel equal in length to standard, semi-circular, obtuse, yellow occasionally tinged with red; wings shorter than or equal to the standard, broadly lunate, obtuse and rounded, yellow; standard 10·3 mm. (8·0–12·0 mm.) long, broadly ovate, obtuse and rounded, yellow to red. Stamens 10, some or all adnate to petals, both persistent after flowering. Ovary villous, style dilated and thickened at base, incurved or subulate above, pubescent with short appressed silky hairs to below the hook. Legume 1–2 seeded, 1–2 times as long as the calyx. Seed reniform.

Distribution: Upper Blue Mountains, central tablelands.

Habitat: Sandstone heath and open dry sclerophyll forest.

Chromosome number: 2n=14, voucher specimen R. C. Jancey, No. 6 (SYD).

Typification: Holotype: Blue Mountains, Sieber, No. 406 (GEN).

Selected specimens examined: New South Wales: Clarence, F. H. Rodway, —, 1908, (AD 96311374); Mt. Tomah, W. Woolls, —, (MEL); Blackheath, Althofer, 8/1945, (MEL); Nov. Holl., Sieber, No. 406, (MEL); Bell, L. A. S. Johnson, 5/1951, (NSW 36470); Eskbank, A. A. Hamilton, 1/1915, (NSW 36485); Mt. Victoria, J. H. Maiden, 12/1896, (NSW 36452); Mt. Victoria, J. L. Boorman, 12/1917, (NSW 36457); Bell, A. A. Hamilton, 1/1915, (NSW 36458); Mt. Wilson, J. H. Maiden, 4/1896, (NSW 36459); Clarence Tunnel, W. F. Blakely, 11/1938, (NSW 36463); Newnes Junction, Blakely and Buckingham, 11/1938, (NSW 36483); Mt. Piddington, Mt. Victoria, Blakely and Buckingham, 1/1939, (NSW 15660); Mitchell's Ridge, Blakely and Buckingham, 1/1939, (NSW 36472); Katoomba, W. Forsyth, 12/1899, (NSW 15659); Katoomba, J. H. Camfield, 12/1908, (NSW 36469); Blackheath, J. H. Maiden, 1/1905, (NSW 36471); Narrow Neck, G. Chippendale, 1/1951, (NSW 36474); nr. Bald Trig., Clarence, W. F. Blakely, 1/1939, (NSW 36462).

Phyllota humifusa Benth.

Fl. Austr., II: 95; Moore and Betche. *Handb. Fl. N.S.W.*, 135 (1893).

A prostrate shrub 8–15 cm. high, with stems pubescent at least in the upper parts. Leaves linear, 4·5 mm. (3·0–8·0 mm.) long, 0·25–0·75 mm. broad, minutely bullate, obtuse to acute (1–3 on the subjective scale); stipules minute. Flowers 8 (2–15) in lax leafy spikes, 7 mm. (1–14 mm.) long, towards the ends of the branches. Pedicel 0·5–1·25 mm. long. Bracts identical in appearance with foliage leaves; bracteoles identical in appearance with foliage leaves, 3 mm. (2–4·5 mm.) long, 0·5 mm. (0·25–0·6 mm.) broad, glabrous or with scattered short appressed silky hairs, borne on the base of the calyx. Calyx 5·0 mm. (4·0–5·5 mm.) long, almost glabrous or with scattered short appressed silky hairs; lower lobes acuminate, shorter than or equal to the tube; upper lobes broader, connate higher up and acute. Corolla: keel equal in length to standard, semi-circular, obtuse and rounded, yellow to yellow-red; standard 7·5 mm. (7·0–8·0 mm.) long, broadly ovate, obtuse and rounded, red to deep red. Stamens 10, some or all adnate to petals, both persistent after flowering. Ovary villous, style dilated and thickened at base, incurved or subulate above, pubescent with short appressed silky hairs to below the curve. Legume 1–2 seeded, 1–2 times as long as the calyx. Seed reniform.

Distribution : Southern tablelands of New South Wales, between Mittagong and Mt. Bullio (see Fig. 4).

Habitat : Deep sandy shale soil in dry sclerophyll forest and in open sparsely grass covered areas.

