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Seasonality in a field population of two New Zealand cockroaches (Blattodea)

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Abstract A population comprising *Celatoblatta peninsularis* and *Parellipsidion pachycercum* was sampled from Banks Peninsula, New Zealand over 1 year. Sub-adult cockroaches were assigned to 6 size classes (probably instars) by interocular distance and hind femur length. *P. pachycercum* was most abundant in December and January and adults were abundant in most months. In contrast, *C. peninsularis* was most abundant from February to June and adults were rare except in November. Adult females were less abundant than adult males in both species. Although both species may be bivoltine, they use difference overwintering strategies.

Keywords cockroaches; binomials; Blattidae; Blattellidae; life cycles; population structure; size distribution; seasonal variations

INTRODUCTION

Apart from taxonomic descriptions (e.g., Johns 1966) and collection records, very little has been published on the endemic cockroaches of New Zealand. There are many publications on the life histories of laboratory-reared cockroaches outside New Zealand (e.g., Willis et al. 1958) but few observations appear to have been made on the life histories of roaches in the field. Life history data were obtained from a series of samples of cockroaches taken (primarily for parasitological research) at about monthly intervals from Kaituna Valley, Banks Peninsula.

Only 2 endemic roaches are known from Banks Peninsula. *Celatoblatta peninsularis* Johns, 1966 (Blattidae) is confined to Banks Peninsula and occurs in several habitats, including tussock, scrub, open forest, and stony areas (Johns 1966). *Parellipsidion pachycercum* Johns, 1966 (Blattellidae) is widely distributed in the wetter and cooler parts of the South Island, in a variety of habitats (Johns 1966). The 2 species are sympatric on Banks Peninsula in the foliaceous bark of the native tree fuchsia (*Fuchsia excorticata* (J. R. et G. Forst.) Linn. f.) which is common in Kaituna Valley.

METHODS

Nymphs and adults of *C. peninsularis* and *P. pachycercum* were collected from the bark on trunks of fuchsia trees growing within 10 m of the stream at the end of the Kaituna Valley Road, Banks Peninsula, Canterbury, New Zealand (43°43′15″S, 172°45′30″E; elevation 250 m). Collections were made once every 5 weeks from 1 March 1981 to 21 February 1982 and an approximately equal volume (about 0.4 m^3) of bark was removed from about 10 trees on every collection date, different trees being sampled on each occasion. As fuchsia bark has paper-thin layers, great care was taken in sorting through this material in the laboratory to ensure that all roaches were removed.

Roaches were killed by crushing the nerve cord behind the head, and then viewed with a stereomicroscope. Interocular distance (the minimum distance between the eyes) and hind femur length of sub-adults were measured to the nearest 25 μm, using an eye-piece graticule. The (brachypterous) adults were not measured.

Although the sex of roaches can sometimes be determined as early as instar 1 (Snodgrass 1937, Amerson & Hays 1967) and I was able to do so at least for instar 2 (Fig. 3, 4), sub-adults were not sexed routinely in this work, although the sex ratio was noted in class 6 and for adults. Rapid dissection was necessary for the parasitological aims of the project and therefore developing reproductive structures were destroyed, especially in smaller nymphs.

RESULTS

All animals, including the smallest nymphs, could be identified to species by differences in head and abdominal markings. The vertex, frons, and clypeus of *P. pachycercum* (Fig. 1) have dark, vertical,

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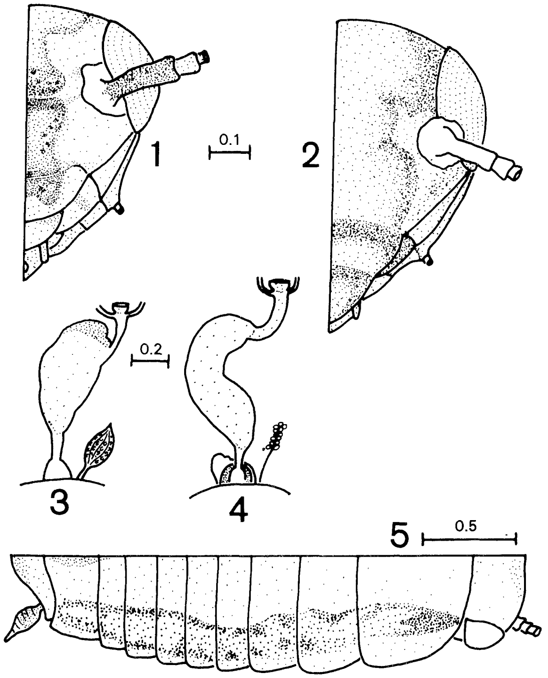


