Pachystegia rufa and allied rock daisies

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Summary

This report presents preliminary information on *Pachystegia rufa* and allied species; the so-called Marlborough rock daisies, here referred to collectively as pachystegias. The report is based on field and experimental information gathered by the author since 1978, and additional data derived from joint studies of seed set and germination, cytology and flavonoid chemistry.

Field visits have been made to many parts of eastern Marlborough and North Canterbury where pachystegias grow to determine the number of taxa involved and their habitats, ecology and lifestyle. Additional information has been gathered from herbarium specimens, both within New Zealand and abroad.

Detailed studies of the biology and character states of the various taxa have been carried out on plants cultivated in the experimental facilities of Landcare Research at Lincoln. More recently plants held at Lincoln and in the Christchurch Botanic Gardens have been used for further taxonomic comparison and studies of floral biology.

Only one species of *Pachystegia*, *P. rufa* is listed among the threatened and uncommon plants of New Zealand, where it is classed as a "Declining" species.

The more obvious threats to *P. rufa* and allied species include roadworks, quarrying, herbicide application, wilding trees, broom infestations, and animal browsing. Of more recent concern, especially for recruitment and sustainability of pachystegias, is the spread of aggressive introduced grasses and herbs which threaten to occupy and dominate crevices and niches in rupestral habitats.

1. Introduction

This report, prepared for the Department of Conservation, Nelson, provides a preliminary account of *Pachystegia rufa* and allied species, the so-called Marlborough rock daisies. The information provided is to be integrated with other work being carried out on the group, more especially that leading to the recovery and management of threatened taxa.

Reference to pachystegias is contained in the formal taxonomic treatments of Hooker (1855), Kirk (1899), Cheeseman (1906,1925),Allan (1961) and Molloy (1987), and informal accounts such as those of Martin (1938), Metcalf (1991), Moore & Irwin (1978), Eagle (1975,1982), Molloy & Simpson (1980) and Poole & Adams (1990). The ecology of pachystegias is touched on at the broad national level by Cockayne (1928) and in greater detail at regional level by Martin (1932),J.Wardle (1971), Molloy & Simpson (1980) and P Wardle (1991).

The cultivation of pachystegias, a favoured group among gardeners, has also featured in popular books and magazines devoted to gardening.

2. Methods

This report is based almost entirely on field and experimental information gathered regularly by the author over a ten-year period beginning in 1978 and continuing intermittently since then. At this stage in the project it is thought desirable to summarise what is known and to identify those areas requiring further study to advance the better management of pachystegias in general and *Pachystegia rufa* in particular. No further fieldwork has been undertaken to date, although regular visits have been made to the cultivated collection of pachystegias presented to the Christchurch Botanical Gardens in 1982 by the author. This collection is now used for reference purposes in understanding the various taxa, but has limited usefulness in studies of floral biology and breeding systems since the plot is shaded from the north and west. However, amenity plantings at Landcare Research, Lincoln, have provided adequate material for this purpose.

Records of joint studies of the cytology of pachystegias, seed set and germination, and leaf flavonoids have been published in part (e.g. Simpson & Molloy 1978; Molloy & Simpson 1980), but much information on plants cultivated at Lincoln remains unpublished. Likewise, preliminary work has been carried out in the preparation of a pachystegia distribution database, based on the author's field collections and records held in the Landcare Research herbarium at Lincoln (CHR).

3. Taxonomy

At present, three species of *Pachystegia* have been formally recognised (Molloy 1987):

Pachystegia insignis (Hook.f.) Cheeseman
Pachystegia minor (Cheeseman) Molloy
Pachystegia rufa Molloy

At least two other entities - *Pachystegia* A and *Pachystegia* B (Molloy & Simpson 1980) - may warrant recognition at species rank. All five taxa can be readily separated by vegetative and floral characters (e.g. Molloy & Simpson 1980) and leaf flavonoids (J. Hemmingson, pers. comm.), and are illustrated in colour by Eagle (1 975,1982). The somatic chromosome number 2n = 108 has been determined for all five taxa (EJ. Beusenburg, pers comm in Molloy & Simpson 1980).

