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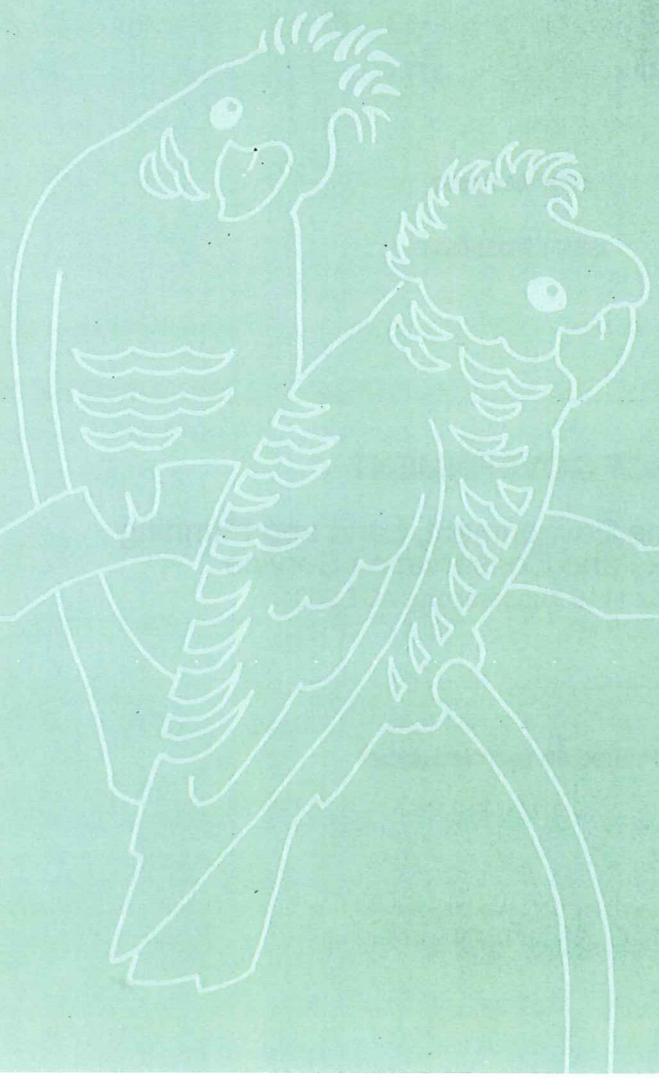
ACT PARKS and CONSERVATION SERVICE

DISTRIBUTION AND CONSERVATION STATUS OF THE ENDANGERED PINK-TAILED LEGLESS LIZARD *APRASIA PARAPULCHELLA* (KLUGE)

W.S.OSBORNE, M.LINTERMANS AND K.D.WILLIAMS

RESEARCH REPORT 5



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DISTRIBUTION AND CONSERVATION STATUS OF THE ENDANGERED PINK-TAILED LEGLESS LIZARD *APRASIA PARAPULCHELLA* (KLUGE)

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ABSTRACT

Aprasia parapulchella is a legless lizard which is classified by CONCOM as an endangered Australian species. Prior to the present survey, *A. parapulchella* was known to occur only in the Canberra region, and near Tarcutta in NSW. The type locality is at Coppins Crossing in the ACT. A survey was carried out to determine their conservation status because there had been no previous study of the distribution and abundance of the lizards.

The survey of suitable habitats determined that the species had a restricted range in and near the ACT. They occurred along the slopes of the Murrumbidgee and Molonglo River corridors, and on nearby hills including Mt. Taylor, Coolamine Ridge, Urambi Hills, The Pinnacle, and Red Hill. Although the lizards were scarce at most sites surveyed, they were locally abundant at four sites: Coppins Crossing, Mt. Taylor, Lower Molonglo and Angle Crossing. Preliminary surveys in NSW showed that the ACT population continues northwards to near Dog Trap Road, 16 km from the ACT border, and east to Googong Dam near Queanbeyan. Searches further north, east and west of this area were unsuccessful, except near Tarcutta where the species was found at two sites. It was our impression that most of the potentially suitable sites in NSW, away from the ACT region, were severely degraded by agricultural and pastoral practices. These sites had a predominance of exotic pasture species and weeds.

In, and near, the ACT *A. parapulchella* were found predominantly under rocks and only in areas underlain by Silurian volcanic rock types. In contrast, near Tarcutta the species was found under rocks amongst granodiorite outcrops. The habitat features which appear to correlate with the species occurrence are: (1) the presence of an extensive scatter of partially buried rocks; (2) a cover of predominantly native grasses, particularly *Themeda triandra*; and (3) little or no woody vegetation. The apparent association of the lizards with native grasses may be related to the ecology of their ant species prey.

An understanding of this aspect is important for appropriate management of the species, and requires further research.

Some habitat for the species in the ACT is protected, but intensive livestock grazing and removal of rocks for landscape gardening presents a significant threat in most other areas. It is recommended that *A. parapulchella* remain on the endangered category of the CONCOM List of Endangered Australian Vertebrate Fauna until further ecological research is carried out to determine the long-term viability of local populations, and the species is secure in gazetted reserves. Such research should include a consideration of diet, reproduction, dispersal, population density, and habitat use. This information is necessary in order to predict the effects of livestock grazing, tree-planting and other disturbance on the survival of local populations. Finally, it is recommended that the status of *A. parapulchella* be determined in all reserves managed by the ACT Parks and Conservation Service and that the scientifically important type locality at Coppins Crossing be protected by minimising livestock grazing and excluding pasture improvement practices including the use of fertilisers.

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INTRODUCTION

The legless lizard genus *Aprasia* (Pygopodidae) is represented in Australia by ten species, six of which appear to have restricted geographic distributions (Kluge 1974, Cogger 1986). *Aprasia parapulchella* (Plate 1) was described by Kluge (1974) from 20 specimens collected at Coppins Crossing in the Australian Capital Territory (ACT) and from one specimen collected near Tarcutta, New South Wales (NSW) (Figs. 1 & 2). The type locality is at Coppins Crossing (Plate 2).

The species is also reported to occur at Bathurst (Cogger 1986; and cited by Waters *et al.* 1987), and Cootamundra (Jenkins and Bartell 1980). Unfortunately there are no museum specimens to support these records, and the details of the location of the collection sites, and of the collectors, are not available. Although a specimen from each area was examined (H. Cogger and R. Jenkins pers. comm.), the occurrence of viable populations of the species in these areas is in doubt. Amateur herpetologists living at Bathurst have never encountered *A. parapulchella* in the Bathurst district during a 30 year period (G. Waters and I. McArthy pers. comm; McArtney 1968). Similarly in the Wagga Wagga region, T. Annabele (pers. comm.) made extensive unsuccessful searches for the species over a ten year period up to 1986. These searches included examination of rocky sites near the Murrumbidgee River, and examination of all school collections in the Wagga Wagga district. Thus, when the present study commenced, apart from the single collection site at Tarcutta in New South Wales, all other confirmed sites of *A. parapulchella* were in the ACT.

Aprasia parapulchella is on the CONCOM List of Endangered Australian Vertebrate Fauna (Burbidge and Jenkins 1984) and is considered to be vulnerable (Ride and Wilson 1982) because individual populations are threatened by loss of habitat, particularly by the removal of stones (Jenkins 1979). Jenkins (1979) observed that the type locality at Coppins Crossing (Fig. 2; see Kluge 1974 for a photograph of the type locality)

was threatened by loss of habitat. Despite the scientific importance of this location, the site has been planted in part with exotic pine trees (Plate 2). Although it has been argued that *A. parapulchella* is likely to have a wider distribution in the Canberra region (Jenkins 1979; Jenkins and Bartell 1980) the region has been extensively subjected to urban development, pine plantings and livestock grazing. The effects of such environmental change on *A. parapulchella* are not known, and because of the very limited knowledge of the species ecology, are difficult to predict.

Aprasia parapulchella is fossorial, living beneath stones in burrows apparently formed initially by ant colonies. The extent of use of these burrows is not known, but probably relates to the diet of the lizards. The species is thought to feed on ants (Jenkins and Bartell 1980), or their eggs and larvae (Kluge 1974). Patchell and Shine (1986) examined the stomach contents of 45 specimens held in museums, however, and found that none contained any food items. This was thought to be because of post-capture digestion of any prey items. Like other members of the Pygopodidae, *A. parapulchella* is oviparous with a clutch size of two. Gravid specimens have been collected in December (Kluge 1974) but nothing is known of the oviposition site or of the number of clutches laid in each season.

The present study was initiated by the ACT Parks and Conservation Service to establish the distribution, habitat occupancy and conservation status of *A. parapulchella* in the ACT. This included carrying out a briefer survey of suitable sites in NSW in an attempt to provide a broader perspective for assessing the conservation status of the species in the ACT.

Figure 1. Distribution of *A. parapulchella* in Australia prior to the present study. Closed circles, specimen-backed records; open circles, literature records not backed by museum specimens or collection details.