Chromosome number : 2n=14, voucher specimen R. C. Jancey, No. 1 (SYD).

Typification : Holotype ; Wombat Brush, Argyll County, A. Cunningham, No. 8 (K).

Specimens examined : Mittagong to Bullio, E. Cheel, 11/1919, (NSW 36449) ; Penrose, Blakely and Buckingham, 11/1939, (NSW 36447).

Species of Phyllota not occurring in New South Wales

All observations on interstate material were based on herbarium specimens on loan from the various State herbaria. A list of material examined, and its origin, is included in the description of each species.

Methods

Since the material in question was on loan from other herbaria, some of the measurements which had been carried out on material collected personally could not be repeated, owing to the amount of destruction involved. In other cases, specimens were so small that it was felt that any further disintegration would be undesirable and, consequently, such specimens were only examined superficially under a dissecting microscope.

Measurements were made on material soaked in a mixture of detergent and water, scored values referring to the same scales as those used in connection with the New South Wales material. To avoid undue destruction of loaned material, the whole range of material was first examined, then measurements made on a limited number of individuals. In many cases, variation in floral parts was negligible, and in these cases single values have been quoted. Where this was not the case, or in the case of other more variable structures, values are quoted for the range of variation, and one for an individual apparently representative of the mean for that particular character. A number of observations other than those employed in the case of the New South Wales taxa were introduced after preliminary examination of the interstate species.

Phyllota barbata Benth.

In *Hueg. Enum.* 33 (1837), and in *Ann. Wien. Mus.*, II : 78 (1838), and in *Fl. Aust.* II : 94 (1864).

Taxonomic synonyms : Pultenaea andrewsii Gardn. ex Blackall and Grieve ' How to know West Australian Wildflowers ', 234 (1953). NOM. NUD. ET ILLEGIT.

A shrub with stems terete, pubescent at least in the upper parts. Leaves linear, 8 mm. (6–10 mm.) long, scabrous, with revolute margins, obtuse and rounded, some also bearing a minute deciduous black mucro (1 on the subjective scale) ; stipules minute. Flowers scattered along the branches, sometimes crowded into leafy spikes towards the ends of the branches. Pedicel 0·5–1·0 mm. long. Bracts identical in appearance with foliage leaves ; bracteoles linear, 8 mm. long, 1 mm. broad, almost identical in appearance with foliage leaves, borne on the base of the calyx. Calyx 5 mm. long, almost glabrous to heavily tomentose ; lower lobes acuminate, longer than, or equal to, or shorter than the tube ; the upper lobes broader connate higher up and less acuminate. Corolla : keel 12 mm. long, tapering to an acute point, red ; wings 7–8 mm. long, cuneate-oblong in their upper parts, yellow red ; standard 12 mm. long, elliptic, yellow-red. Stamens 10, some adnate to petals at base, both deciduous after flowering. Ovary villous ; style villous below and barbulate in the distal half on the upper edge with persistent white hairs. Legume 1–2 seeded, as long as or longer than the calyx. Seed reniform.

Distribution : Coastal south-western area of Western Australia.

Habitat : Sandy heath.

Chromosome number : 2n=14. Voucher specimen, V. Sands, No. 638/19/4. Determined by V. Sands (unpublished).

Typification : Holotype.

Discussion : P. barbata is distinguished from all other species of *Phyllota* with the exception of *P. gracilis* Turcz. by the bearding of the distal half of the style. From *P. gracilis* it differs in the length of the peduncle, and in the flowers which are almost sessile in *P. barbata* but borne on a pedicel 4 mm. long in *P. gracilis*. These latter two species also differ in leaf length. Only one specimen of *P. andrewsii* was available for examination (Gardner, 2219). Having been collected by the author of the manuscript name, and bearing his determination, it may be taken, however, as an authoritative example of the intended taxon. The specimen examined was bearded on the inner edge of the style, as is characteristic in *P. barbata* and *P. gracilis*, whereas, in ' How to Know West Australian Wildflowers ', *P. andrewsii* is distinguished by two characters, one of which is the absence of bearding. The position of the inflorescence, however, was found to be in agreement with the text quoted, being terminal in the specimen of *P. andrewsii*, as opposed to the rather lax and interrupted spikes characteristic of *P. barbata*. Since the distinction proposed between the species was based, at least in the case of the specimen examined, on one character, it is not proposed at this stage to give formal status to the name proposed by Gardner. There seems little doubt that the range and degree of morphologic differentiation in this section of the genus in Western Australia is not as yet fully represented in herbarium collections.