Within each of the five recognised taxa there are distinct variants which seem to be genetically fixed and would repay further investigation. This variation, as reflected by the shape and dimension of leaves, inflorescences and plants, is more apparent in the most widespread taxon, *P insignis,* and less apparent in *P. rufa,* perhaps the most restricted. This in turn reflects their respective ranges in habitats, more. especially rock types.

Within the circumscription of *P. insignis,* at least four forms require further comparative study, i.e. material from the type locality in the Awatere Valley, the large-leaved form fromWoodside Creek, the long narrow-leaved form from Ward Beach, and the disjunct robust leaved/flowered form from the Lowry Peaks Range in North Canterbury. At least two distinct leaf forms of *P. minor* are recognised, one with diamond-shaped (rhomboid) leaves (e.g. *Pachystegia* C var. (i) of Molloy & Simpson 1980, and Eagle 1982), and one with obovate leaves (e.g. *Pachystegia* C var. (ii) of Molloy & Simpson 1980, and Eagle 1982). The former matches the type material of *P. minor* selected by Cheeseman (1916). There is a large-leaved form of *P. minor,* which also needs further study, along the south bank of the Clarence River.

Within *P. rufa* there is an apparent difference in leaf size and shape between the smaller northernmost plants from the type locality in Beaumont Creek and those which seem consistently larger overall in the southernmost gullies of the "Little Haldon Hills". The two putative species, *Pachystegia* A and *Pachystegia* B, are the least well known and require more detailed study throughout their ranges, especially where the two meet along the Conway River and probably elsewhere.

Where the recognised taxa meet, putative hybrids can occur, usually confined to the immediate point of juxtaposition. The hybrids seem to be fertile, leading to a range of hybrid progeny. Such hybrid "swarms" occur in at least two places in the Haldon Hills where *P. insignis* and *P. rufa* meet, and on the north bank of the Clarence River where *P. insignis* and *P. minor* are sympatric. Hybrid progeny commonly arise from plants of the various taxa grown in close proximity in cultivation. A taxonomic revision of *Pachystegia* is timely, and is recommended accordingly. This revision should include an analysis of variation within the recognised taxa to determine the range of genetic diversity to be considered for conservation management. To this end the use of leaf flavonoid data could be helpful. The DNA sequence of *P. insignis* has been established by Landcare Research scientists in relation to other genera placed in the family Compositae (Asteraceae), but a similar analysis of other taxa of *Pachystegia* is not anticipated in the near future (S. Wagstaff, pers.comm.).

4. Distribution

The distribution of the genus is now reasonably well established. The eastern limit extends along the coast from the Wairau River in Marlborough to the Waiau River in North Canterbury. The Wairau River also forms the northern boundary of the genus, with a north-south line joining Molesworth homestead with the township of Waiau as an approximate western boundary. The southern boundary approximates an east-west line drawn between the Leamington Stream headwaters in the Lowry Peaks Range and the mouth of the Waiau River. Thus the genus covers a large part of eastern Marlborough, with a southern extension into North Canterbury.

The distribution of the genus and its constituent taxa is strongly influenced by the tectonic history of eastern Marlborough and North Canterbury, particularly by the uplift and position of the Inland and Seaward Kaikoura Ranges and bordering hill blocks. In practically every case, the distribution boundaries of the various taxa seem controlled by major and minor geological faults.

