*Journal of Biogeography* (1977) 4, 327–332

# Distributions of the dipteran genera *Drosophila* and *Scaptomyza* in Australia in relation to resource utilization

I. R. BOCK and P. A. PARSONS Australian *Drosophila* Research Unit, Department of Genetics & Human Variation, La Trobe University, Bundoora, Victoria, 3083, Australia

ABSTRACT. The two Australian *Scaptomyza* species, especially the endemic *S. australis*, have broader limits for resource utilization as measured by temperature and relative humidity than do endemic *Drosophila* species. This has enabled *S. australis* in particular to spread to both hot arid and cold high upland regions of the continent where no *Drosphila* are found.

## Introduction

Australian *Drosophila* species have a maximum range for resource utilization of about from 12–26° C (or 14° C), with many endemic species possessing somewhat smaller ranges (Parsons, 1975, 1977). Ranges of < 16°C are characteristic of aquatic animals (Andrewartha & Birch, 1974) living in places where differences between maximum and minimum temperatures are small. Terrestrial or amphibious animals, however, live in places where temperatures are more variable, with ranges of usually > 20°C. The narrow *Drosophila* range appears to be explained by the fact that at least most members of the genus exploit the moist microbial degradation products of plants (Throckmorton, 1975), and thus occupy niches with some analogies to the aquatic environment.

The genus *Scaptomyza* is closely related to *Drosophila* and indeed in Hawaii flies are found with characters intermediate between those of the two genera (Carson *et al.*, 1970). *Scaptomyza* species can, however, exist in more extreme habitats than *Drosophila* species (Throckmorton, 1975), so that in Hawaii where there are major radiations in both genera, the scaptomyzoids are often found in drier and more exposed habitats of high light intensity, although they also broadly overlap into drosophiloid habits; in addition Hawaiian scaptomyzoids are found in cooler regions than drosophiloids. In South America, the southernmost endemic *Drosphila* species occurs at about 44° S, while endemic *Scaptomyza* are found in the vicinity of Punta Arenas at 53° 40′ S (Brncic & Dobzhansky, 1957). *Scaptomyza* species are also common in the Arctic (Basden, 1956).

From the above observations it is tempting to generalize that *Scaptomyza* may occur in more severe habitats than *Drosophila* both at cool and warm extremes. This paper reviews the situation in respect of the Australian species.

## Methods and species

Flies were collected by sweeping foliage with a deep net (0.39 m diam.), permitting the precise characterization of preferred microhabitats. In a few cases flies were collected directly into vials from fern fronds where they were motionless. Temperature and humidities were taken with a Bacharach Hygrometer. The Victorian and Tasmanian habitats surveyed (Fig. 1) are the tree fern/sedge temperature zone habitats described in Parsons & Bock (1977). The South Australian habitats have plants with fleshy leaves, and flowers characteristic of the arid zone flora in these regions. The endemic *Drosophila* species, with all of the subgenus *Scaptodrosophila*, are described in Bock (1976), with the exception of two

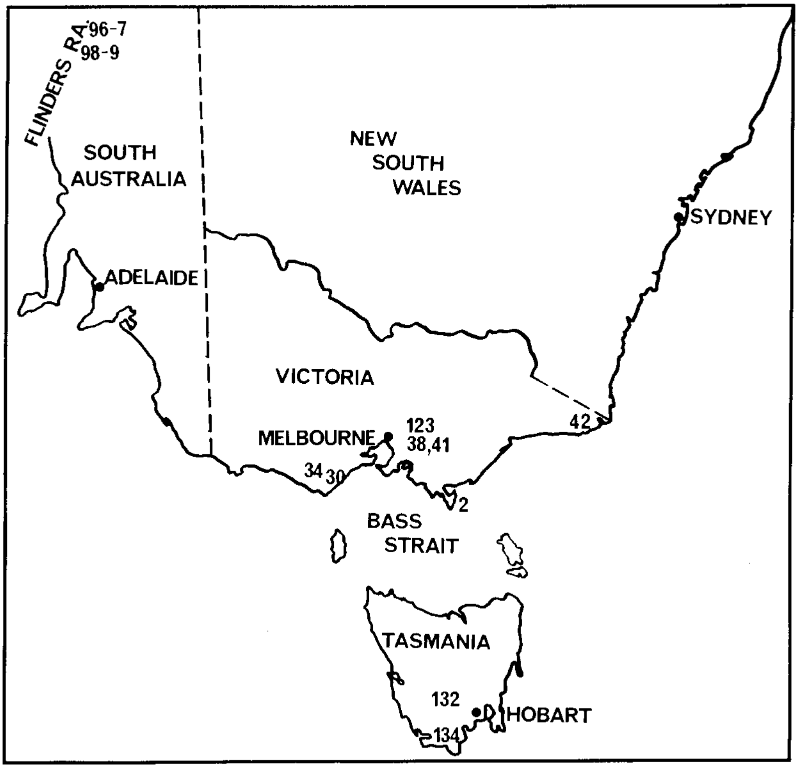


FIG. 1. Map of southeastern Australia showing localities in Table 1 from which flies were collected.

