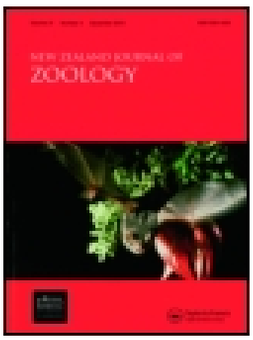

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Aspects of the ecology, morphology, and taxonomy of two skinks (Reptilia: Lacertilia) in the coastal Manawatu area of New Zealand

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Two kinds of skink (*Leiolopisma*), sympatric in the coastal Manawatu, are considered on morphological and ecological grounds to be separate biological species, rather than morphs of a single species. One is conspecific with the holotype of *Tiliqua zelandica* Gray, 1843, and should be called *Leiolopisma zelandicum* (Gray) even though it appears to accord with McCann's (1955) concept of *L. ornatum*. The second species is McCann's "*L. zelandica*", but this name cannot be applied, so the lizard is provisionally referred to as *Leiolopisma* sp. Common to both species is a basic pattern of longitudinal stripes and bands, and the colour is brown above and pale ventrally. However, subtle differences become apparent on close analysis, and certain metric and meristic characters differ between the 2 populations. Analysis of stomach contents reveals differences in both the composition and size of items taken. In the Manawatu the 2 species can be classed as neighbouringly sympatric, and their respective habitats are broadly distinct, that of *L. zelandicum* being more shady and moist. Both skinks may be infested with dermal mites and gastric nematodes, and in both the breeding cycle of the female is essentially similar.

INTRODUCTION

On the basis of superficial appearance and limited ecological data, it has been held that 2 species of skink of the genus *Leiolopisma* occur in the coastal Manawatu, 100 km north of Wellington (Fig. 1a). These forms are generally similar in colour, pattern, and ecological requirements, and the differences, though consistent, are subtle. That the phena are biologically distinct is suggested by electrophoretic studies. Samples of the 2 forms were given to Mr G. S. Hardy (Victoria University) for analysis of lactic dehydrogenases from heart tissue and of haemoglobins. In both analyses distinct differences in banding patterns between the samples were found. Because the 2 phena are sympatric, they are either separate, reproductively isolated sibling species, or morphs of the same species.

During 1974–75 I studied the taxonomic and ecological relationships of the skinks of the coastal Manawatu. My conclusion from analysis of differences in their colour, pattern, bodily proportions, habitat, and diet and the reproductive cycle of the female is that they are of 2 separate species. For directness and simplicity I refer to them as such throughout the following account.

Little is known about the ecology of skinks on mainland New Zealand, and comparison of those which occur in sympatry is of particular interest. One of the species in the present investigation is of rather limited distribution, and has never before been studied.

The unresolved taxonomy of certain of New Zealand's skinks has in various ways inhibited their study. A modification in nomenclature is proposed here. Although a small contribution, it represents part of the new taxonomic advances in a field which, but for the description of a species (Robb 1970), has been stagnant since McCann's monograph (1955).

TAXONOMY

Of all the lizards, the leiolopismid skinks are considered to be one of the most difficult groups to classify, and the New Zealand representatives pose particular problems (Robb 1973). Moreover they are relatively recent arrivals in New Zealand, and are probably still engaged in adaptive radiation. Although McCann (1955) described a species of *Sphenomorphus*, Greer (1974) placed all the New Zealand skinks in *Leiolopisma*, as part of a worldwide revision of skinks with leiolopismid affinities.

The nomenclature of many New Zealand skinks is confused. Eight species were described between 1839 and 1887 by taxonomists in the Northern Hemisphere, who examined the specimens which early scientific expeditions collected in this country. Descriptions of the time are mostly inadequate, and