The main populations of *P. insignis* extend northwards from the north bank of the Clarence River above State Highway 1, almost to the outskirts of Blenheim. From here the species extends westwards as far as Upcot in the Awatere Valley, and southwards into the catchments draining the northern parts of the Kaikoura Ranges. A remarkably disjunct form occurs on the north-facing slopes of the Lowry Peaks Range,Waiau River catchment, at the southern end of the Kaikoura Ranges, suggesting isolation and stranding by uplift of the Kaikoura Ranges. At the other extreme, *P rufa* is confined to four prominent valleys or gullies, all in close proximity to each other, and all confined to the fault-bounded "Little Haldon Hills", in turn bordered by the main Haldon Hills to the east, and outwash and alluvium to the west, both occupied by *P. insignis.* If we assume, as King (1934) does, that the Little Haldon Hills with its downcut streams arose later and independently of the main Haldon Hills, we can postulate that *P. rufa* may well be a recent isolate of *P. insignis,* the possible "founder" of the genus as we know it today in New Zealand.

The full distribution of *P. minor* and its forms have still to be determined, especially their western limits. The species extends northwards from the Puhipuhi River to the north bank of the Clarence River, with the obovate-leaved form prominent in the coastal Ohau Point-Black Millar Stream area, and the rhomboid-leaved form elsewhere. Again, the distribution of these forms seems to be controlled by geological faults.

Of the two putative species, *Pachystegia* A is essentially coastal in its distribution. Its northern limit is at Irongate Stream north of Kaikoura, and its southern limit is the mouth of the Waiau River (south bank). *Pachystegia* B, on the other hand, is essentially western in its distribution, i.e. inland of the Kaikoura Ranges. It is sympatric with *P. insignis* at Upcot in the Awatere Valley and extends westwards to the Yeo Stream, Molesworth. From there it extends southwards to north of the township of Waiau, and westwards to about the inland Kaikoura road. Its southern limit, and that of the genus, is on the south bank of the Leamington Stream, Lowry Peaks Range.

Although the overall boundaries of the genus and most of the constituent taxa are known, there are substantial gaps in our knowledge of the distribution of all recognised taxa except *P. rufa* and more particularly the areas of overlap and sympatry.

It is recommended that a distribution database of both map and herbarium records be assembled as soon as practicable, and be added to from existing and future field survey records (e.g.Williams 1982; Breese et al. 1986; Courtney & Arand 1994; Moore 1999).

5. Habitats

All species of *Pachystegia* can be classed as rupestral plants. Apart from exceptional cases where I have found plants of *P. minor* growing in stable riverbed alluvium (Jordan Stream) and plants of *P. insignis* growing on stable coastal sands (Valhalla Stream), most plants are confined to steep rocky, or stony sites composed of jointed sandstone/mudstone bedrock, volcanics, limestone and consolidated gravels. The principal attributes of these habitats suitable for pachystegias are stability, good irrigation and drainage, exposure to wind and sun, ample niches for establishment and subsequent growth, and relatively few competitors. Softer, more easily eroded materials are unsuitable.

So far the rock types associated with pachystegias have included Miocene and Late Pleistocene cemented gravels, Jurassic sandstones and mudstones, Tertiary limestones, and volcanics. A common thread running through all these rock types is their relatively high level of natural fertility, especially an abundance of readily soluble calcium-bound phosphorus (Ca-P).

Since all these rock types have relatively high levels of Ca-P and other bases we can infer that pachystegias and their regular associates such as *Heliohebe hulkeana* would qualify as calcicoles *sensu* Molloy (1994a), i.e. species confined to base-rich habitats.

Within the range of rock types occupied by pachystegias, *P. rufa* is restricted to Jurassic sandstones and mudstones along with *P. minor*, which also grows on limestone within its range. Both species in addition occur on cemented gravels derived from these rock types. By contrast, *P. insignis*, the probable "founder", occurs on all the available rock types, including cemented gravel derivatives, whereas the two unnamed taxa have a more restricted range. *Pachystegia* B, for instance, seems to grow on the widest range of volcanic rock types available, but not on others.