Specimens examined : Cape Riche, R. T. Lange, No. 13, 3/1958, (PERTH) ; Albany, W. E. Blackall, 12/1937, (PERTH) ; Mt. Manypeaks area, S. P. Pfeiffer, No. 12, —, (PERTH) ; Narrikup, R. T. Lange, No. 13, 3/1958, (PERTH) ; Cheyne Beach, J. M. Storr, No. 3900, 5/1959, (PERTH) ; King George's Sound, B. T. Goadby, No. 92, 2/1899, (PERTH) ; Sand heath south of Stirling Range, W. E. Blackall, 4/1939, (PERTH) ; Nr. West Mount Barren, C. A. Gardner, 10/1928, (PERTH) ; Nr. Albany, Maxwell, No. 33, 7/1858, (MEL) ; King George's Sound, A. Hugham, No. 22, 1869, (MEL) ; South West Australia, Mills, 6/1861, (MEL) ; Cape Riche, Preiss, No. 846, 1843, (MEL) ; Sand Plains, Wilson's Inlet, Oldfield, No. 766, —, (MEL) ; Bremer River, Webb, 1884, (MEL) ; Phillip's River, C. R. Andrews, 10/1903, (NSW 36498) ; King River Road, F. Staer, 2/1911, (NSW 36519) ; King George's Sound, Rev. R. Collie, 1898, (NSW 36513) ; Western Australia, Drummond, No. 84, —, (NSW 36514) ; Torbay, A. E. Sheath, 1/1903, (NSW 36515) ; Warejinup, —, —, (NSW 36517) ; South West Plantagenet, E. Pritzel, No. 207, 1/1901, (NSW 36518) ; Western Australia, Drummond, No. 85, (4th collection), 1848, (NSW 36512).

Phyllota gracilis Turcz.

In *Bull. Soc. Nat. Mosc.*, XXVI : 1267 (1853) ; Benth, *Fl. Austr.*, II : 94 (1864).

Nomenclatural synonym : Pultenaea gracilis (Turcz.) Gardner, *Enum. Pl. Austr. Occ.*, 59 (1930).

A shrub, with stems terete, pubescent with short white hairs (densely so in the upper parts) ; scarcely rugose with decurrent leaf bases (1 on the subjective scale). Leaves linear, minute, 1–3 mm. long, 0–5 mm. broad, with a scattered pubescence, revolute margins, obtuse and rounded bearing a deciduous black mucro (1 on the subjective scale) ; stipules minute. Flower solitary, near end of branch. Pedicel 4 mm. long. Bracts identical in appearance with foliage leaves ; bracteoles linear-lanceolate, 1–5 mm. long, herbaceous, sparsely pubescent, borne on the base of the calyx. Calyx 3 mm. long, densely villous with pale yellow simple hairs ; lower lobes acute, equal to or longer

than the tube ; upper lobes acute, equal to or shorter than the tube. Corolla not seen dissected ; 5 mm. long from receptacle to apex of keel ; keel dark red ; wings dark red ; standard dark red. Ovary not seen ; style bearded in distal half. Legume not seen. Seed not seen.

Distribution : Not known.

Habitat : Not known.

Chromosome number : Not known.

Typification : Holotype : Swan River, Western Australia, Drummond, No. 91, *ca.* 1845. KW. Isotypes MEL, K.

Discussion : While this species shows affinities to *P. barbata* in the bearded style and boat-shaped keel, it shows striking morphologic distinction in the very much smaller bracteoles, the lesser overall length of flower, very much longer pedicel and much shorter leaves. The differentiation from *P. barbata* is such as to merit specific rank.

Specimen examined : Swan River, Western Australia, Drummond, No. 91, *ca.* 1845, (MEL).

Phyllota luehmannii F. Muell.