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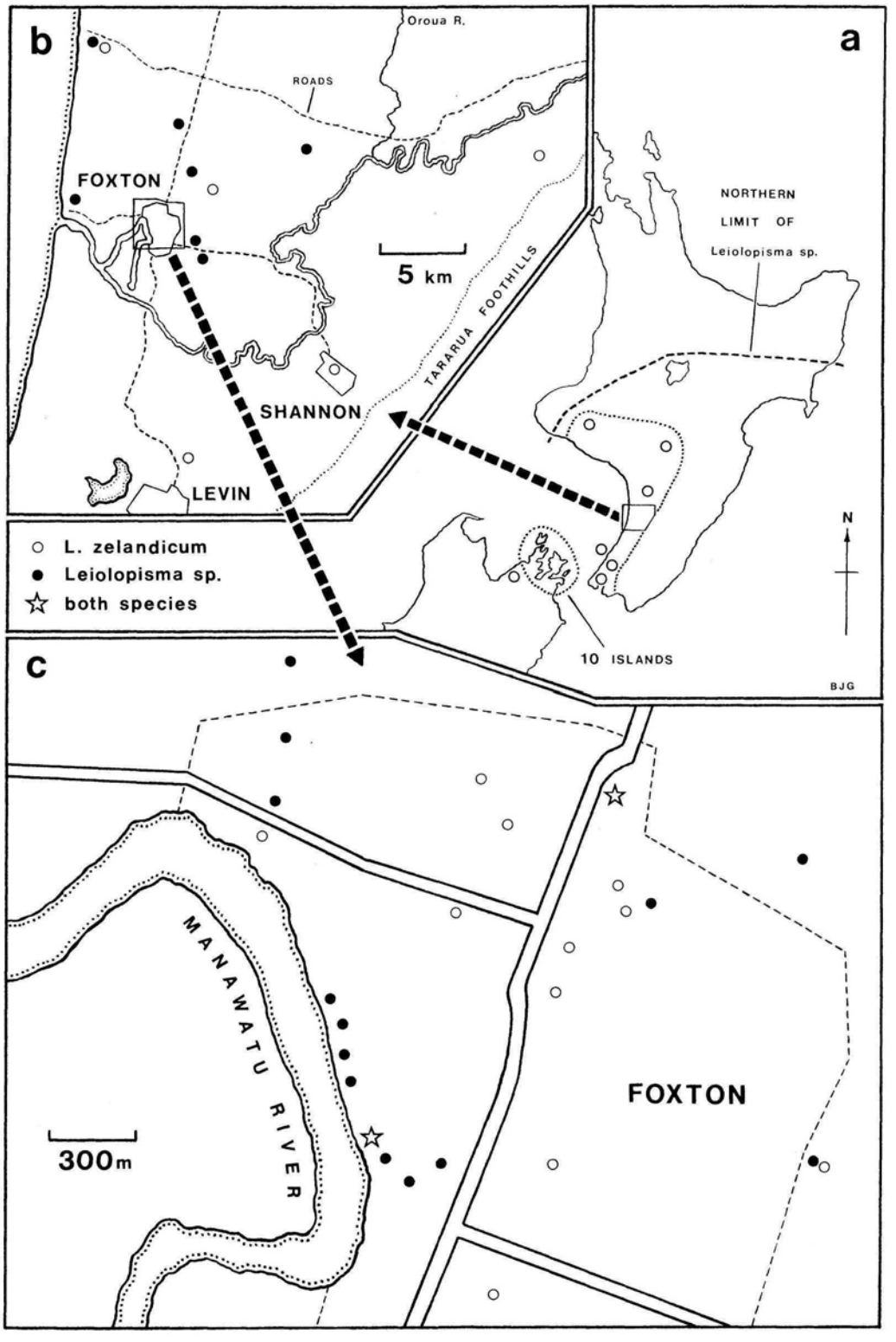

b
Oroua R.
ROADS
FOXTON
5 km
TARARUA FOOTHILLS
SHANNON
LEVIN
a
NORTHERN
LIMIT OF
Leiolopisma sp.
N
10 ISLANDS
BJG
L. zelandicum
Leiolopisma sp.
both species
c
MANAWATU RIVER
300m
FOXTON

it is difficult to relate contemporary specimens to type material by consulting the early literature alone. The identity of type specimens can finally be resolved only by examination; unfortunately many type specimens are in overseas museums. The modern concept of the type specimen was unknown before about 1850 (Mayr 1969), and so some species are based on an array of syntypes, rather than on a single, unambiguous holotype.