Fig. 1–5 *Parellipsidion pachycercum* and *Celatoblatta peninsularis*: (1) head, class 1 nymph, *P. pachycercum*; (2) head, class 1 nymph, *C. peninsularis*; (3) hind gut, *P. pachycercum* class 2 ♀; (4) hind gut, *C. peninsularis* class 2 ♂; (5) *P. pachycercum*, class 1 nymph, entire. Measurements in mm.

median bands whereas *C. peninsularis* (Fig. 2) has no such patterning. The dorsal and ventral abdomen of *P. pachycercum* are distinctly mottled (Fig. 5), but the abdomen is almost uniformly dark brown in *C. peninsularis*. There are also internal differences. The hind gut of *P. pachycercum* nymphs is shaped like an inverted flask, and is fawn with a greenish 'cap' (Fig. 3); that of *C. peninsularis* is almost uniform in diameter and it is fawny yellow (Fig. 4).

Size classes

For sub-adults, plotting interocular distance against hind femur length gave 6 clusters for both *Parellipsidion pachycercum* (Fig. 6) and *Celatoblatta peninsularis* (Fig. 7). Size classes 1 to 4 were distinct and probably represent instars, but classes 5 and 6 were indistinct. For the life history analysis, half of the individuals in the overlapping region were assigned to class 5 and half to class 6.

Adults were the most abundant class throughout the year in *P. pachycercum*, but they were the least common class in *C. peninsularis* (Fig. 8). In both species, more adult males were collected than were adult females (sex ratio for *P. pachycercum*, 1:1.71; for *C. peninsularis* 1:2.5). Overall, classes 2, 3, and 6 of both species were abundant, but there were few in classes 1, 4 (*C. peninsularis*), and 5 (*P. pachycercum*).

Seasonal abundance

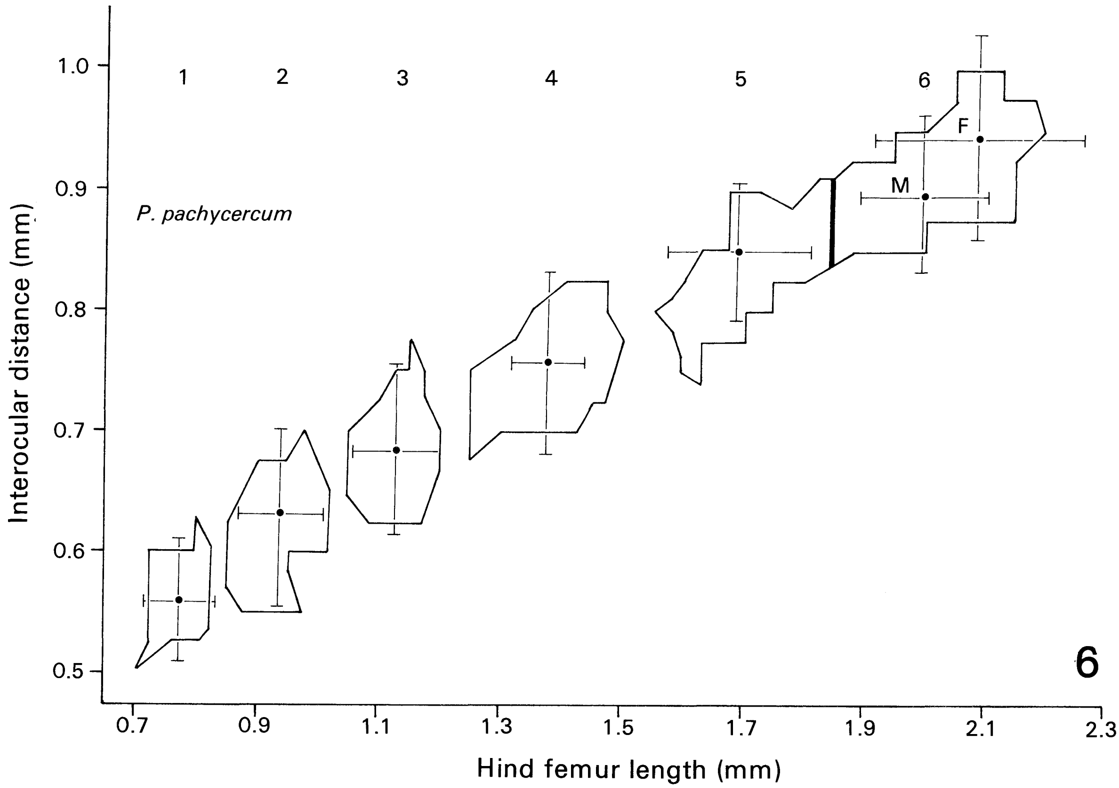
There was some seasonal variation in the percentage of each species in each sample (Fig. 9). Small numbers of both species were collected from early winter to late spring (July–November). *P. pachycercum* was abundant in early summer (December 1981–January 1982), whereas *C. peninsularis* was abundant in early autumn and winter (March, June 1981) and in late summer (February 1982).