The relatively high level of natural fertility of pachystegia habitats is enhanced further by continuing activity along geological faults, resulting in shatter zones and fresh mineralisation. Indeed, the combination of numerous faults and rock types is worth pursuing as a major determining factor in the genetic variation evident in most of the taxa to date.

From a study of pachystegias associated with forest remnants, it seems fairly certain that all the recognised taxa, including the more restricted *P. rufa*, were at one time part of a forest environment in which forest types dominated by coastal or inland mixed conifer/hardwoods predominated. Within these essentially forested landscapes, pachystegias were confined to well-lit steep rock faces and outcrops generally inimical to forest trees, in rupestral scrub communities collectively termed "bluff scrub" by J. Wardle (1971). This scrub is seldom taller than 3 m, and the three most important species are *Pachystegia* spp., *Brachyglottis monroi,* and *Heliohebe hulkeana.* Akeake, fivefinger, and broadleaf are other common woody associates.

With widespread deforestation in Polynesian and early European times, pachystegias seem to have expanded their territory as more suitable habitats become available, and have now become more conspicuous than ever before. However, all species, including the two unnamed ones, can still be found in their original habitats in well lit forest enclaves in some part of their present range.

The relationship between faulting, rock type and the diversity of species and forms of pachystegias appeals as a worthy topic for further investigation with positive spin-off for conservation management. An approach along these or similar lines is recommended.

6. Ecology

Pachystegias are relatively long-lived shrubs in nature, with basal stems on dead plants (sprayed with herbicide) yielding up to 40, presumably annual, growth rings. However, information on the longevity of the various taxa is scanty, likewise the age structure of populations, although the wide range in the size of plants in most extensive populations suggests an equally wide age range of individual plants. All the taxa appear to be reasonably light demanding in their establishment requirements, although capable of continued albeit slower growth in partial shade. The taxa also appear to be dependent on cool winters and warm summer temperatures and low rainfall and humidity for optimum growth. They are highly resistant to summer drought by virtue of their thick leathery leaves and dense felt-like tomentum on young stems, petioles, peduncles, capitula, and the transpiring underside of leaves. In addition, the root system of established plants is often deeply and extensively developed throughout cool moist fissures in rock bluffs and outcrops. Nonetheless, in prolonged droughts plants have been noted to wilt markedly, only to recover again with the onset of autumn rains.

Pachystegias seem to occur on any aspect topographically, provided that the other necessary attributes of the habitat are met. Most of the taxa are more prominent at low altitude, although some will ascend up to 900 m given favourable habitat conditions. At least three species are common on exposed coastal bluffs subject to persistent salt spray, without suffering from "burn off" or spray damage. Associated plants are usually few and well spaced, providing little competition for pachystegias. Other shrub associates commonly found, in addition to those already noted above, include dwarf kowhai, leafless clematis, *Phormium cookianum,* and several species of *Coprosma* and *Carmichaelia.* Associated herbs and ferns are usually few in number, low in stature and widely spaced, and again provide minimal competition. However, the recent upsurge in competitive introduced grasses and other herbs gives cause for concern.

Pests and diseases noted on flowering plants include aphids *(Macrosiphon euphorbiae, Myzus persicae, Brachycaudus helichrysi,* thrips *(Thrips tabaci, Haplothrips niger)* and the wheat bug *(Nysius huttoni)*. An inflorescence rot (*Phoma* sp.) has been observed on some plants in the wild, particularly after periods of continuous rain, and a leaf rust *(Uredo wharanui)* has also been recorded. This list is by no means exhaustive and there may be other pests and diseases found on pachystegias but not yet recorded. The net effect of these organisms appears to be minimal, except perhaps in reducing seed production in some circumstances. *Pachystegia insignis* also forms an occasional host for the parasitic common mistletoe *(Ileostylus micranthus)*, but not it seems to the detriment of either. More information on the age structure of populations of pachystegias would be desirable, although it might be difficult to obtain without undue damage to plants. A database of associated plants would also be desirable. Both attributes will be helpful in determining species recovery programmes, whether taxon- or site-based.