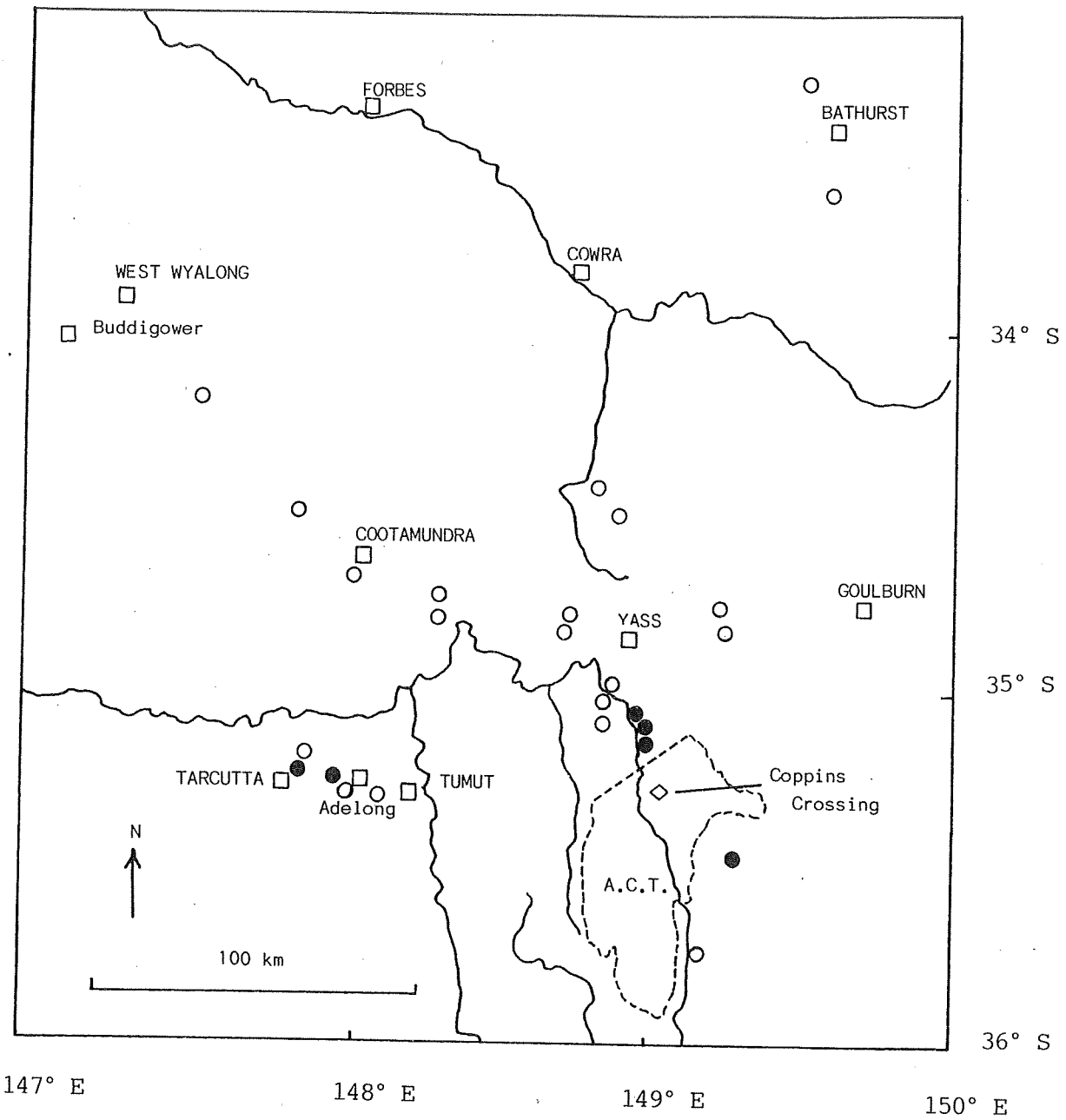


Figure 2. Location of sites surveyed for *A. parapulchella* in New South Wales .

Closed circles, sites where specimens of *A. parapulchella* were found; open circles, sites where *A. parapulchella* were not found; squares represent locality names; diamond represents type locality.

Plate 1. An adult specimen of *Aprasia parapulchella* from Coppins Crossing, ACT.

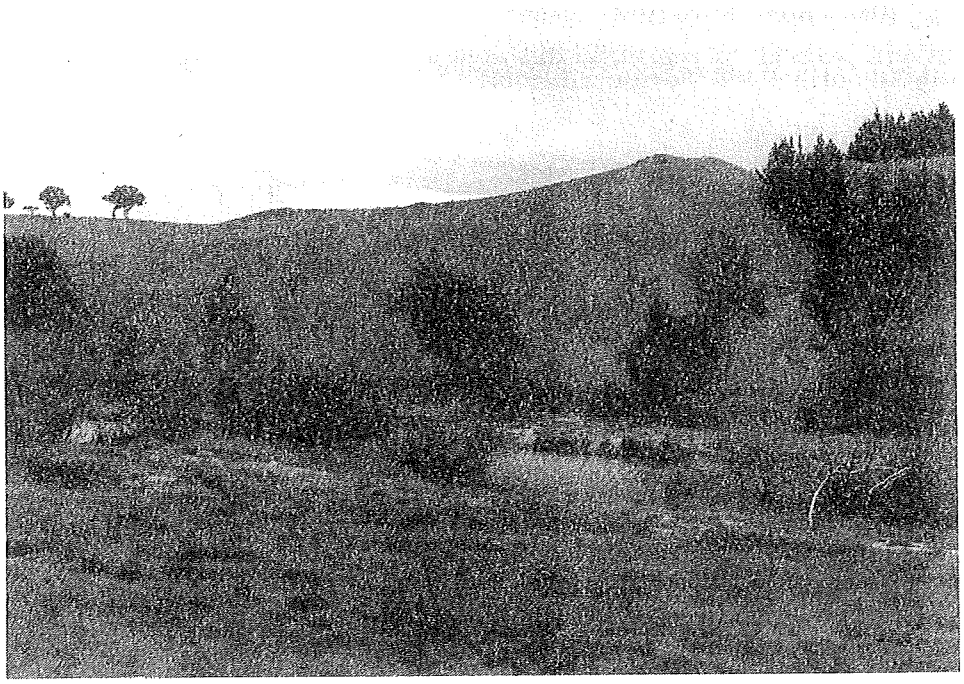


Plate 2. The type locality of *Aprasia parapulchella* at Coppins Crossing near the Molonglo River, ACT. The species was described by Kluge in 1974 from 20 specimens collected at this location. Despite the great scientific importance of the site, part of the area was planted with *Pinus radiata* in the mid 1970's. Searches made beneath rocks in the pine plantation (RHS of photograph) indicate that individuals no longer occur in the plantation. The rest of the type locality is subject to uncontrolled livestock grazing.

METHODS

Preliminary fieldwork in the Canberra region indicated that specimens of *A. parapulchella* could be found beneath shallowly imbedded rocks (Plate 3). Because of the varying density of stone cover it was decided to count the number of stones examined, rather than to survey plots of fixed-size. The preliminary results indicated that at least 150 stones had to be turned to be reasonably confident of finding a specimen or sloughed skin.

Specimens have been found under stones throughout the year, including the winter months (Plate 3). However, observations indicated that they were more difficult to detect during hot dry periods, although their sloughs (shed skins) could still be found at this stage (Plate 4; see also Kluge 1974). Previous reptile surveys in the ACT (Gilmour *et al.* 1987; Helman *et al.* 1988; Lintermans, 1989) indicated that the species is not found in the mountainous southern parts of the region, so this area was excluded from the survey.

Survey procedure

Based on the above observations the following survey procedure was adopted. Sites chosen for sampling were selected so as to cover a range of rocky tableland environments in the ACT and nearby areas in NSW. The surveys carried out in NSW were of a preliminary nature and should not be seen as being comprehensive.

Plate 3. Side elevation view of an *A. parapulchella* burrow system, with ground surface at the top of the photograph. This specimen was found in its winter hibernation site beneath a stone. Note the burrow leading to the ground surface.

Plate 4. The sloughs (shed skins) of *A. parapulchella* provide a useful indication of the presence of the species.

A preliminary stratification was carried out in order to sample a range of aspect, altitude, geology and vegetation type. Sites were rocky, generally with either extensive outcropping or with a considerable surface scatter of partially buried stones. During the summer months surveys were carried out in the morning, or on partly cloudy days, because by midday on sunny days soil temperatures beneath the rocks were often considerably higher than the temperatures tolerated by reptiles. In contrast, late autumn and winter surveys were conducted on clear sunny days because warming of the surface rocks appeared to attract individuals to the soil surface beneath the rocks.