Life history patterns

Parellipsidion pachycercum Despite all size classes having occurred in all months, a growth pattern can be inferred from the data (Fig. 10). There were 2 main cohorts. One consisted of nymphs which appeared in late summer and overwintered in class 2, 3, or 4, each class becoming progressively more abundant from autumn to early spring. Later classes developed more rapidly with the onset of warmer weather and gave rise to adults in late spring. A second cohort which developed rapidly through all classes during summer may have arisen from eggs laid by these adults.

Celatoblatta peninsularis Adults were abundant in late spring, but were infrequent or absent in other months (Fig. 11). Two main cohorts were also noted. One arose from the class 1 nymphs which appeared in early summer and these developed rapidly during the warmer weather. Nymphs overwintered in class 6 and adults became abundant in November. The second cohort arose from class 1 nymphs which appeared in late summer. These developed slowly and many overwintered in classes 2 and 3 (class 2 nymphs decreased in number, and class 3 nymphs increased, through winter). Class 6 nymphs appeared by summer as a result of the rapid development of nymphs in warmer weather, but these either failed to mature, or moved elsewhere.

Oothecae Oothecae are tanned capsules produced by female cockroaches to protect a cluster of eggs. In some species (e.g., *Blattella germanica* and *Blaberus craniifer*), oothecae are carried by the female until the young are about to emerge (Guthrie & Tindall 1968, p. 99). *P. pachycercum* and *C. peninsularis* produced and deposited oothecae amongst fuchsia bark throughout the year. Those of *C. peninsularis* were larger (6.2×3.9 mm) than those of *P. pachycercum* (4.9×2.7 mm), although they were similar in shape and in colour (dark brown). *C. peninsularis* oothecae contained 10–12 developing