McCann revived interest in the lizards, and in 1955 produced a comprehensive monograph which recognised 17 species of skink. However, he did not produce an unambiguous diagnostic key. Furthermore, he was unable to examine many of the early types, and some of his assumptions regarding their identity have proved mistaken. Robb (1970), in describing *Leiolopisma alani*, brought the number of described species to 18.

During the past decade interest in New Zealand's lizards has increased greatly. At least 15 biological species are now known with some accuracy, but many have yet to be matched with holotypes and lectotypes so that nomenclature may be stabilised. To date, the names coined in the 19th century have been applied to many species only by considered opinion, and little attention has been paid to whether or not the skinks in a population match the diagnosis of the species whose name is applied.

In an attempt to provide names for the 2 species — initially labelled A and B — present in the coastal Manawatu, I used McCann's diagnostic key (1955) to identify 45 preserved lizards. McCann's key makes use of 4 characters: the form of the lower eyelid; the locality of capture; the number of longitudinal rows of scales at mid body; and the number of subdigital lamellae under the 4th toe. All specimens from the Manawatu were found to have lower eyelids with palpebral discs, and all were collected south of latitude 38°S. Separation was therefore based on the numbers of lamellae and mid-body scales (Table 1). Three-quarters of the specimens individually keyed out to 2 or even 3 of McCann's species. Each of the remaining 11 specimens could be assigned to 1 of 5 species (*Leiolopisma aeneum*, "*L. zelandica*", *L. latilinearum*, *L. lineoocellatum*, and *L. ornatum*). Two specimens were outside the range of any named species. McCann acknowledged that his key contained an "overlap in some of the more important diagnostic characters"; it is clearly unworkable for skinks in the coastal Manawatu.

Following a trip to the British Museum (Natural History) in January 1974, I examined 4 type specimens of New Zealand skinks to compare them with the species found in the Manawatu. That McCann did not examine this material is unfortunate, because it has led to a misidentification that has been perpetuated to the present.

In 1843 Gray described *Tiliqua zelandica* from a single specimen, and in 1845 transferred it to the genus *Mocoa*. The holotype, BM(NH) XIV.26.a = 1946.6.16.19 (type locality "Cook's Straits"), is conspecific with species B (Table 1) from the Manawatu. This species can therefore correctly be called *Leiolopisma zelandicum* (Gray), and is referred to as such hereafter.*

The specific epithet *ornata* was used by Gray in 1843 to describe *Tiliqua ornata*, again from a single specimen. In 1845 he defined *Hinulia ornata*, of which there are 3 syntypes labelled as follows:

BM(NH) XIV.11.a — 1946.8.19.38
BM(NH) XIV.11.a — 1946.8.19.39
BM(NH) XIV.11.b

Specimen BM(NH) XIV.11.b, for which the type locality is "N. Zealand", is an example of species A (Table 1), but the other 2 syntypes are neither A nor B. To explain their position it must first be pointed out that among the New Zealand skinks 2 groups of species with possible generic or subgeneric differences can be recognised (Bull & Whitaker 1975).

Both species in this study are examples of the group of skinks having pointed snouts, longer limbs and digits, and elliptical cross-sections at mid body. These are skinks of relatively open country with diurnal, basking habits. The other skinks have short snouts, relatively large eyes, shorter limbs and digits, and a squarish cross-section at mid body. Such lizards tend to be nocturnal, with a preference for moist and shaded habitats. The BM(NH) XIV.11.a specimens are faded, and may or may not be conspecific. However, they are both examples of the latter group, and as such could possibly belong to a separate genus from specimen BM(NH) XIV.11.b (species A).

It is not clear which, if any, of the 3 syntypes of *Hinulia ornata* is the holotype of *Tiliqua ornata*, and it is probably necessary to nominate one as lectotype. Comparison of the syntypes with Gray's description of *Tiliqua ornata* suggests that one of the pair BM(NH) XIV.11.a might be the holotype. However, an illustration of *Hinulia ornata* appearing in one of Gray's later publications (1867) is clearly either

*"Leiolopisma" is derived from the Greek "leio" meaning smooth, and "lopisma" (the peel) referring to a sloughed outer layer. The gender of this compound is neuter, and the specific epithet *zelandicum* is in agreement

(Opposite page)

Fig. 1. Distribution of *L. zelandicum* and *Leiolopisma* sp.: **a,** northern limit of *Leiolopisma* sp. (Bull & Whitaker 1975) and known distribution of *L. zelandicum*; **b,** locality records for the Manawatu; **c,** points of capture of skinks in Foxton, 100 km N of Wellington.