Searches were restricted to an area of relatively homogeneous habitat within each site, and involved a careful search beneath all rocks that could be turned over. Each rock was then replaced. If continued searching revealed no specimens, then at least 200 stones were turned. If specimens or sloughs were found a number of environmental measurements were taken (Table 1). Records were also kept of all other reptiles found at each site.

The latitude, longitude and altitude of each site at which *A. parapulchella* were recorded provided the basis for carrying out a bioclimatic analysis (BIOCLIM, see Nix 1986). The BIOCLIM analysis provides estimates of climatic attributes for the sites with specimens, and allows for predictive mapping of the expected distribution of the species based on these attributes. Based on a map generated by the BIOCLIM program, a number of additional sites were selected and then surveyed in NSW (Fig. 3). Sites surveyed near Cootamundra did not correspond well with the predicted BIOCLIM distribution because much of the predicted area did not support recognizably suitable *Aprasia* habitat. In other apparently suitable areas, it was not possible to gain access to the sites.

Table 1. Measurements made at each survey site.

Variable	Measurement
Date and time	
Weather conditions	general description
Location	map reference and locality name
Altitude	from topographic map
Aspect	compass bearing
Slope	clinometer
Vegetation	general description including estimate of per cent projected foliage cover of dominant species
Geology	general description of outcropping rock, geological type taken from geology map
Disturbance	evidence of fire, grazing, rock removal, etc.
Size of stone	length X width X height (cm)
Depth of stone at position of specimen	cm
Ants	present, absent; sample taken?
Burrows	present, absent, specimen in burrow?
Distance to nearest stone	measured with tape measure (cm) Distance to nearest rock outcrop measured with tape measure (cm)
Soil moisture beneath stone	dry, damp, saturated
Size of specimen	snout–vent length (SVL) or classification adult (A), subadult (S) or juvenile (J)

RESULTS

During the survey 80 sites were searched for the presence of *A. parapulchella*, and the species was recorded at 22 of these sites (Table 2; Fig. 3). Fifty-three specimens were encountered, and a further 44 sloughs were found. Of these records, seven were obtained from areas in NSW (Figs. 2 & 3).

Geographic distribution

In the Canberra region, *A. parapulchella* was found to occur from Angle Crossing on the southern border of the ACT, northwards in a narrow strip through the ACT, to near Dog Trap Road 16 km north of the ACT border (Fig. 3). Within this region most sites with the species were within five kilometres of the Murrumbidgee (Plate 5) or Molonglo Rivers with 55 per cent of the specimens being found within one kilometre of one or other of these rivers. Specimens were also found at one site near Googong Dam.[1]

The lizards were also found at two sites near Tarcutta in NSW (Fig. 2). The first site at Tarcutta (Plate 6) was previously recorded by Kluge (1974) and by G. Swan (personal communication). However the second site near Adelong, 16 km east of the first site, provides a new locality for the species in this region. Searches at 14 other locations in central-western NSW (Fig. 2) yielded no further specimens. The species was found over an altitudinal range from 300 m near Tarcutta NSW to 800 m on the slopes of Mount Taylor in the ACT (Fig. 4).

1 Several specimens of *A. parapulchella* also were recorded by the ACT Herpetological Association on Googong Hill four kilometres south of the site where we recorded the species at Googong.

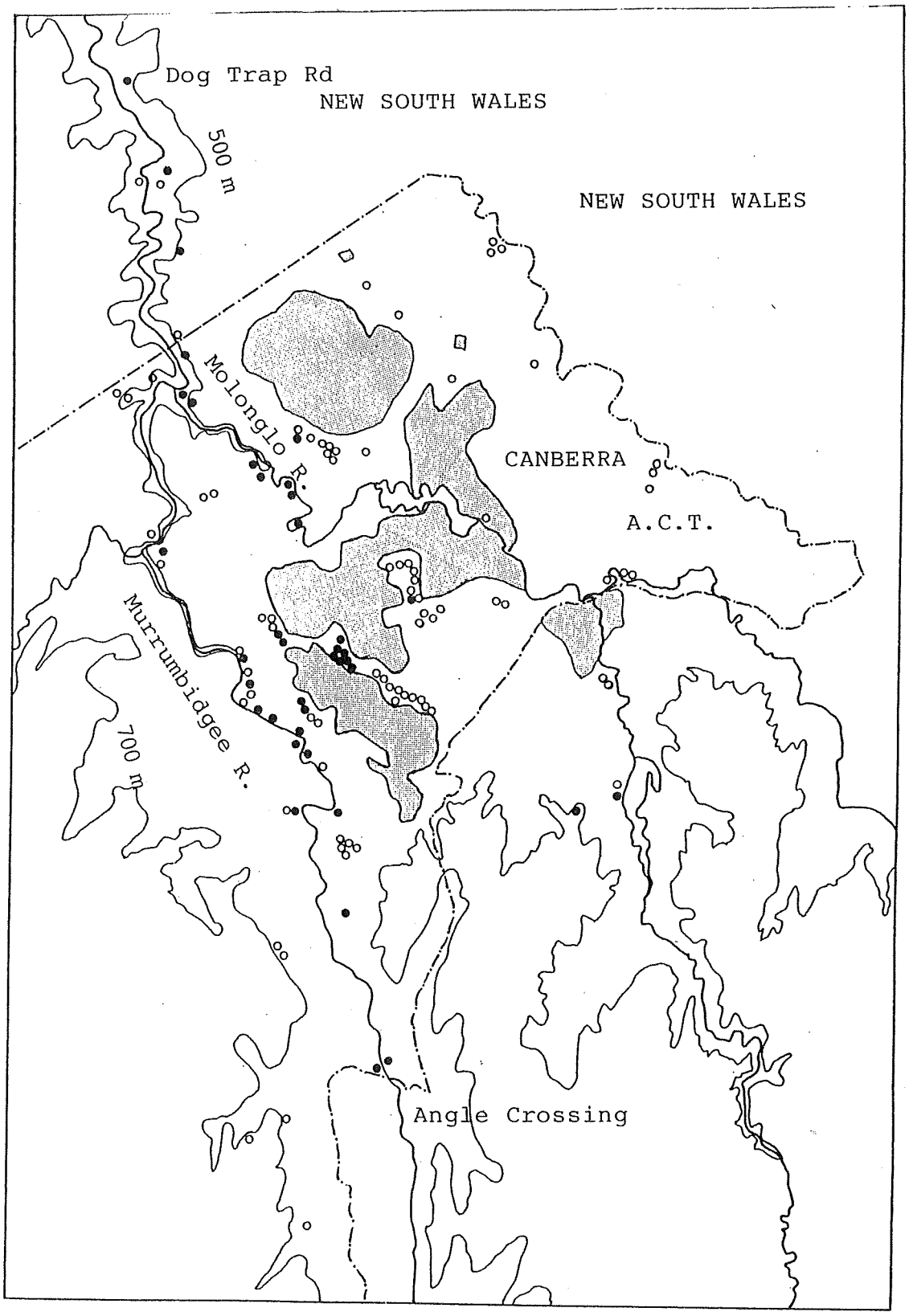


Figure 3. Distribution of *A. parapulchella* in the Canberra region. Closed circles, sites with *A. parapulchella*; open circles, sites without the species. The stippled area represents urban development; solid lines indicate 500 m and 700 m contours.

Table 2. Sites where *A. parapulchella* were recorded in and near the A.C.T. and numbers of specimens and skins observed.

Locality	Grid ref.	Altitude	Specimens	Sloughs
ACT Sites				
Angle Crossing	903601	640	3	3
Angle Crossing	903602	645	1	
Tharwa	890690	640	1	
Lambrigg	860744	620		1
Point Hut	884746	600	1	
Pine Island	865783	560	1	3
Freshford	861787	560		1
Tuggeranong Ck.	861791	560		1
Red Rocks Gorge	840799	540		1
Kambah Pool	835804	560		1
Kambah Pool	829819	540	1	
New Station Ck.	827833	550	3	
Cotter Mouth	778881	510	1	
Casuarina Sands	781896	500	4	
Lower Molonglo	794980	490	1	
Lower Molonglo[1]	796979	500	6	1
Spring Valley[2]	834944	520		1
Spring Valley[2]	835937	520		1
Coppins Crossing	855932	530	12	
Pinnacle	857964	680	1	
Belconnen West	790006	500	1	
Mt. Taylor	835880	700–800	7	28
Red Hill[1]	925864	680	1	
Urambi Hills[2]	862809	650	1	1
Urambi Hills[2]	863805	670	1	
Cooleman Ridge[2]	847849	680	1	
Cooleman Ridge[2]	851846	700	1	
NSW Sites				
Wallaroo Rd.	789067	500	2	1
McCarthy Rd	780109	460	1	
Dog Trap Rd	757163	430	1	
Googong Dam	043757	700	3	2
Total			56	46

1. R. Bennett, ACT Parks and Conservation Service, personal communication.

2. C. Crisp, unpublished internal report, ACT Parks and Conservation Service.

Relative abundance

At sites where they were found *A. parapulchella* were usually very uncommon, being recorded on the basis of one or two specimens or sloughs (Table 2). However at three locations in the ACT, Coppins Crossing, Lower Molonglo, and Mt. Taylor, larger numbers of individuals were found, with up to 11 specimens being found during a single search. Groups of between two and five individuals were also found under a single stone at these locations.