Fragm. Phytogr. Austral., X : 33 (1877), as *Phyllota luehmannii.*

Nomenclatural synonym : Pultenaea luehmannii (F. Muell.) Gardner, *Enum. Pl. Austr. Occ.*, 59 (1930).

Taxonomic synonym : Phyllota georgii Hemsl. in *Hook. Ic. Pl.*, t. 2778 (1905). *Pultenaea luehmannii* var. *georgii* Gardn. ex Blackall and Grieve ' How to Know West Australian Wildflowers ', 234 (1953). NOM. NUD. ET ILLEGIT.

A shrub with stems terete, covered with a pale gold tomentum at least in the upper parts. Leaves linear, 6 mm. (4–10 mm.) long, scarcely scabrous, bearing a sparse pale golden tomentum, with revolute margins ; leaf tips acuminate recurved (4 on the subjective scale) ; stipules minute. Flowers crowded into spikes at the ends of the branches becoming terminal by die-back of the axis. Pedicel 0·5–1·0 mm. long. Bracts identical in appearance with foliage leaves, occasionally with somewhat less revolute margins ; bracteoles linear-lanceolate, 4–6 mm. long, 0·5 mm. broad, herbaceous, with a pale golden tomentum, borne on the base of the calyx. Calyx 6 mm. long, densely tomentose with a pale golden tomentum ; lower lobes acuminate, about equal in length to the tube ; the upper lobes broader connate higher up and less acuminate. Corolla : keel 8 mm. long, obtuse, purple ; wings equal to or (more usually) 1 mm. shorter than the keel, cuneate-oblong in upper parts, yellow ; standard orbicular, 11 mm. long, yellow with a red marking at the base. Stamens 10, some slightly adnate to the petals, both deciduous after flowering. Ovary densely villous ; style villous below, glabrous in the distal half, Legume 1–2 seeded, as long as or longer than the calyx. Seed reniform.

Distribution : The Victoria Desert region of Western Australia.

Habitat : Sand plain.

Chromosome number : 2n=14, also n=7. Voucher specimen V. Sands, No. 639/1/5 (SYD). Determined by V. Sands (unpublished).

Typification : Syntypes of *Phyllota luehmannii* F. Muell. : Near Waring, Western Australia, F. Mueller ; Elder Exploring Expedition, Victoria Desert Camp 58, R. Helms sine num., 21/9/91. Lectotype : Elder Exploring Expedition, Victoria Desert Camp 58, R. Helms sine num., 21/9/91. MEL. Isolectotypes : K., AD.

Phyllota georgii Hemsl. Holotype : Railway between Cunderdin and Dedari, G. H. Thistleton-Dyer, K.

Discussion : There appear to be no features distinguishing *P. georgii* from *P. luehmannii*, at least among the specimens examined. The short, obtuse

leaves quoted in ' How to Know West Australian Wildflowers ' as characteristic of *P. luehmannii* var. *georgii* were found to be so variable within specimens as to be unsatisfactory for discriminatory purposes.

Specimens examined : Karalee, C. A. Gardner, 9/1934, (PERTH) ; East-west railway, C. French, —, (MEL) ; No. 15 Pumping Station, Yerbillon, M. Koch, No. 2892, 10/1923, (MEL) ; Victoria Desert Camp 58, Elder Exploring Expedition, R. Helms, 9/1891, (MEL) ; Karoling, Elder Exploring Expedition, R. Helms, 11/1891, (MEL) ; Victoria Springs, Young, 10/1875, (MEL).

Phyllota pleurandroides F. Muell.

In *Trans. Phil. Soc. Vic.*, I : 38 (1833) ; Benth., *Fl. Austr.*, II : 96 (1864).