TABLE 1. Microhabitats of *Drosophila* spp. and *S. australis* for various collections (see Fig. 1) in southern Australia with temperatures and relative humidities at 1 m from permanent moisture

| Collection No. | Temperature (°C) | Relative humidity (%) | Distance from permanent moisture | |
|---|---|---|---|---|
| | | | *Drosophila* | *S. australis* |
| 2 | 25 | 62 | 1 m | 15 m |
| 30 | 15 | 87 | 3 m | Open forest |
| 34 | 15.5 | 95 | 3 m | Open forest |
| 38 | 20 | 73 | 2 m | 2 m |
| 42 | 18 | 82 | 2 m | 4 m |
| 96 | 17 | 40 | — | 1 m |
| 97 | 23 | 28 | — | 1 m |
| 98 | 23.5 | 29 | — | 1 m |
| 99 | 26 | 29 | — | 1 m |
| 123 | 14 | 90 | — | Off ferns |
| 132 | 17 | 74 | 2 m | 3 m |
| 134 | 16 | 83 | 2 m | 2 m |

species in Parsons & Bock (1977); and the two Australian *Scaptomyza* species are re-described in Bock (1977). All of these species hardly ever come to conventional fermented baits.

## Results

Approximate distances from permanent moisture are given in Table 1, with temperatures and relative humidities at about 1 m from permanent moisture, for twelve collections in southeastern Australia in which *Scaptomyza australis* was found. The lowest humidities (R.H. $\leqslant$ 40%), which are also associated with quite high temperatures, are from the Flinders Range collections (96–99), where *S. australis* only was found. The humidities of the latter collection sites are lower than those at any sites where *Drosophila* species have been detected, and indeed out of over 150 southern Australian collections from which one or more *Drosophila* species were recovered, made during the last 2 years, the relative humidity was < 60% only six times and never <50%. For collections 2, 30, 34, 42 and 132, *S. australis* was further, or considerably further, from permanent moisture than *Drosophila* ('open forest' may of course include rivers and creeks, but the *Scaptomyza* recovered from these collections were found at considerable distances from permanent moisture), and not unexpectedly there are collections (38, 134) where no differentiation could be made. It is quite clear, however, that where collections were made at the same site, *S. australis* showed a marked tendency to be less dependent on permanent moisture than *Drosophila*, while the converse situation never occurred. It should be noted that *S. australis* is frequently collected off flowering plants, indicating possible differences in resource utilization; however, collections 96–99 show that *S. australis* can clearly exist in physical environments far more extreme than *Drosophila*.

*S. australis* only was found for collection 123 at a temperature of 14°C when flies were knocked off fern fronds. This is a temperature at which *Drosophila* can only be swept with difficulty. Indeed at higher temperatures *Drosophila* but not *S. australis* were readily swept at this site; three such collections yielded a total of 102 *Drosophila* of five species, compared with five *S. australis* for collection 123. These findings suggest that *S. australis* may be active at lower temperatures than *Drosophila* species.