The total number of individuals of ten of the more common species of reptiles encountered during the survey (Fig. 5) indicates that *A. parapulchella* is encountered uncommonly within the particular habitats examined. However the lizards are apparently no less common within these areas than species such as stone gecko, *Diplodactylus vittatus*, four-fingered skink, *Carlia tetradactyla*, inornate legless lizard, *Delma inornata*, and black-headed snake, *Unechis spectabilis*, all relatively cryptic species which inhabitat open rocky areas and grassland (Jenkins and Bartell 1980).

The activity of the lizards appeared to be affected by temperature and soil moisture. They were not found beneath stones when daily air temperature rose above about 26° C. Moreover during dry summer weather specimens could not be found at sites where they were normally easy to find (eg Coppins Crossing) until after a period of substantial rainfall.

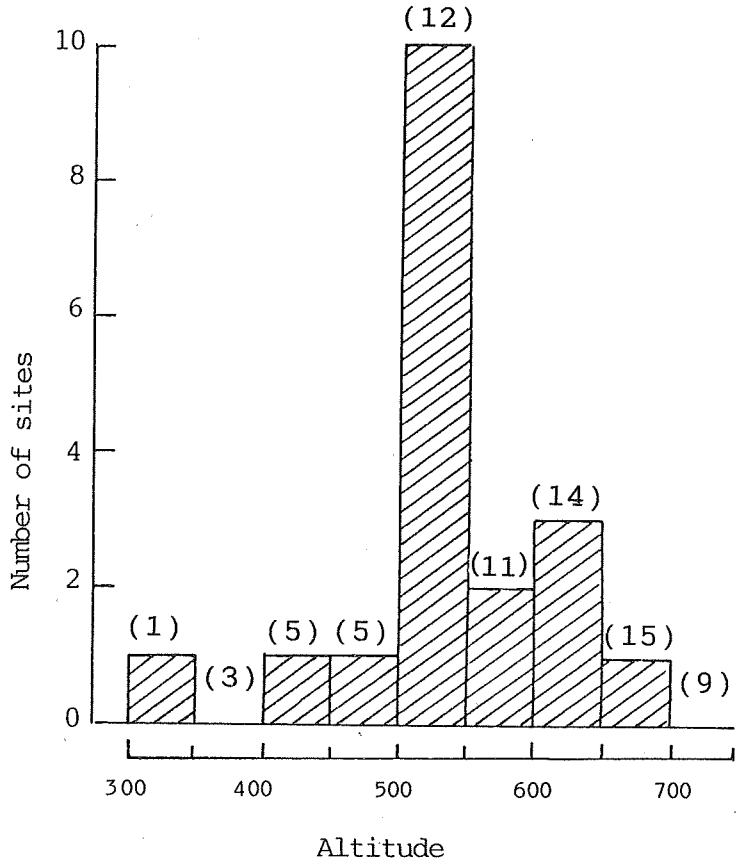


Figure 4. Distribution of *A. parapulchella* in relation to altitude. Numbers in parentheses are the total number of sites examined in each altitudinal class.

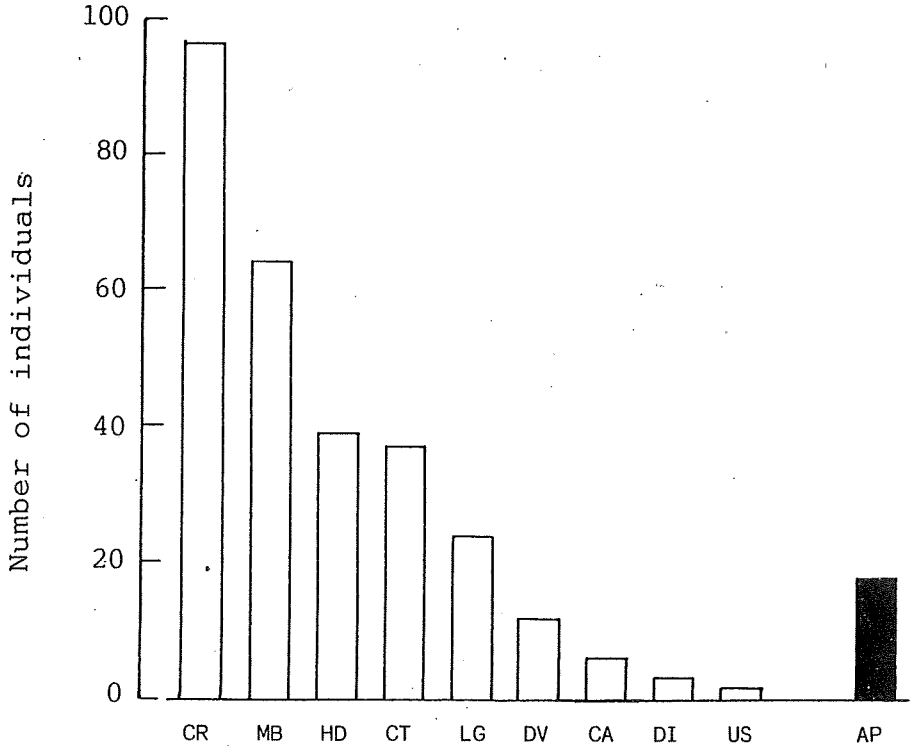


Figure 5. Total numbers of ten species recorded during the survey compared to that of the numbers of *A. parapulchella* recorded.

Code:		
	CR	*Ctenotus robustus*
	MB	*Morethia boulengeri*
	HD	*Hemiergis decresiensis*
	CT	*Ctenotus taeniolatus*
	LG	*Lampropholis guichenoti*
	DV	*Diplodactylus vittatus*
	CA	*Carlia tetradactyla*
	DI	*Delma inornata*
	US	*Unechis spectabilis*
	AP	*Aprasia parapulchella*

Plate 5. Suitable habitat for the species has a patchy distribution along the length of the Murrumbidgee River corridor and nearby hills. The location shown (centre) is near junction of the Murrumbidgee and Molonglo Rivers.

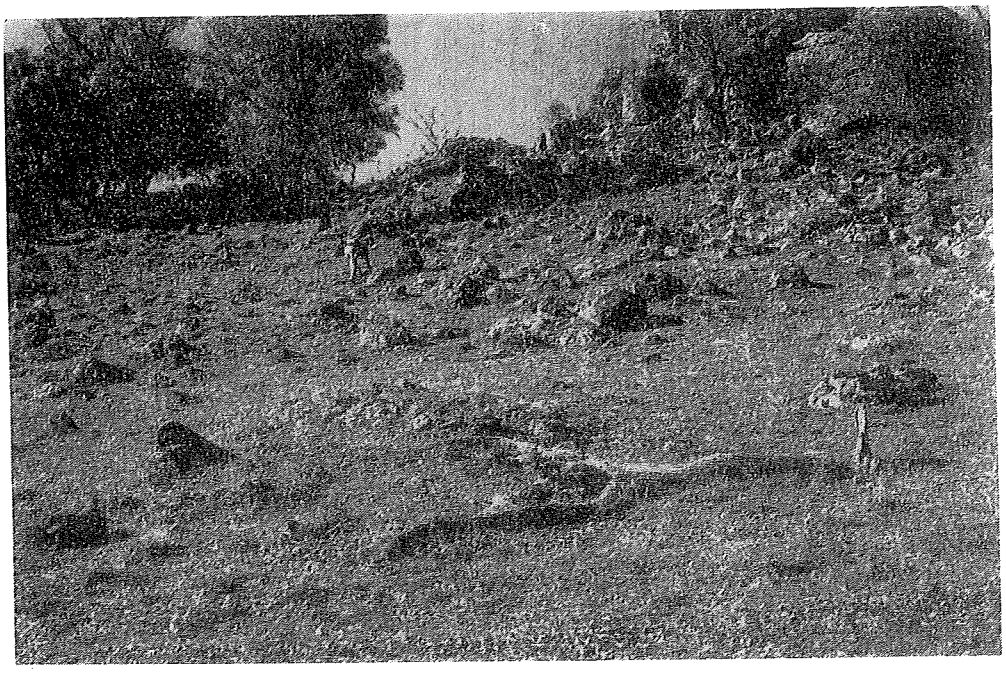


Plate 6 Location where *Aprasia parapulchella* was found north of Tarcutta in NSW. The site is similar to sites with the species in the ACT although the rock type at Tarcutta is granodiorite (see text).

Habitat

Aspect and slope

Most specimens were found on moderate to steep slopes ranging from 3 to 15 degrees. All aspects were occupied by the species (Fig. 6). Whilst fewer specimens were collected on south facing slopes, sampling effort was less on this aspect.