XIV.11.b or a specimen conspecific with it. All else being equal, this specimen should be nominated as lectotype (Mayr 1969); otherwise a name other than *ornatum* must be found for species A. The nomination of lectotype is best made as part of a total revision of the nomenclature of New Zealand skinks, and is not attempted here. Thus, species A, as recognised in the Manawatu, is presently without a name, and is referred to as *Leiolopisma* sp. hereafter.

The identification of species B as *Leiolopisma zelandicum* has unfortunate implications. It is clear that McCann's "*Leiolopisma zelandica* (Gray)" is closely equivalent to species A, not B. Only one (NMNZ R108) of the many hypotypes listed by McCann (1955) as "*L. zelandica*" and held in the National Museum (Wellington) is a skink of species B; most of the rest are A, and a few are neither. Species B is approximately equivalent to McCann's *Leiolopisma ornatum*. Nine of the 10 hypotypes of *L. ornatum* listed by McCann are species B; the exception (NMNZ R447) belongs to the other group of New Zealand skinks. To summarise, *Leiolopisma* sp. as used here corresponds to McCann's "*L. zelandica*", and the true *L. zelandicum* equates roughly with McCann's *Leiolopisma ornatum*.

For reference, the following specimens from the coastal Manawatu have been lodged in the collection of the National Museum, Wellington: NMNZ R1585–1589, as examples of *Leiolopisma* sp. (species A); NMNZ R1590–1594, as homoeotypes of *Tiliqua zelandica* Gray (species B).

MORPHOLOGY

With experience the 2 skinks in the coastal Manawatu can be identified at a glance. This amounts to a complex visual analysis of pattern, colour, and proportions allied to the way in which we learn to recognise a particular human face. Lorenz (1941) describes a "classifying instinct" that "rests upon an unconscious evaluation of a . . . number of characteristics which, not easily accessible to individual observation, are woven into the general impression which . . . an animal group makes upon the investigator". Once learnt, the skill precludes the need for any diagnostic characters, such as the number or arrangement of individual scales, which require meticulous observation; the problem lies merely in communicating the technique to the uninitiated.

Colour and pattern are important factors in the classifying instinct, although McCann (1955) believed that "colour descriptions of skinks are most inadequate and of little or no diagnostic value". However, Clarke (1965) compared 4 closely related species of *Leiolopisma* in Australia and found that colour and pattern were the only definite diagnostic features for use with individual specimens.

Table 1. Identity of 45 *Leiolopisma* skinks from the coastal Manawatu according to key characters in McCann (1955); see text for full explanation

Sp.	Mid-body scales	Lamellae* L	Lamellae* R	*n*	Identity
A	28	17	18	1	*aeneum*
A	28	18	18	1	*aeneum*
A	28	22	22	1	*'zelandica'*
A	28	20	23	1	*'zelandica'*
A	30	21	21	1	*'zelandica'*
A	30	22	18	1	*'zelandica'*
A	30	22	22	1	*'zelandica'*
A	30	—	22	1	*'zelandica'*
A	30	—	19	1	*latilinearum*
A	30	18	20	1	*zel./lat.*
A	30	20	20	4	*zel./lat.*
A	30	20	21	1	*zel./lat.*
A	30	21	20	2	*zel./lat.*
A	30	22	20	2	*zel./lat.*
B	30–32†	20	21	1	*zel./lat./orn.*
B	31–33†	21	21	1	*zel./lin./orn.*
A	32	20	21	1	*zel./lin./orn.*
A	32	21	22	1	*zel./lin./orn.*
A	32	20	20	1	*zel./lin./orn.*
B	32	20	20	2	*zel./lin./orn.*
B	32	18	20	1	*zel./lin./orn.*
B	32	18	19	1	*zel./lin./orn.*
B	32	21	19	1	*zel./lin./orn.*
B	32	21	21	3	*zel./lin./orn.*
B	32	18	17	1	*ornatum*
B	34	19	—	1	*lin./orn.*
B	34	20	19	1	*lin./orn.*
B	34	20	20	5	*lin./orn.*
B	34	20	21	1	*lin./orn.*
B	34	21	21	1	*lin./orn.*
B	34	22	22	1	*lineoocellatum*
B	35–36†	—	17	1	outside range of key
B	38	20	20	1	outside range of key