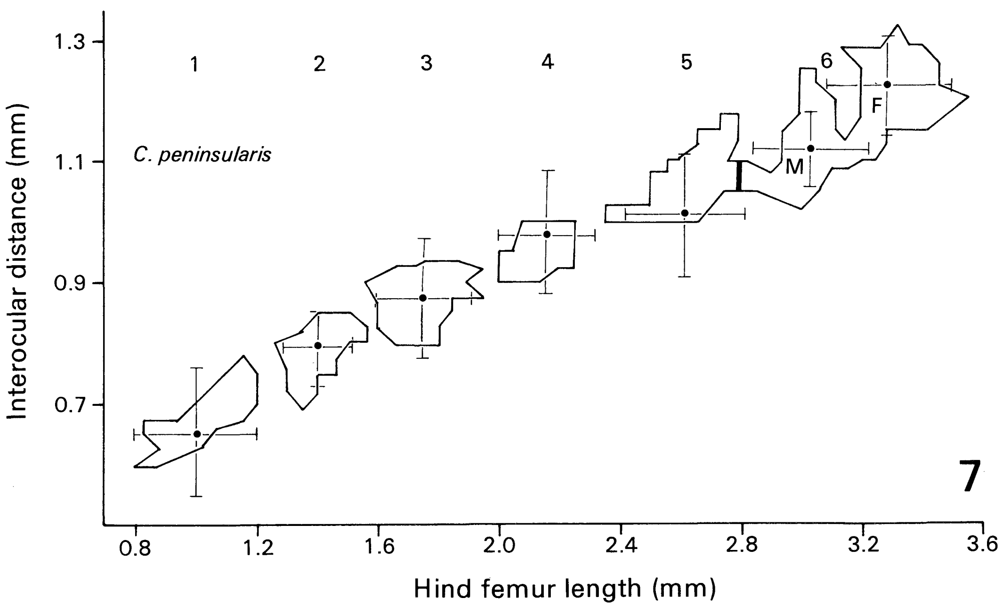


Fig. 6, 7 (6) *Parellipsidion pachycercum*; (7) *Celatoblatta peninsularis*. Sub-adult size class groups (1–6), showing extreme boundaries (continuous outer enclosing lines), means, and 95% confidence intervals of each group (*n* in each size class as in Fig. 8). M, size class 6 ♂; F, size class 6 ♀. Wide vertical band between classes 5 and 6 is an arbitrary division between the groups.

nymphs, whereas the smaller oothecae of *P. pachycercum* contained 12–14. Some oothecae had been deposited loosely and fell out when the layers of bark were separated; others were 'glued' to the bark. Some were also camouflaged with small pieces of bark glued on to their outer surfaces.

DISCUSSION

Parellipsidion pachycercum was nearly 3 times as abundant as *Celatoblatta peninsularis* in fuchsia bark at Kaituna Valley. Whether this reflects the relative abundance in the entire population is not known as the canopy was not investigated. However, few roaches were found in other habitats searched and it is therefore likely that the bark is a major habitat of both species. The probable 7 instars (at least 6 sub-adult, plus terminal instar) proposed for *C. peninsularis* and *P. pachycercum* agrees with the findings of Willis et al. (1958) and Brown (1980) for *Blatella germanica*, *B. vaga*, *Ectobius lapponicus*, and *E. pallidus*, but many European species have more.

There may be 2 reasons for the blurring of size classes 5 and 6. Firstly, the adult females of both species are larger than the adult males and this sexual differentiation may result in less defined, and possibly overlapping, clusters. Secondly, some roaches and other insects can have a variable number of instars, which may enable them to reach a species 'norm' for adult size (Tanaka 1981). Seamans & Woodruff (1939) found that the number of moults undergone by *Blattella germanica* was influenced by diet and injury. Gier (1947) found that *Periplaneta americana* had a variable number of instars and that dietary deficiency delayed or stopped moulting; Willis et al. (1958) found that *Pycnoscelus surinamensis* could have 8–12 instars. Therefore the overlap between clusters 5 and 6 possibly reflects a difference in the number of moults undergone by some individuals.

The unbalanced sex ratio found in adults of both species was not reflected in the sex ratio of the penultimate class, which was close to 1:1, as has been found in adults of other species of roach (Willis et al. 1958). Adult females may move away from the fuchsia bark habitat and therefore not have been sampled.

Numbers in each successive size class can be expected to decline because of moult failure, predation, and other factors. Willis et al. (1958) found that maturation success varied with the species but from their data I estimate that an average of 79.7% of roaches (in 12 species) reached adulthood under laboratory conditions. Poor survival of nymphs could have been the reason for the few adult *C. peninsularis* found or, alternatively, adults may favour the canopy and therefore were not collected. Conversely, sub-adult *P. pachycercum* may favour the canopy and adults the trunks, making the latter the most frequently collected group. The life span of adult *P. pachycercum* could also be longer than that of any of its nymphal stages and this is strongly supported by 3 adult *P. pachycercum* having survived for 550 days in the laboratory.