Geology

In the Canberra region, *A. parapulchella* were found only in association with Late Silurian acid volcaniclastic deposits (Fig. 7). The specific rock types at sites where the lizards were found included rhyodacite, rhyolite, dacitic tuff and volcaniclastic sediments. At sites where the largest numbers of specimens were observed the surface rocks were well-weathered with a considerable amount of fracturing resulting in a high density of broken, surface rock material. Near Canberra, searches in areas with outcropping granodiorite, leucogranite and Ordovician sediments yielded no specimens. However the three individuals recorded near Tarcutta in NSW were found under exfoliated boulders of granodiorite. Sampling was not carried out on Quaternary alluvium because of the lack of surface rocks.

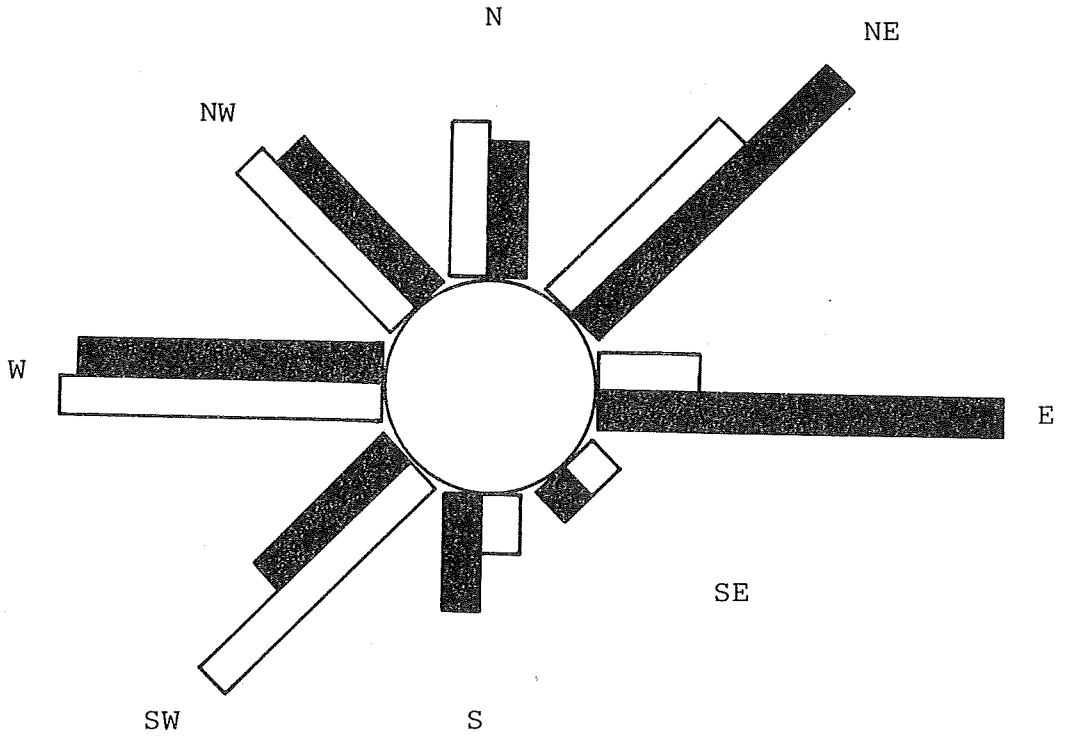


Figure 6. Distribution of sites with and without *A. parapulchella* in relation to aspect.

Closed bars sites with *A. parapulchella*; open bars sites without the species. The shortest closed bar (SE) represents two sites, the longest closed bar (E) represents 21 sites.

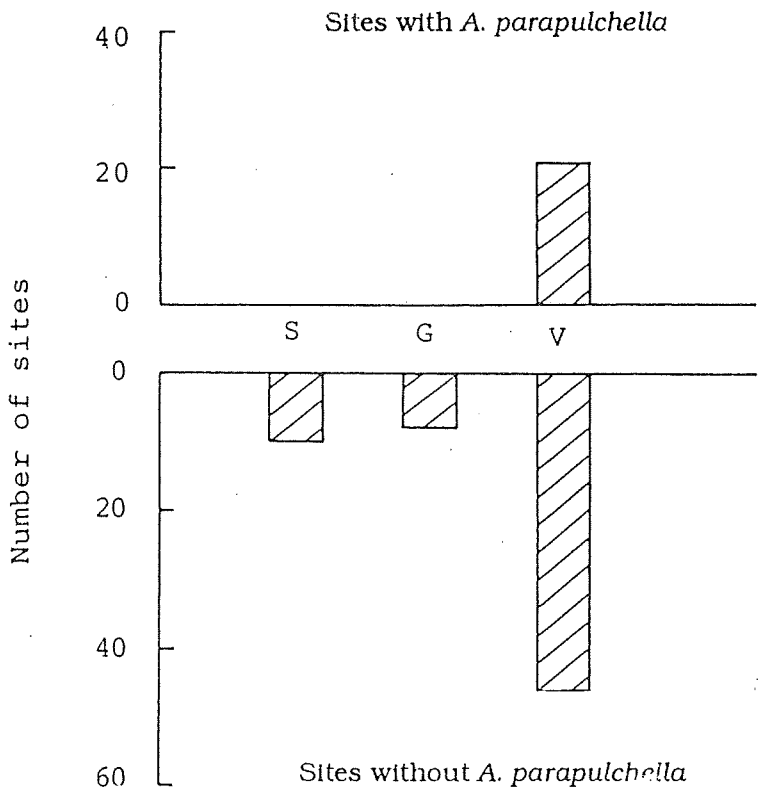


Figure 7. Occurrence of *A. parapulchella* in relation to geology in the Canberra region. S, sedimentary; G, granodiorite; V, volcanics.

Stone size

Apart from seven individuals collected from beneath logs (all at the same site), all specimens of *A. parapulchella* were found under stone. In the Canberra region the stones that specimens were found beneath were generally small in size, averaging less than 500 cm^2 in basal area in contact with the ground (Fig. 8). This impression of stone size is, however, probably slightly biased towards smaller stones because smaller stones predominated at most sites. Large, deeply-imbedded stones were difficult to move so fewer large rocks were examined. Despite this, no specimens were found under large rocks.

Vegetation

All sites with *A. parapulchella* were in relatively open areas. Tree and shrub cover at the sites was sparse, and included scattered trees of Blakely's red gum *Eucalyptus blakleyi*, yellow box *E. melliodora*, red stringybark *E. macrorhyncha* and brittle gum *E. mannifera*, and shrubs such as *Grevillea juniperina*, *Kunzea ericoides*, *Bursaria spinosa*, *Cassinia* spp., *Melichrus urceolatus*, and *Brachyloma daphnoides*.

Sites with the species had significantly different vegetation types to sites without the species (chi-square test: df=5; X=15.29; P<0.01). Native tussock grasses comprised a conspicuous and significant element of the ground cover present at 84 per cent of the sites at which *Aprasia* specimens were found (Fig 9). Kangaroo grass *Themeda triandra* occurred at all sites with the lizards, whilst other native tussock grasses such as *Bothriochloa macra*, *Danthonia* spp. and *Stipa* spp. occurred at 47 percent of the sites. Exotic tussock-forming grasses such as *Erogrostis* sp. also contributed significantly to ground cover at several of the sites with *A. parapulchella*.