*Counts given for both feet (—, missing digit)
†Circumferential counts at different points give different results, owing to irregularities in scalation.

Traditionally, the New Zealand skinks have been separated on the basis of scalation — the arrangement of head shields, the number of rows of scales around the middle of the body, and the number of lamellae beneath the 4th digit of the hind limb. The following analysis is an attempt to separate 2 species on the basis of colour, pattern, and bodily proportions. In addition, counts of the scales at mid body are found to give partial separation.

Pattern and Colour

The subsequent account is based on examination of 46 preserved lizards (23 of each species). In both species the pattern consists of the same basic elements. The body of each lizard between the pectoral girdle and the pelvis can be thought of as a cylinder displaying, in total, the following features:

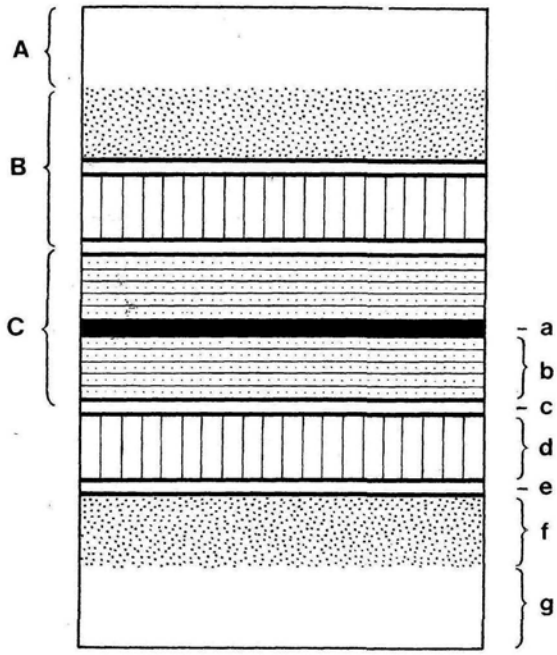


Fig. 2. Diagrammatic representation of basic pattern at mid body common to *Leiolopisma* sp. and *L. zelandicum* (**A**, belly; **B**, side; **C**, back; **a**, dorsal stripe; **b**, dorsal band; **c**, dorsolateral stripe; **d**, upper lateral band; **e**, lateral stripe; **f**, lower lateral band; **g**, ventral surface).

a dorsal stripe, 2 dorsal bands, 2 dorsolateral stripes, 2 upper lateral bands, 2 lateral stripes, 2 lower lateral bands, and a ventral surface. The spatial arrangement of these features can be represented diagrammatically as shown in Fig. 2.

The following analysis of pattern outlines similarities and differences between the 2 species, as they occur in the coastal Manawatu. Where the pattern of the tail is mentioned only intact portions are considered; in regenerated sections the pattern is modified.

Dorsal stripe. Extends from base of head (nuchal scales) along dorsal surface of body into tail; 2 half-scales wide (Fig. 3c,d, 4e,f). Always prominent and continuous between head and base of tail in *Leiolopisma* sp. (Fig. 4f,l); always reduced over same area in *L. zelandicum* — either broken (Fig. 4e,m) or present only along anterior 30–50% of body (Fig. 4g). Prominent (Fig. 4f) or reduced to faint blotches along tail of *Leiolopisma* sp.; reduced to blotches (Fig. 4e,m) or absent along tail of *L. zelandicum*. Usually absent towards tip of tail in both species.