7. Breeding system

All the taxa of *Pachystegia* flower annually on a regular basis. *Pachystegia insignis* is usually the first to flower, *P. minor* the last, with the flowering season beginning in the field in November and ceasing in February. Seed matures and is shed over a relatively long period from about January to April, depending on the individual taxon.

The flowers of pachystegias are borne in compound heads or capitula surrounded by rows of protective felty bracts. Each flowerhead consists of a centrally placed collection of disc florets with both stamens and pistils, and one or more outer rings of ray florets, each with a white strap-like ligule (petal) and a pistil but no stamens.

Pachystegia insignis has the largest flowerheads, with each head supporting on average up to 450 disc florets and 100 ray florets. In cultivation, heads may be larger still, supporting up to 700 florets. *Pachystegia rufa* is the next largest, with heads producing on average 250 disc florets and 100 ray florets. Again cultivated plants may produce slightly larger heads, with a total of about 450 florets. The other taxa generally have smaller heads, with a total of 200 or less florets. However, what they lack in no. florets/head can be balanced to some extent by the production of more flowerheads/plant, especially in *P. minor.*

Seed set in the family Asteraceae is generally poor for several reasons, one of which is widespread self-incompatibility. Pachystegias seem to be no exception, as indicated by the data on seed set in *P. insignis* and *P. minor* reported by Simpson & Molloy (1978) and unpublished data on all taxa held by the author. From these data a consistent pattern emerges. Open-pollinated plants in the wild generally have heads with good but variable seed set, but still a large number of empty presumably non-pollinated/non-fertilised seeds.

Isolated plants in cultivation generally have very poor seed set, ranging from nil to one or several sound seeds only in each head.

These preliminary data indicate that pachystegias are partially self-incompatible and dependent on insects for pollination and cross-fertilisation. The flowerheads open in sequence from the ray florets (female) progressively through the central disc florets. The pollen tends to aggregate around the stamens, is sticky and heavy, and is dependent on insects for transfer within and between plants. Pollen vectors observed to date include native bees *(Leioproctus fulvescens, Lasioglossum sordidum),* hover flies *(Melanostoma novae zelandiae, Erestalis tenax,* and the wheat bug *(Nysius huttoni).*

During the past season, a small pilot trial was carried out at Lincoln on two separate plants of *P. insignis* to test the compatibility of the group further. In this trial, selfed flower heads on both plants were compared with hand-pollinated (crossed) heads within and between the plants and those pollinated by insects, in this case native bees and hover flies. Although the scope of the trial was very restricted, it did tend to confirm field observations, viz. that there is a progressive increase in the number of sound seed set from selfed heads to open, insect-pollinated heads. The efficiency of insect-pollination over hand-pollination was also clearly demonstrated.

There is good evidence to show that although pachystegias can be generally regarded as self-incompatible, the system is by no means watertight and some "leakage" occurs.

While it is probably safe to act on the above assumption for all taxa, it would be useful to test the breeding system further, on *P. rufa* in particular and any other taxon of conservation priority.

8. Recruitment

Some information relevant to this aspect arose during my assessment of major and routine roadworks along State Highway 1 at Ohau point (Molloy 1985), Punchbowl Corner (Molloy 1989) and the Kaikoura Coast (Molloy 1994 b). In these particular cases populations of *P. minor, P. insignis* and *Pachystegia* A were involved. In the relatively short time since the roadworks at Ohau Point (*P. minor* - obovate-leaved form) and Punchbowl Corner *(Pachystegia* A), recruitment of pachystegias to both sites by newly established seedlings is proceeding, albeit slowly across the massive freshly exposed rock faces. As anticipated, this dispersal and establishment in suitable niches has originated from undisturbed mature plants at or near the top of the rock bluffs.