A shrub, suckering freely from the roots. Stems terete, more or less pubescent. Leaves scattered to virgate, linear, 8 mm. (6–10 mm.) long, 0·75–1·25 mm. broad, bullate, tip acuminate and recurved ; stipules minute. Flowers scattered among the virgate clusters of leaves. Pedicel 0·5–1·0 mm. long. Bracts similar in appearance to foliage leaves, somewhat narrowed and villous towards the base, as are other leaves of the virgate clusters ; bracteoles ovate-obtuse, 1–5 mm. long, 1 mm. broad, coriaceous, pubescent, borne on the base of the calyx. Calyx 4 mm. long, villous with white hairs ; lower lobes acute, equal in length to the tube ; upper lobes broader and connate higher up. Corolla : keel 6 mm. long, obtuse, yellow-red ; wings slightly exceeding the keel, oblong in upper parts ; standard broadly ovate, 5 mm. long, yellow. Stamens 10, some adnate to petals at base of claw, both deciduous after flowering. Ovary villous ; style villous below, glabrous in upper parts. Legume 1–2 seeded, 1–2 times as long as the calyx. Seed reniform.

Distribution : South-eastern parts of South Australia, and south-western Victoria.

Habitat : Deep sandy soil on sand ridges of sand plain.

Chromosome number : Not known.

Typification : Syntypes : Kangaroo Island, F. Mueller, Herb. W. Sonder : Grampians, Wilhelm, F. Mueller, 1857 : Mount Abrupt, F. Mueller, MEL, K. It is proposed to select Mount Abrupt, F. Mueller, MEL as lectotype of this species. Isolectotype : Mount Abrupt, F. Mueller, K.

Selected specimens examined : South Australia : Bool Lagoon-Lucindale, D. Hunt, No. 796, 5/1962, (AD 96227095) ; Southern Mt. Lofty Range, nr. Mt. Compass, —, 1/1882, (AD 96311376) ; South Australia, —, —, (AD 96311378) ; Kangaroo Island, —, No. 1217, 3/1884, (AD 96311375) ; Lower Mt. Lofty Range, nr. Strathalbyn, E. C. Black, 2/1944, (AD 96311330) ; Malinong, 45 km. south of Murray Bridge, R. D. Sharrad, No. 13, 8/1960, (AD 96149180) ; Encounter Bay, J. B. Cleland, 11/1924, (AD 96311377) ; Kangaroo Island, Mt. Pleasant, —, 1/1883, (AD 96311380) ; Bordertown, D. Hunt, No. 748, 3/1962, (AD 96220087) ; Mt. Abrupt, F. Mueller, —, (MEL) ; Square Waterhole, O. Tepper, No. 30, 7/1882, (MEL) ; Gawler Ranges, Dr. Sullivan, —, (MEL) ; Lacepede Bay, Herschel and Babbage, —, (MEL) ; Penola, Rev. Tenison-Woods, No. 15, —, (MEL) ; N.W. of Lake Albacutya, C. French, 10/1887, (MEL) *Victoria :* Grampians, H. B. Williamson, 4/1904, (MEL) ; Grampians, J. W. Audas, 11/1920, (MEL) ; Mt. Zero, C. Wilhelmi, 2/1857, (MEL) ; Wimmera, D'Alton, No. 16, 1890, (MEL) ; West of Wimmera, D'Alton, 7/1892, (MEL) ; Shire of Dimboola, F. M. Reader, 1/1893, (MEL) ; Keith, R. L. Crocker, 9/1943, (CANB 11633).

Phyllota remota J. H. Willis

In *Vic. Nat.*, LXXIII : 191 (1957).

A shrub, with stems terete, tomentose at least in the upper parts, rugose with decurrent leaf bases (2 on the subjective scale). Leaves linear, 8 mm. (5–10 mm.) long, distant, occasionally becoming virgate, tomentose when young,

papillose with age, revolute margins, acute to obtuse, sometimes bearing a minute black mucro (2 on the subjective scale); stipules minute. Flowers scattered, solitary or occasionally in pairs. Pedicels 0·5–1·0 mm. long. Bracts identical in appearance with foliage leaves; bracteoles ovate, 4 mm. long, scarious, keeled and with a mucronate apex, almost enveloping the calyx. Calyx 3–4 mm. long, glabrous to villous; lower lobes acute, more or less equal to the tube; upper lobes broader and connate higher up. Corolla: keel 6 mm. long, obtuse, yellow; wings slightly exceeding the keel, oblong in upper parts; standard broadly ovate, 5 mm. long, yellow. Stamens 10, some adnate to petals at base, both deciduous after flowering. Ovary villous; style villous below, glabrous in upper parts. Legume 1–2 seeded, twice as long as the calyx. Seeds reniform.