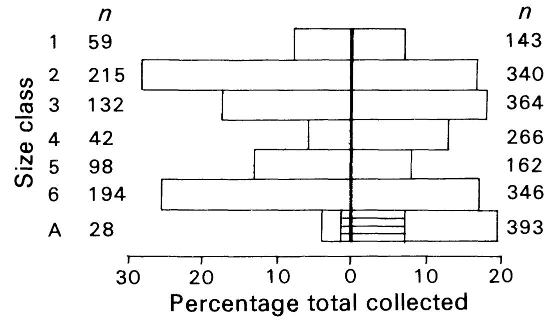


Fig. 8 Percentage of the total number of roaches collected over year in each size class (*n*, numbers per class). Left of heavy line, *C. peninsularis* (n=768); right, *P. pachycercum* (*n*=2014). (1–6, nymphs; A, adults — horizontal shading, ♀; open, ♂).

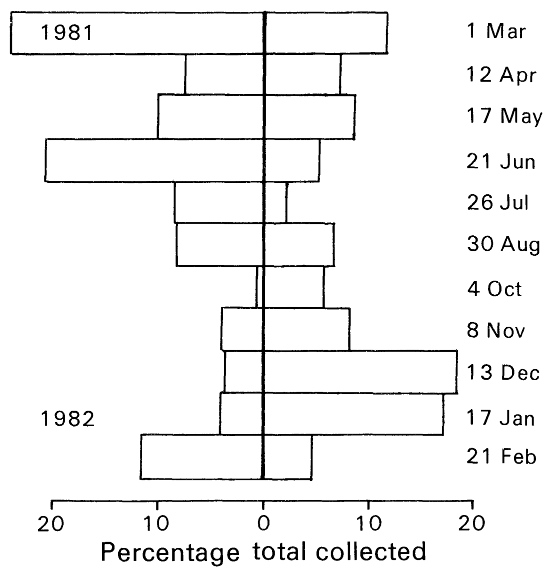
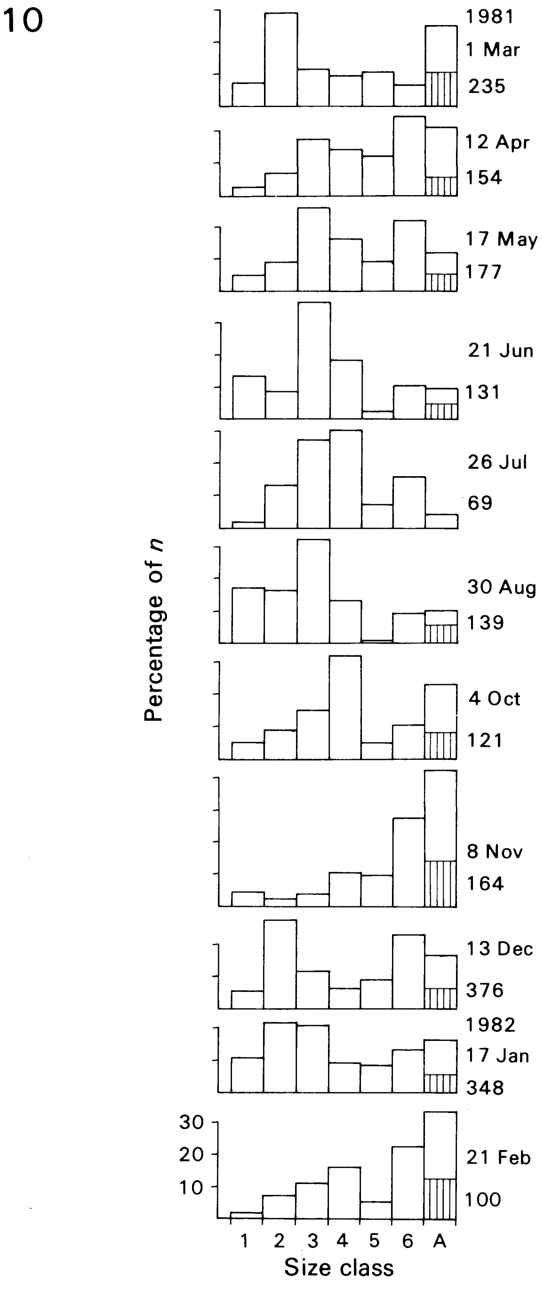


Fig. 9 Percentage of the total number of cockroaches collected in the year on each collection date (*n* for each date same as Fig. 10, 11). Left of solid line, *C. peninsularis*; right, *P. pachycercum*.