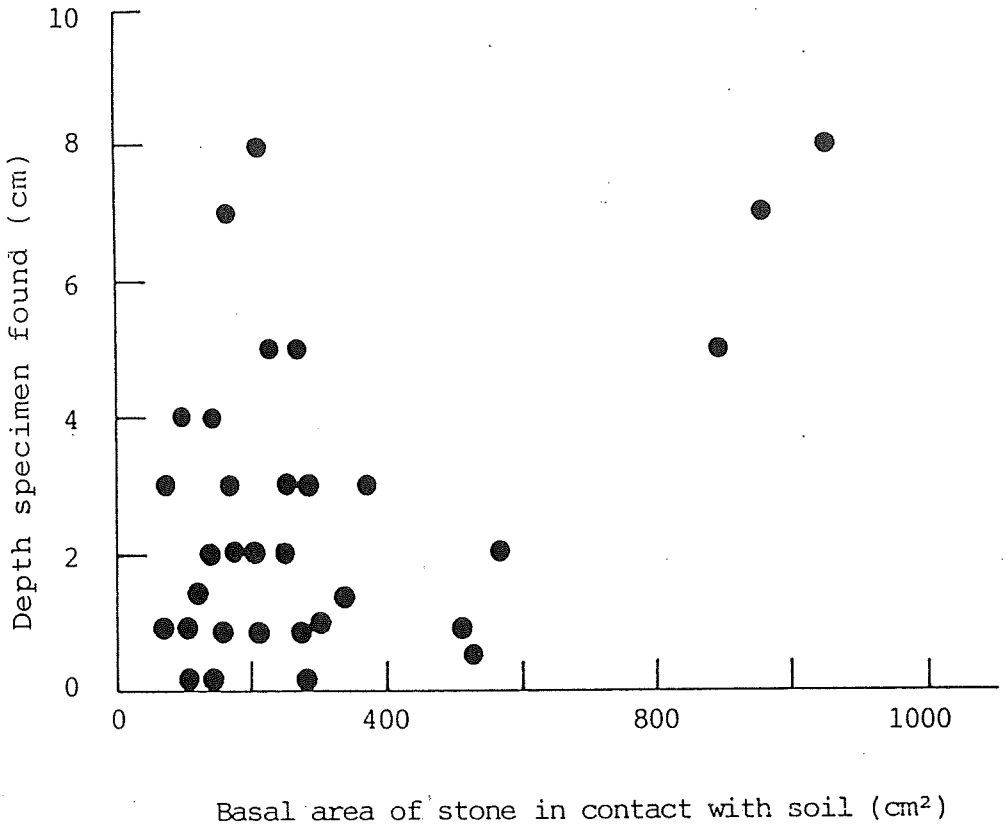


Figure 8. Size of stones under which specimens and sloughs of *A. parapulchella* were found and the depth that each stone was buried at the position of each specimen.

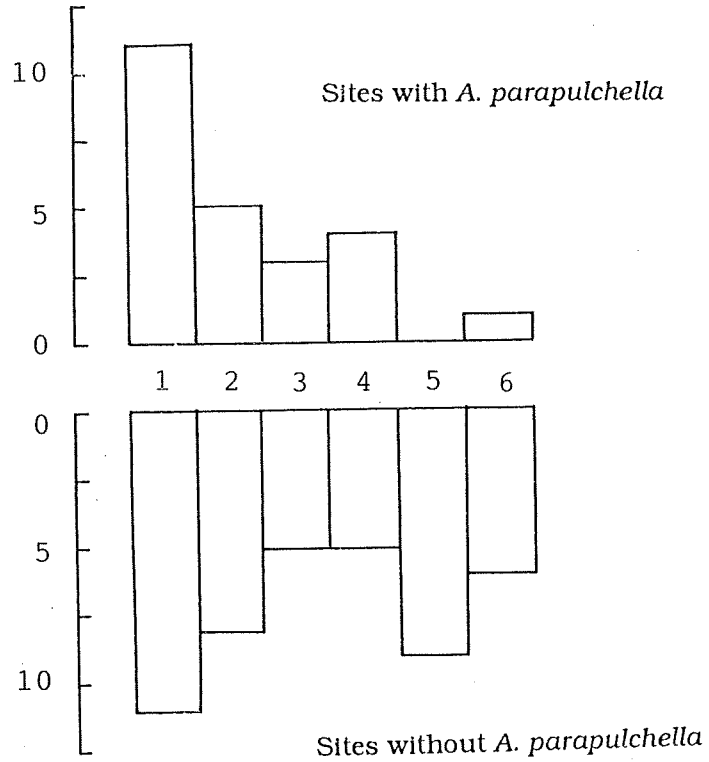


Figure 9. Ground cover type characteristic of sites with and without *A. parapulchella*.

1. > 50% cover *Themeda* sp.; site dominated by native grasses.
2. < 50% cover of *Themeda* sp.; site dominated by native grasses.
3. 10–50% cover of native grasses; exotic grasses < 20% cover.
4. 10–50% cover of native grasses; exotic grasses > 20% cover.
5. cover entirely of exotic pasture species.
6. < 20% cover of any vegetation; bare ground very prominent.

Association with ants and small burrows

Ninety-three per cent of the specimens (n=46) were found in, or near, small burrows under the rocks. Some individuals retreated down these burrows when disturbed. Whilst it was not always obvious, the burrows appeared to have been constructed by ants, which occurred at 79 per cent of the stones with specimens.

Bioclimatic analysis

There are significant differences in the predicted temperature and precipitation of sites with the species in the ACT when compared to Tarcutta, and Adelong (Table 3). Although ACT sites are slightly colder, the mean temperatures of the wettest and driest quarters are significantly higher in the ACT (Table 3), indicating a difference in the seasonality of rainfall between the two areas. Mean annual precipitation is highest at Adelong (865 mm) and lowest at Buddigower (470 mm).

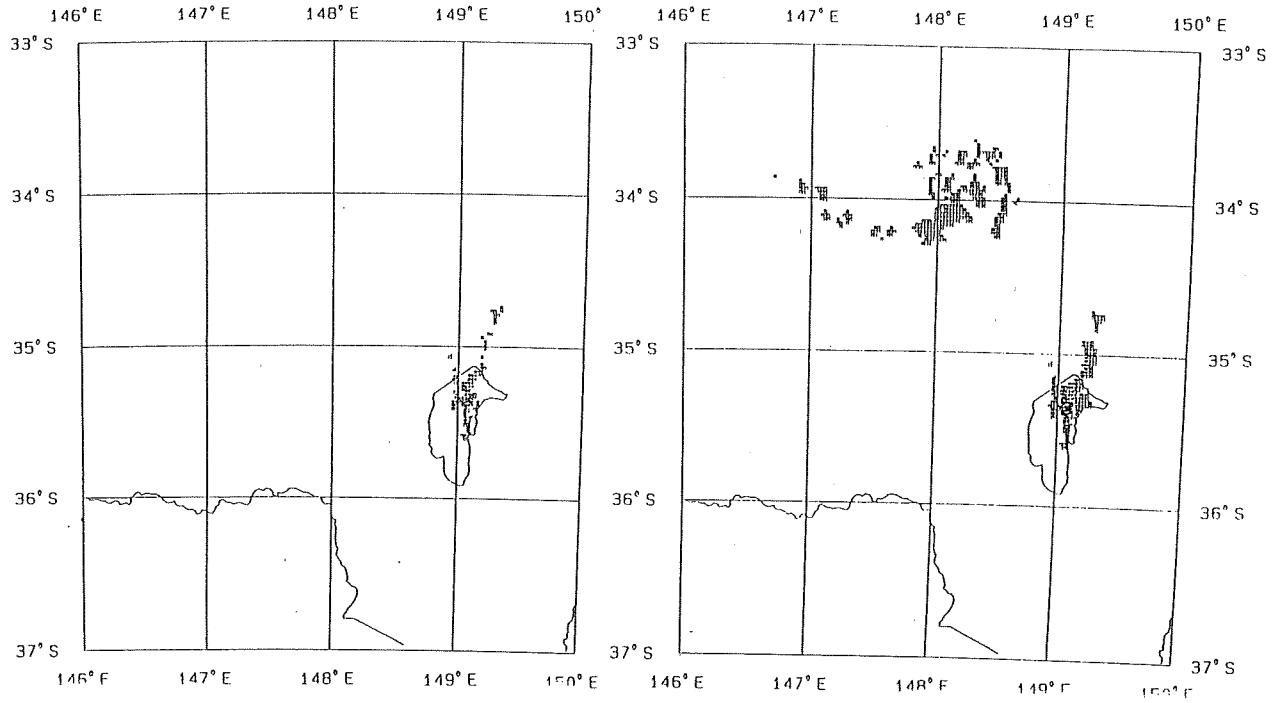
The BIOCLIM predicted distributions of sites with climates similar to those with *A. parapulchella* are not extensive (Fig 10). When ACT sites only are used in the analysis the predicted distribution is confined to a narrow strip of land in and near the ACT; adding Tarcutta and Adelong broadens the distribution to include a large area north and west of the ACT; adding Buddigower Nature Reserve (see Table 3) to the ACT sites predicts the occurrence of suitable climates in the Cootamundra region as well as near Canberra; and when all sites are used in the model, the predicted distribution extends from near Bathurst to north-eastern Victoria (Fig. 10).

Table 3. Climate profiles for 18 sites with *A. parapulchella* near Canberra, and for single sites with the species at Tarcutta and Adelong. A climate profile is also provide for Buddigower Nature Reserve for *A. pseudopulchella*. [1] Significance of differences tested using single-factor ANOVA.