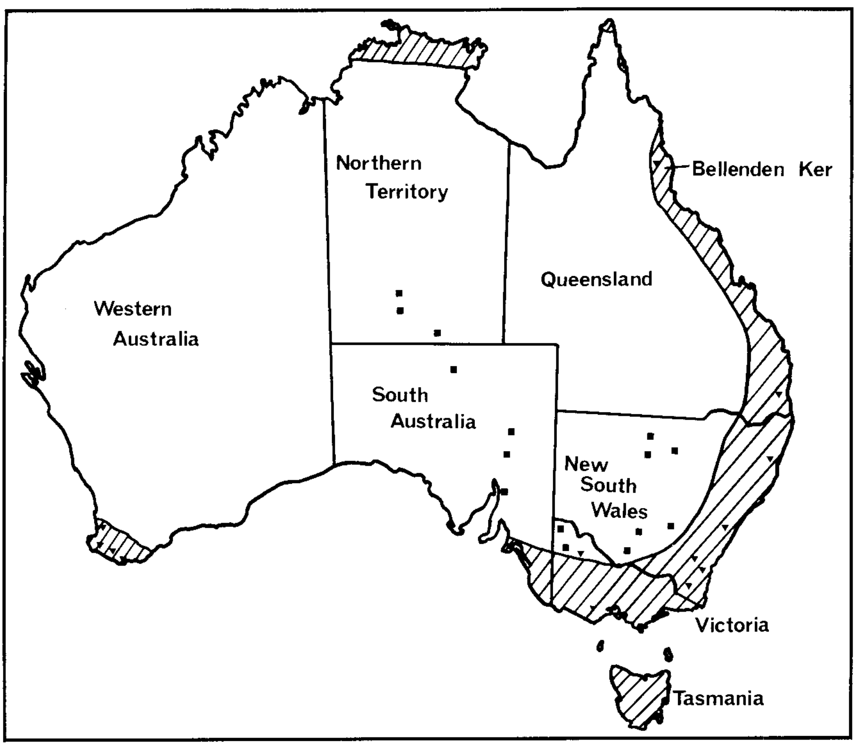


FIG. 2. Map of Australia showing the approximate known distributions of *Drosophila* (shaded). All known localities where *S. pallida* has been found are indicated. *S. australis* has been found in almost all of the *Drosophila* areas, and further specific localities for *S. australis* are given outside these areas. ■ *S. Australis*; ▲ *S. pallida*.

Parallel results have been obtained for the much rarer *Scaptomyza pallida,* which was found to be common in a sedge habitat on the summit of Mt Bellenden Ker (1591 m), the second highest mountain in Queensland (Fig. 2), on a day when the temperature was 11–14°C. Over fifty individuals were collected (Bock & Parsons, 1977), which exceeds the total of previously collected Australian specimens of this species! No *Drosophila* were collected by baiting or sweeping. Later in the year, when the temperature was 18–19½°C, 146 *Drosophila* of several species came to fruit baits, twenty to mushroom baits and fifty-six were swept, but *S. pallida* was not found.

## Australian distribution data

Localities where endemic *Drosophila* and *Scaptomyza* species have been collected over a total period of several decades are given in the references listed in the methods section. These are plotted, along with the localities indicated in Fig. 1, in Fig. 2. The shaded *Drosophila* region corresponds to the wetter sections of Burbidge's (1960) temperate and tropical floristic zones, a finding which is not unexpected, as with few exceptions endemic *Drosophila* occur mainly in rain forests and permanently damp undisturbed habitats within dry sclerophyll forests, grassy forests and woodlands; the latter habitats account for the extension of *Drosophila* outside rain forests into a number of southern habitats, including southwest Western Australia. There is no such extension away from rain forests in the north, presumably because of the high temperature/desiccation stresses of these regions. The drier inland and northern regions would exceed the postulated upper limit of 26°C for *Drosophila* resource utilization for long periods of the year, while this is not so in the south.

*S. australis* occurs throughout the *Drosophila* regions but, in addition, is also found in much more arid regions, as shown by the records in Fig. 2; this finding might be predicted from collections 96–99 in Table 1. *S. australis* therefore extends well into Burbidge's (1960) Eremaean floristic zone, which covers the whole of arid Australia. *S. pallida,* on the other hand, has not to date been detected in the Eremaean floristic zone. A morphological difference between the two species of possible ecological significance is that the egg guides of *S. australis* are weakly sclerotized, while those of *S. pallida* are small but strongly sclerotized (Bock, 1977). *S. australis,* especially in arid regions, is often to be found on the fleshy flowers and leaves characteristic of these regions, suggesting that its larvae might be miners of soft plant parts, and indeed *S. australis* larvae are known to mine the soft fleshy leaves of chick-weed (*Stellaria media*) (Bock, 1977). In contrast, *S. pallida* larvae may be miners of some of the less fleshy (sclerophyll) leaves which are widespread in the Australian flora outside tropical rain forests (Webb, 1959), as at the summit of Mt Bellenden Ker; such an environment would be harsh indeed in the Eremaean zone.

At the cool end of the temperate range, there are records of *S. australis* at altitudes of just above 1600 m in the uplands of southern New South Wales; for *D. fuscithorax,* which occurs at the highest altitudes for *Drosophila* in this region, there are no records above 1500 m (Bock, 1976, 1977). Considering latitudinal extremes, both species have been found at sea level at Catamaran (collection 134 – Table 1), at the extreme south of Tasmania; the upland collections do, however, indicate the likelihood that *S. australis* may be tolerant of cooler temperatures than *Drosophila. S. pallida* has been collected in upland habitats of southern New South Wales, although not as high as *S. australis*; the total number of known specimens of *S. pallida* listed in Bock (1977) is, however, only twenty for the entire continent, so that the records are inadequate for firm conclusions to be drawn. The Mt Bellenden Ker data do, however, suggest the likelihood that *S. pallida* is more cold-tolerant than *Drosophila.*