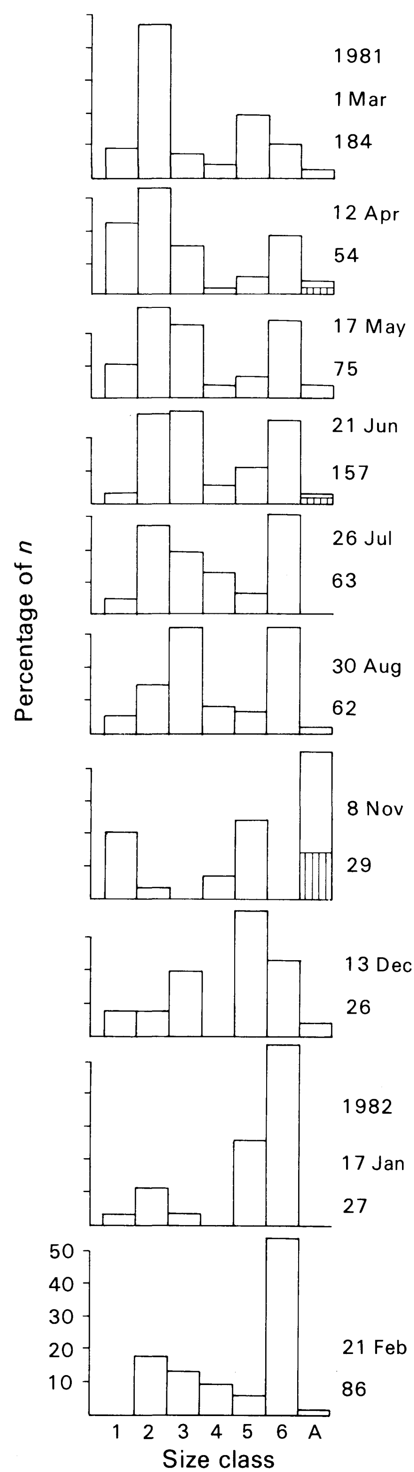


Fig. 10, 11 (10) *P. pachycercum*; (11) *C. peninsularis* Percentage frequency of each size class per month (*n* collected given below each collection date; ordinants in units of 10). (Size class 1–6, nymphs; A, adults — vertical shading, ♀; open, ♂). Small collection (*n*=5) of 4 October not shown).

Considering the larger numbers of sub-adult *C. peninsularis* found in December, January, and February, it was surprising that so few adults were seen. It is possible that they, and all classes of *P. pachycercum* suffered high mortality in those months because of unseasonably low rainfall in Canterbury — it was 56% below average between November 1981 and February 1982 (Christchurch Meteorological Office). This would be in accordance with the findings of Brown (1980) and Cornwell (1976, p. 461) that egg success and roach numbers are reduced by low humidity and drought.

Size class analyses indicated that both species may be bivoltine with 2 major cohorts per year. However, these were not clearly defined and most size classes of both roach species were present in all months. Continuous development is typical of at least some other orthopteroid insects in New Zealand (Cary 1981, Richards 1961, 1973) and a winter diapause is unusual in New Zealand endemic insects (Watt 1973). Oothecae of *P. pachycercum* and *C. peninsularis* probably, and nymphs certainly, do not diapause. Development, however, may have been slowed in certain classes (2, 3, and 6) during the colder months of the year. This is unlike the situation described for several non-domesticated species of roach in Europe, none of which is known to be bivoltine. They may be univoltine instead, overwintering only as oothecae, or semivoltine with an overwintering ootheca and a variety of quiescing or diapausing nymphal instars (Brown 1980).

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