CLIMATIC VARIABLES	CANBERRA MEAN (n=18)	SD	CV	TARCUTTA (T) MEAN (n=1)	ADELONG (A) MEAN (n=1)	BUDDIGOWER (B) MEAN (n=1)	CxTxA F	P	CxB F	P
(1) Mean annual temperature	12.9	0.4	3.1	14.7	13.6	16.2	10.0	**	61.7	***
(2) Mean temperature coldest month	5.6	0.3	5.3	6.9	5.9	8.1	9.1	**	66.0	***
(3) Mean temperature hottest month	20.3	0.6	2.9	21.8	20.8	24.4	11.4	***	44.9	***
(4) Annual temperature range (3-2)	15.0	0.3	2.3	16.8	17.4	15.6	32.1	***	2.5	NS
(5) Mean temperature wettest quarter	13.9	2.1	15.8	7.7	6.8	8.9	8.3	**	4.9	*
(6) Mean temperature driest quarter	10.6	4.4	41.3	22.2	20.8	20.6	5.6	*	4.9	*
(7) Mean annual precipitation	674.9	20.4	3.0	672.6	864.7	470.0	40.9	***	94.9	***
(8) Precipitation wettest month	70.1	2.3	3.3	68.8	92.7	44.5	46.1	***	119.0	***
(9) Precipitation driest month	52.3	6.5	12.4	40.1	44.8	34.6	2.2	NS	7.0	*
(10) Annual precipitation range (8-9)	18.6	3.8	20.5	28.7	47.9	9.9	30.4	***	4.9	*
(11) Precipitation wettest quarter	187.2	5.6	3.0	202.5	272.8	123.8	111.4	***	120.5	***
(12) Precipitation driest quarter	155.9	5.7	3.7	132.8	158.2	112.1	8.0	**	55.7	***
(13) Mean rainfall coldest month	50.5	1.8	3.5	40.1	44.8	34.6	20.1	***	75.7	***
(14) Mean rainfall warmest month	70.2	2.3	3.2	68.8	92.6	44.5	46.4	***	119.9	***

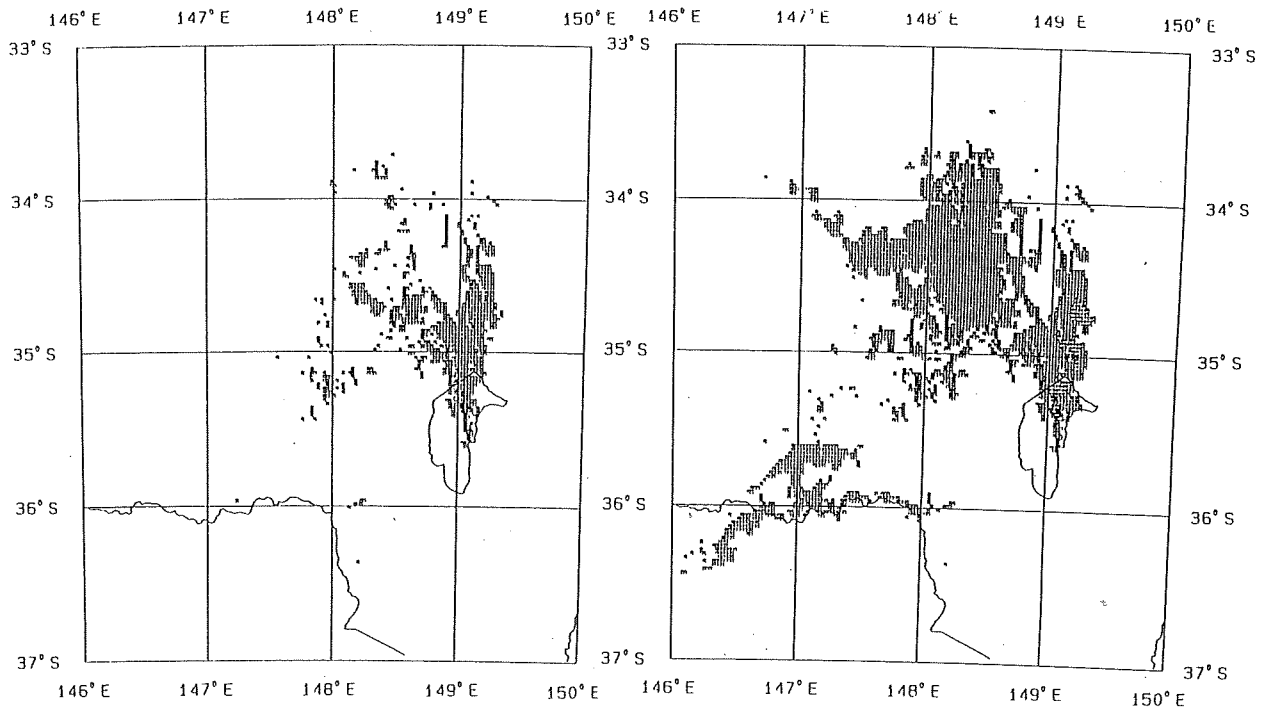
* p 0.05; ** p 0.01; *** p 0.001; NS = not significant

1. Estimates are also provided for Buddigower Nature Reserve near West Wyalong, where a single specimen of a species of *Aprasia* was collected by J. Caughley in 1988. This specimen is now lodged with the CSIRO Australian Wildlife Collection, Canberra, and has been tentatively recorded as *A. pseudopulchella* (J. Wombey pers. comm.). We examined the specimen and found that it also closely resembles *A. parapulchella* and therefore we included the Buddigower site in the BIOCLIM analysis for its interest value.



(a) Sites with *A. parapulchella* in the Canberra region (n=18).

(b) Sites with *A. parapulchella* in the Canberra region (n=18) plus site with *A. Pseudopulchella* at Buddigower (n=1)



(c) Sites with *A. parapulchella* in the Canberra region (n=18) plus Tarcutta and Adelong (n=2).

(d) All sites with *A. parapulchella* (n=20), plus the one site with *A. pseudopulchella* at Buddigower (n=1).

Figure 10. BIOCLIM predicted distribution of sites with climate profiles similar to those where *A. parapulchella* has been observed. The record of *A.pseudopulchella* has been included because of its interest value and because of the uncertainty of the identification of this specimen.

DISCUSSION

Assessment of the survey technique

Whilst we agree with Ehmann and Cogger (1985) that *Aprasia* spp. are difficult to find except under certain ideal conditions, we nevertheless feel that the method adopted here was appropriate. The success of a search in any particular area is not only dependent on the occurrence and abundance of *A. parapulchella* in the area, but also on prevailing weather conditions, and possibly the conditions of the previous day or days. Capture success appeared to be highest in spring and early summer on warm, but not hot days, after a period of rainfall extending over several days. It was not practical to limit the survey to these periods of ideal weather. Detection of the conspicuous sloughs at other times made it likely that the search method was suitable for determining presence or absence.

Bioclimate

The bioclimatic analysis indicated that areas with climates predicted to be similar to that at sites known to be occupied by *A. parapulchella* have a comparatively restricted extent in south-east Australia (Fig. 10 *c*). Whilst this indicates that there is potential for the species to have a much broader distribution than that presently known, it must be remembered that extensive parts of the region predicted to have suitable climates for the species will have other environmental components that are unsuitable. For example the area may be heavily timbered or may have unsuitable geology, soil types and land use. Nevertheless, the bioclimatic prediction should prove to be useful in planning subsequent surveys for the species.

Relative abundance and conservation status

Aprasia parapulchella is an uncommon species. It occupies a small geographic range (known distribution probably less than 150 km^2), exhibits a high degree of habitat specificity, is probably a dietary specialist, and has a low clutch size; these are all features which are representative of rarity (Rabinowitz, Cairns and Dillon 1986). However, it is clearly not a species in immediate danger of extinction. It has a comparatively wide distribution in and near the ACT where it has been recorded at over 20 sites. Nevertheless, we believe that *A. parapulchella* should be considered as an endangered species (*sensu* Ride and Wilson 1982), and maintained on the CONCOM list until further information on the ecology and habitat requirements of the species is available and until it is located in secure reserves.

Although, as suggested by Ehmann and Cogger (1985), the species may be rarely found because its habits are poorly known, our results indicate that it has a very restricted geographic distribution in Australia and, where it occurs, is confined to a specific, and often localised habitat. Our preliminary reconnaissance in NSW revealed that suitable habitat is not widespread and that livestock grazing and cultivation has degraded the habitat potential of many sites. Similarly in the ACT, apart from some areas of protected habitat in small insecure reserves, most sites containing the species are subject to the continuing threat of habitat deterioration from livestock grazing and rock removal (Table 4).

The proposed gazettal of a large part of the Murrumbidgee River Corridor (Anon. 1988) as a series of conservation reserves in the ACT should protect from further degradation, a narrow, disjunct linear portion of the predicted habitat for this species in the ACT (provided livestock grazing is excluded).

Table 4. Non-gazetted ACT reserves supporting populations of *A. parapulchella*.

Reserve name	No. of specimens recorded	Condition of habitat	Perceived threats
Murrumbidgee Corridor	19	1,2	3
Mt. Taylor	15	1,2,3	1,2
Red Hill	1	1,2	2
Urambi Hills	2	1,2	2,3
Cooleman Ridge	2	1,2	2,3
Ainslie-Majura	1 (site unknown)	1,2,3	2
The Pinnacle	1	2,3	3

Condition of habitat:

1 largely undisturbed, mainly native grasses
2 partially modified, moderate cover of native grasses
3 highly modified, predominantly exotic pasture species

Perceived threats

1 disturbance of stones by children
2 frequent grass fires
3 uncontrolled livestock grazing

A further contribution to the management of the species would be to protect suitable habitat along the corridor of the Molonglo River west of Green Hills pine plantation near Scrivener Dam. At a more site specific level the type locality at Coppins Crossing should be carefully managed to retain the remaining native grass cover. This site is particularly important not only as a scientific reference site, but also because the greatest density of individuals of *A. parapulchella* yet observed has been recorded at this site.