Dorsal bands. Speckled, blotched, or lined in both species; individual scales markedly striate in *Leiolopisma* sp. (Fig. 4f,l) and faintly striate in *L. zelandicum* (Fig. 4e,g,m). Dorsal band plus dorsolateral stripe 3 scales wide ($\frac{1}{2}.1.1.\frac{1}{2}$) at mid body in *Leiolopisma* sp. (Fig. 3c, 4f,l); 4 scales wide ($\frac{1}{2}.1.1.1.\frac{1}{2}$) in *L. zelandicum* (Fig. 3d, 4e,m).

Dorsolateral stripes. Formed where pale margin of dorsal band meets dark margin of upper lateral band; extend from above eye along body and tail; lower margin always linear in *L. zelandicum* (Fig. 4a,d,m, 5b), but usually toothed in *Leiolopsima* sp. (Fig. 4b, c,l, 5a). Sometimes especially prominent in *L. zelandicum* over anterior 30–50% of body in concert with mid-dorsal stripe (Fig. 4g).

Upper lateral bands. Extend above points of insertion of limbs from behind eye to tip of intact tail. Sometimes with 1 or 2 median rows of pale spots (Fig. 4b,l), only in *Leiolopisma* sp. Always reduced to crescentic blotches along tail of *Leiolopisma* sp. (Fig. 4c, 6b), but continued intact in *L. zelandicum* (Fig. 4d, 6a).

Lateral stripes. Extend from behind eye, through ear opening, along body above points of insertion of limbs; always continuous along body (Fig. 5a) and absent along tail in *Leiolopisma* sp. (Fig. 4c), but usually broken along body in *L. zelandicum* (Fig. 5b) and continued along tail (Fig. 4d). Upper margin always linear in *L. zelandicum* but usually toothed in *Leiolopisma* sp. (Fig. 4a–d,1,m).

Lower lateral bands. Extend from labial scales about mouth, along body and into tail; not sharply distinct from ventral surface; often appearing spotted in *Leiolopisma* sp. (Fig. 4b,c) and streaked in *L. zealandicum* (Fig. 4a,d). Dark spots usually more obvious in *L. zelandicum* between snout and forelimbs, giving upper and lower labials a speckled appearance (Fig. 4d).

In general, the lateral and dorsal surfaces of *Leiolopisma* sp. tend to be spotted whereas those of *L. zelandicum* are striped (cf. Fig. 4l & 4m). The more intensely striate dorsal scales of *Leiolopisma* sp. contribute to its speckled appearance.

Limbs. Outer surface of forelimbs striped in *L. zelandicum* (Fig. 7b), irregularly blotched in *Leiolopisma* sp. (Fig. 7a). Hind limbs blotched in *Leiolopisma* sp., blotched or striped in *L. zelandicum*.

Details of colour were determined by reference to 103 living specimens (42 *L. zelandicum*, 61 *Leiolopisma* sp.). Both species are brown over the dorsal and lateral areas, but the intensity of this basic ground colour is highly variable. The brown of the dorsal and upper lateral bands is usually paler in *L. zelandicum*, the paleness accentuated by the simpler pattern lacking the prominent striations on individual scales and the very dark speckles of *Leiolopisma* sp. The colour of the upper surface complements the pattern in facilitating instantaneous recognition, but is more difficult to analyse and

describe. Ventral coloration, however, is diagnostically more useful, and can be considered in 4 sections: the throat; the belly; the underside of the tail; and the soles and palms. Only the adult coloration is considered below.

Throat. Pale straw-coloured or grey in both species, often with copperish suffusions; black spots rare in *Leiolopisma* sp. but always present in *L. zelandicum*, though often only at edges (Fig. 4h–k).

Belly. Usually yellowish in *Leiolopisma* sp.; usually orangeish, reddish, or bright red in *L. zelandicum*; may be grey or pale straw-coloured in both species. Unspotted.

Ventral tail. Variable in *Leiolopisma* sp. — pale straw-coloured, grey, yellowish, copperish, or reddish; sometimes black-spotted, especially at edges. Usually orangeish or reddish with black spots distally in *L. zelandicum*, otherwise grey. Reddish where regrown in both species (as on upper surface of regenerated portions).