In these cases it will be some time before a sizeable population is formed on the new faces. Some idea of the length of time involved can be gained from the thriving populations on the rock faces above the rail tunnel portals constructed in the 1930s along the Kaikoura Coast. These faces are now liberally covered with a range of pachystegia plants established from seed dispersed down and possibly across the face from established plants above. Germination tests show that sound seed of all pachystegias germinates readily, usually within two weeks of seedfall, yields very high germination percentages (80-90%), and has a relatively short life when stored (Simpson & Molloy 1978; Molloy unpublished). Field observations indicate that the seed of pachystegias is not dispersed widely by wind, but falls vertically through and around the parent plants. This may in part be a function of the capitulum, which holds the seeds together, opening fully on warm sunny days, when the seed may be shed, and closing on cool wet days. It may also be in part a function of the seed and pappus. The individual seeds are relatively robust and heavy and the pappus is hygroscopic and reacts to wetting and drying by screwing the seed into the soil at the point of contact. It would seem that this combination makes pachystegias very suited to establishment in rupestral habitats, and the recruitment of the various taxa thereby seems assured. The process of dispersal and establishment is undoubtedly aided by the retention of clifftop populations, which should be one of the aims of conservation management.

9. Rarity

At present, only one species, *P. rufa,* is listed among the threatened and uncommon plants of New Zealand (de Lange et al 1999). It is included among 60 named taxa in the category "Declining", defined as: "Taxa that are numerically abundant but which are either under threat from serious adverse factors throughout their range, or occur as widely scattered, typically small populations, many of which are undergoing decline through loss of reproductive ability, recruitment failure, predation, or through other processes of often subtle habitat change. Declining taxa are listed to highlight their plight, for without some level of management they are destined to become the future threatened plants of New Zealand".

While *P. rufa* may well meet some aspects of this definition, it may not meet others. At this point I prefer to reserve judgement on its rarity until the species is revisited in the Little Haldon Hills and its status, threats and management are canvassed afresh with Cathy Jones and Jan Clayton-Greene, local landholders, and in the case of the Waterfalls property which supports the largest population, with the QEII National Trust, which has put in place a registered covenant over this population.

Since this project places emphasis on *P. rufa,* it is appropriate to use this species as a sounding board for judging the comparative rarity of other pachystegias, in particular those significant genetic variants that become apparent and are of conservation concern. It is also an appropriate time to trial all the taxa through the draft DOC document "Classifying species according to the threat of extinction" circulated recently for comment by Janice Molloy.

10. Threats

Some of the more obvious threats to populations of pachystegias include the following:

- Roadworks, e.g. Ohau Point *(P. minor)*; Punchbowl Corner (*Pachystegia* A)
- Quarrying, e.g. Little Haldon Hills *(P. rufa)*; Waipapa Bay *(P. minor)*
- Herbicide application, e.g. Awatere catchment *(P. insignis)*; Conway River *Pachystegia* B)
- Wilding trees, e.g. Waihopai River *(P. insignis)*
- Broom infestations, e.g. Kaikoura Coast (*Pachystegia* A), Conway River (*Pachystegia* A, B)
- Animal browsing, e.g. all species, throughout their range (sheep, goats, possums, rabbits)

A more recent threat of concern is the widespread increase in the growth of introduced grasses such as cocksfoot, *Poa pratensis* and chewings fescue, all vigorous and aggressive polyploids, and introduced herbs such as hawkweed, *Hieracium pilosella*, and stone crop, *Sedum acre*. All these plants can be classed as calcicoles *sensu* Molloy (1994a), and are emerging as major threats to the recruitment and sustainability of indigenous rupestral communities of pachystegias and associated plants in parts of their natural range.

Managing these threats will form a significant part of any programme of recovery and site protection for threatened species of *Pachystegia*. The challenge will be to develop appropriate management solutions. This will need to be carefully researched during the next and final stage of this project.

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