Habitat preference

It is clear from the present study that sites where *A. parapulchella* occur are characterised by: 1) a cover of predominantly native grasses, particularly *Themeda triandra;* 2) sparse or no tree cover; 3) little, or no, leaf litter (although dead grass cover was usually high); and 4) scattered small rocks lightly imbedded in the soil surface, or resting on soil on top of more deeply buried rocks. The species has not been collected in forested environments or in dense woodland or scrub. Kluge (1974) notes that *A. pulchella*, a Western Australian species, does not occur in dense jarrah forest. The apparent association of *A. parapulchella* with native grasses may be related to the ecology of their ant species prey, and requires further research.

The habit of sheltering beneath stones is not peculiar to *A. parapulchella.* Kluge (1974) records that *A. repens* in Western Australia is commonly found beneath small slabs and chips of exfoliated granite before the ground dries in spring and summer, and *A. pulchella* is collected regularly from under lateritic boulders and pieces of granite where the soil is slightly moist. Apart from seven specimens found beneath fallen wooden fence posts in a rocky area, all our field records of *A. parapulchella* have been of specimens found beneath stones. This would indicate that the cover of shallowly imbedded rock comprises a critical part of the habitat requirements of the species.

Structural elements which would benefit the lizards directly include firstly the scarcity, or absence, of shading vegetation, thus permitting incident sunlight to warm the rocks and ground surface, and secondly the small size of rocks under which the specimens were found. These conditions would enable the rocks to warm up rapidly in sunlight. Overheating of individuals would be avoided by them entering burrows.

The influence of livestock grazing

Despite over 150 years of livestock grazing in the Canberra region, *A. parapulchella* is still widely distributed. However, the results of our survey indicate that there is a positive correlation between the presence of native grass species and the occurrence of the lizards (Fig. 9). Heavily grazed and/or cultivated paddocks were usually found to be dominated by a cover of exotic pasture species, and often, by extensive thickets of weeds, particularly on rocky hilltops where livestock often congregate at night. Despite other aspects of the habitat being suitable (e.g. rock type and rock cover), no specimens were found on such heavily grazed sites. Therefore we suggest that in the long-term, livestock grazing and/or cultivation has the potential to alter the habitat (see also Moore 1959, 1962, 1967) in such a way as to eliminate the species from these sites. Considerably more work is needed, however, to demonstrate the causality of such a relationship involving livestock grazing (see recommendations below).

Habitat fragmentation, reserve design and conservation

Within the Canberra suburban area, *A. parapulchella* has been recorded in six reserves (Table 3). The species is apparently very rare in the Ainslie-Majura, Red Hill and Pinnacle reserves, and is abundant in the Mt Taylor reserve. The Canberra Nature Park reserves are generally disjunct, being separated by urban development (Plate 7) or agricultural lands.

Because of their small size, populations in each area may be prone to stochastic population events (e.g. random changes in sex ratio, or fertility), and susceptible to local catastrophes such as drought, disease, predation and habitat disturbance (e.g. fire, weed or woody vegetation invasion). Moreover the small size of isolated populations may lead to loss of genetic diversity through drift and inbreeding (Frankel and Soule 1981). The proposed gazettal of four nature reserves along the Murrumbidgee River (Anon. 1988) potentially protects a considerable area of *A. parapulchella* habitat in the ACT. However these reserves have a narrow, disjunct, linear, configuration making them highly susceptible to edge effects. Recreational use of the reserves (Plate 8) is expected to increase, adding to the risk of frequent fires and other habitat disturbance.

MANAGEMENT CONSIDERATIONS AND RECOMMENDATIONS

Conservation status

Our results suggest that *A. parapulchella* should not be removed from the CONCOM "endangered" category. The reasons for this are as follows:

(1) the species has a small known geographic distribution;

(2) most of the known range is contained in areas highly modified by agricultural practices;

(3) many areas near Canberra have been modified by urban development and pine plantings; and

(4) in rural areas, removal of rock for landscape gardens presents a significant and increasing threat to the viability of local populations.

(5) little is known of the ecology and habitat requirements of the species so that threats to the species cannot be adequately assessed at this stage.

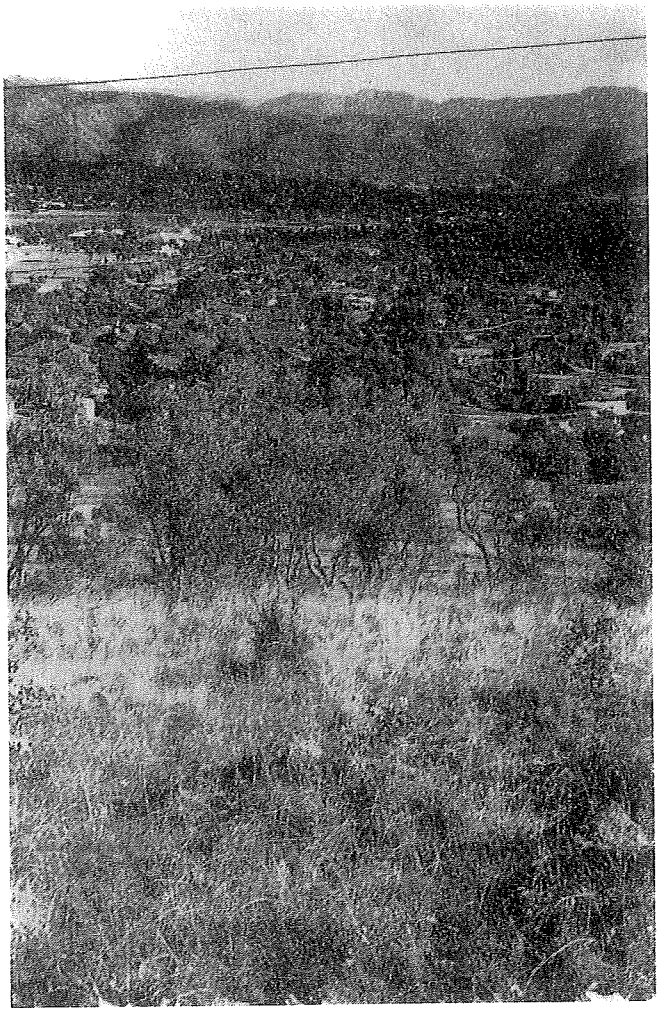


Plate 7. Over 30 specimens of *Aprasia parapulchella* have been found on Mt Taylor. This is the largest concentration of the species recorded. Whilst Mt Taylor is a very important reserve for the species, it is surrounded by urban development and thus is isolated from other areas of suitable habitat.

Plate 8 The route of the existing Murrumbidgee walking trail passes through considerable areas of suitable *A. parapulchella* habitat. Specimens were found within one metre of the walking track at this location.

Further distributional surveys

There is an urgent need to carry out further distributional surveys in the ACT, and particularly in NSW, to more fully assess the conservation status of the species. It is not possible at this stage to provide any estimate of abundance of the lizards at any site. Such information is fundamental to determining the extent of vulnerability of the population. Surveying the extent of the species disjunct distribution near Tarcutta also should be given a high priority by the appropriate wildlife management organisation.

Ecological research

Further research should be conducted on the ecology of *A. parapulchella* so that the habitat requirements of the species are better known. Such research should include a consideration of diet, reproduction, dispersal, population density, and habitat use. An important consideration would be to determine the population density of *A. parapulchella* in all reserves to gain a better understanding of the size of the protected population, and thus provide information on population viability. Research should also be undertaken into the possible effects of livestock grazing on the habitat of the species.

Habitat conservation and protection

As a matter of priority, grazing by livestock should be excluded or markedly restricted from reserves known to support *A. parapulchella*. In the Canberra region this may involve changing management practices in some areas managed by the ACT Parks and Conservation Service (e.g. horse holding paddocks). Consideration also should be given to providing increased protection to the remaining part of the type locality by excluding uncontrolled livestock grazing from the site and removing woody plants. This may best be put into practice by declaring a reserve which includes this site.

The extent of tree-plantings within some reserved areas is reason for concern, particularly as it has been demonstrated that the species does not favour sites with extensive tree cover. Thus, the extent of tree-plantings in relation to the occurrence of suitable *A. parapulchella* habitat in areas such as Mt. Taylor and the Murrumbidgee River Corridor should be carefully planned and monitored. If necessary, thinning of trees, or their complete removal, may be necessary in some areas designated as suitable *A. parapulchella* habitat.

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