## Discussion and conclusions

From the foregoing data, it appears valid to conclude that in a continent with an extreme diversity of habitats *Scaptomyza* species, especially *S. australis,* occur in more extreme habitats than *Drosophila.* To what extent the range of 12–26°C for resource utilization determined for *Drosophila* is extended by

*Scaptomyza* is difficult to say; indeed the temperature range may not be greatly extended, although the effectiveness of resource utilization at the extremes is probably increased relative to that of *Drosophila*. There is no doubt, however, that *S. australis* is tolerant of much lower humidities than is any endemic *Drosophila* species.

The Australian endemic *S. australis* occurs on both sides of the Nullarbor Plain which separates the temperate zones of southwestern and southeastern Australia (*S. pallida* is a cosmopolitan species). *D. fuscithorax*, a species tolerant of greater environmental extremes than other related *Drosophila* species, is the only endemic *Drosophila* species previously recorded on both sides of the Nullarbor, although one individual of a second endemic species (*D. collessi*) was recently found in the southwest. *D. fuscithorax* would probably have maintained cross-Nullarbor links during recent arid times longer than other related southern species which, while all belonging to the *inornata* species group, are differentiated into closely related southwestern and southeastern forms (Bock, 1976; Parsons & Bock, 1977). By comparison, the lack of differentiation of *S. australis,* given that it exploits arid zone plant resources, is to be expected. Indeed detailed collections across the Nullarbor Plain for *Scaptomyza,* which to our knowledge have not been carried out, may well provide specimens.

In conclusion *Scaptomyza australis,* the only endemic member of its genus in Australia, is demonstrably more resistant to environmental extremes than are the *Drosophila* species and it has therefore been able to occupy territory far outside the *Drosophila* ranges. *S. pallida,* a cosmopolitan species, appears to be more resistant at least to cold than the *Drosophila* species but data for *pallida* are insufficient as yet to warrant further conclusions about this. The findings for *S. australis* concur with those for *Scaptomyza* species in other parts of the world.

**Acknowledgments**

We acknowledge the Australian Biological Resources Survey (IRB) and the Australian Research Grants Committee (PAP) for partial financial support, and Telecom Australia for providing access to Bellenden Ker.

**References**

Andrewartha, H.G. & Birch, L.C. (1954) *The Distribution and Abundance of Animals.* University of Chicago Press, Chicago.

Basden, E.B. (1954) Diapause in *Drosophila* (Diptera: Drosophilidae). *Proc. R. Ent. Soc. Lond. (A)*, 29, 114–118.

Bock, I.R. (1976) Drosophilidae of Australia I. *Drosophila* (Insecta: Diptera). *Aust. J. Zool. Suppl. Series,* 40, 1–105.

Bock, I.R. (1977) Drosophilidae of Australia II. *Scaptomyza* (Insecta: Diptera). *Aust. J. Zool.,* 25, 337–345.

Bock, I6R. & Parsons, P.A. (1977) *Scaptomyza pallida* in Australia. *Drosophila* Information Service (in press).

Brncic, D. & Dobzhansky, Th. (1957) The southernmost Drosophilidae. *Amer. Nat.* 91, 127–128.

Burbidge, N.T. (1960) The phytogeography of the Australian region. *Aust. J. Bot.* 8, 75–209.

Carson, H.L., Hardy, D.E., Spieth, H.T. & Stone, W.S. (1970). The evolutionary biology of the Hawaiian Drosophilidae. In: *Essays in Evolution and Genetics in Honor of Theodosius Dobzhansky* (Ed. by M.K. Hecht and W.C. Steere), pp. 437–543. Appleton-Century-Crofts, New York.

Parsons, P.A. (1975) The effect of temperature and humidity on the distribution patterns of *Drosophila inornata* in Victoria, Australia. *Environ. Ent.* 4, 961–964.

Parsons, P.A. (1977) Genes, Behavior and evolutionary processes: the genus *Drosophila. Advances in Genetics,* 19, 1–32.

Parsons, P.A. & Bock, I.R. (1977) Australian endemic *Drosophila* I. Tasmania and Victoria, including descriptions of two species. *Aust. J. Zool.,* 25, 249–268.

Throckmorton, L.H. (1975) The phylogeny, ecology and geography of *Drosophila.* In: *Handbook of Genetics,* Vol. 3 (Ed. by R.C. King), pp. 421–469. Plenum Press, New York.

Webb, L.J. (1959) A physiognomic classification of Australian rain forests. *J. Ecol.* 47, 551–570.