Distribution: South-eastern South Australia and south-western Victoria.

Habitat: In shallow sandy soil between sand ridges of mallee heath.

Chromosome number: Not known.

Typification: Holotype: Keith, R. L. Specht and P. Rayson, 1954, (MEL).

Specimens examined: Boston Point, Spencer's Gulf, Wilhelmi, —, (MEL); Lillimur, nr. Wimmera, A. J. Hicks, 9/1954, (MEL); Eyre Peninsula, 85 km. north of Port Lincoln, R. L. Specht, No. 2602, 11/1960, (AD 96109031); Dark Island, 14 km. east of Keith, Specht and Rayson, 2/1950, (AD 96311331); 11 km. east of Meningie, on Lake Albert, M. C. R. Sharrad, No. 486, 12/1959, (AD 96150850); Keith, Specht and Rayson, 1954, (MEL).

Phyllota diffusa (Hooker f.) F. Mueller

Fragm., I: 8 (1877).

Nomenclatural synonym: Pultenaea diffusa Hooker, f., *Fl. Tasm.*, I: 91, t. 14 (1860); Benth., *Fl. Austr.*, II: 119 (1864); Curtis, *Stud. Fl. Tasm.*, pars 1, 132 (1956).

A small diffuse shrub, much branched and ascending, 10–30 cm. high, and spreading 30–50 cm. Stems terete, glabrous to pubescent with short appressed hairs. Leaves linear, 7 mm. (5–10 mm.) long, bullate, acute (3 on the subjective scale); stipules minute. Flowers scattered along the stem, solitary or in pairs, sometimes crowded towards the ends of the branches. Pedicel 2–2·5 mm. long. Bracts identical in appearance with foliage leaves; bracteoles lanceolate, 1·75 mm. long, 0·75 mm. broad, scarcely herbaceous, glabrous or a few scattered short silky hairs, borne on the base of the calyx. Calyx 3–4 mm. long, almost glabrous or with a few scattered silky hairs; lower lobes acute, shorter than or equal to the tube; upper lobes broader connate higher up, obtuse. Corolla: keel equal in length to the standard, broadly lunate to semi-circular, obtuse, yellow-red; wings equal in length to the standard, oblong to obovate, obtuse and rounded, yellow; standard 6–8 mm. long, orbicular, yellow. Stamens 10, almost wholly free, deciduous with the petals after flowering. Ovary pubescent to villous, style dilated or thickened at base, incurved or subulate above, pubescent with short appressed silky hairs to below the hook. Legume 1–2 seeded, 1–2 times as long as the calyx. Seed reniform.

Distribution: Tasmania, endemic. Local near the east coast and in the extreme north west.

Habitat: Sandy heaths.

Chromosome number: Not known.

Typification: Holotype: Loc. non cit. J. D. Hooker, (K).

Specimens examined: Coast Rd. to George's Bay, A. Simson, No. 1325, 11/1878, (MEL); St. Paul's River, nr. Broadshead, —, 1/1858, (MEL); Coast nr. Scamander River, A. Simson, 11/1878, (MEL); South Port, Stuart, —, (MEL); South Port, —, No. 1515, 1/1856, (MEL); George's Bay, L. Rodway, 6/1900, (NSW 36497); Tasmania, A. H. S. Lucas, 1910-1930, (NSW 36499).

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EXPLANATION OF PLATES XXIX–XXX

Plate xxix

A, Illustrating from left to right, the subjective values from 4 to 1 for calyx and bracteole indumentum. B, Leaves showing values of 1 to 4 on the subjective scale for size of leaf bullae. C, Leaves showing values of 1 to 4 on the subjective scale for number of leaf bullae. (In both B and C cases it will be seen that many of the epidermal hairs are still present, while these are lost with increasing age of the leaf, the bullae remain.) D, Four leaf tips of *P. phylicoides* showing examples of the values from 1 to 4 on the subjective scale for leaf tip shape.

Plate xxx

A, Growth habit of group 1. B, Growth habit of group 4. C, Growth habit of groups 7 and 8. (Scales equal 12 inches.)