Soles and palms. Always black in *L. zelandicum* and always yellowish in *Leiolopisma* sp.; however, the digits of both species are dark on their lower surface.

It is useful to be able to discriminate species on the basis of easily observed morphological characters.

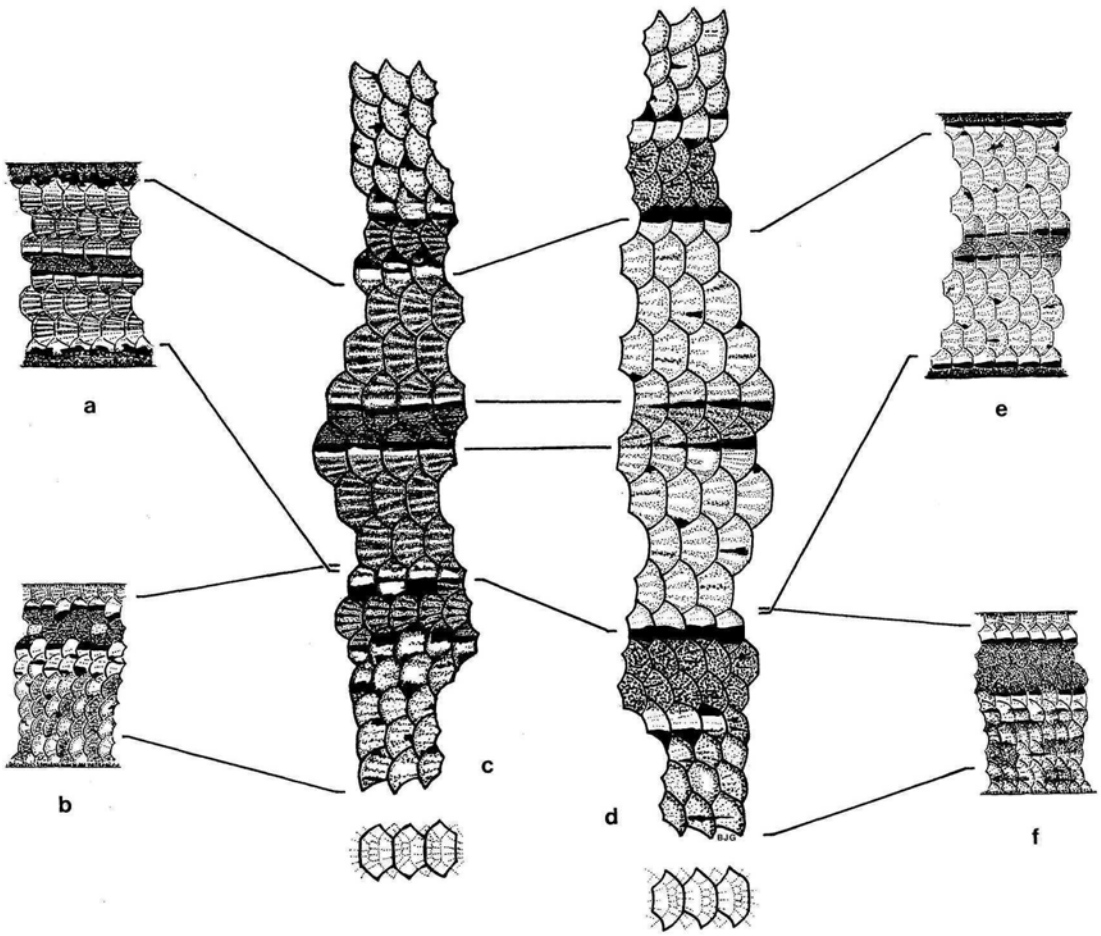
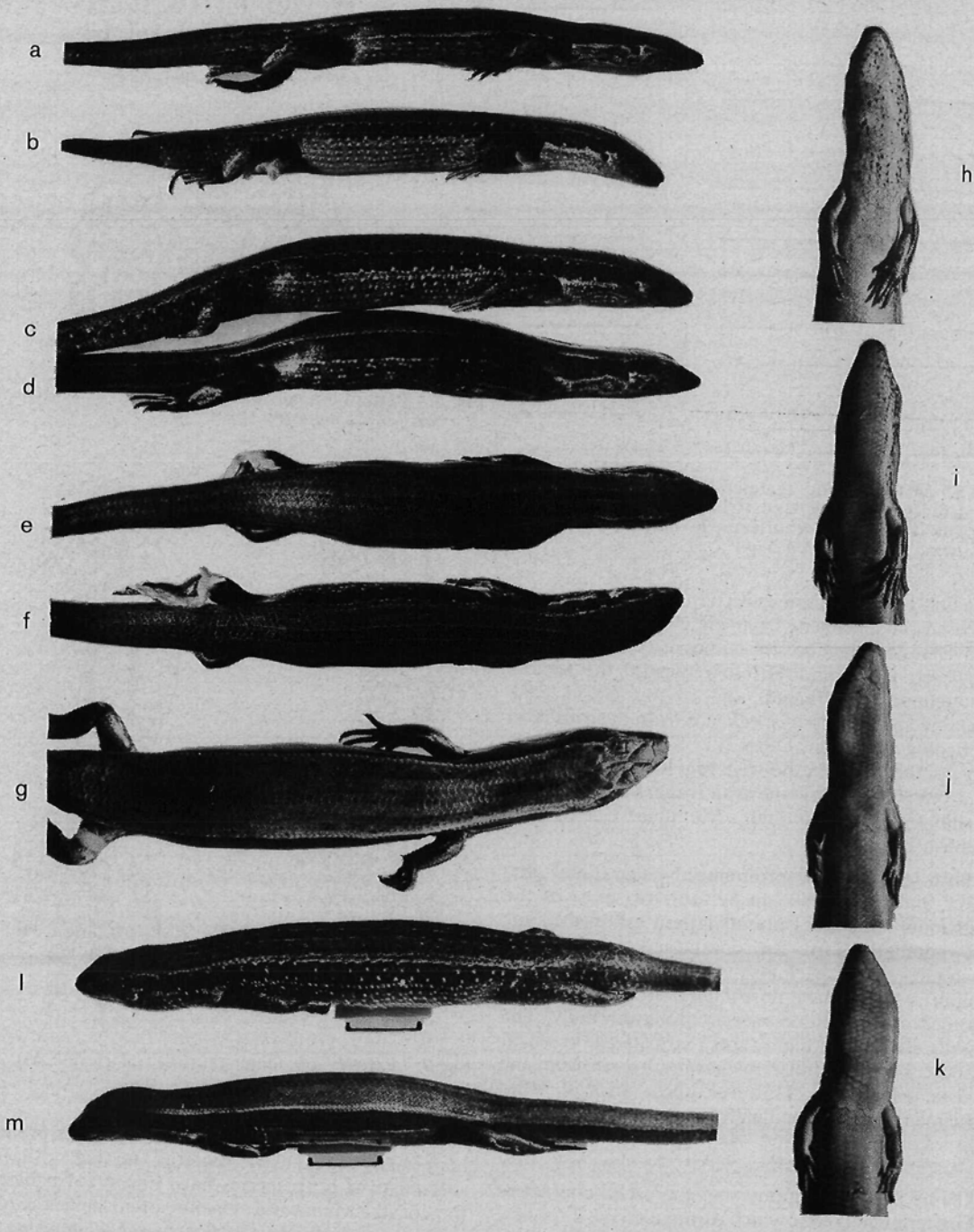


Fig. 3. Pattern of individual scales at mid body, based on selected specimens of (**a–c**) *Leiolopisma* sp. and (**d–f**) *L. zelandicum:* **a, e,** dorsal aspect; **b, f,** lateral aspect; **c, d,** detail of dorsal, lateral, and 3 ventral scales. Illustrations of the 2 species are opposed as mirror images; lines join equivalent sections.

(Opposite page)

Fig. 4. Specimens **a, d, e, g, h, i,** and **m** are *L. zelandicum*; specimens **b, c, f, j, k,** and **l** are *Leiolopisma* sp. Some specimens are illustrated twice: a=i, b=j, c=f, d=e, h=m. Scale line on l and m=10 mm.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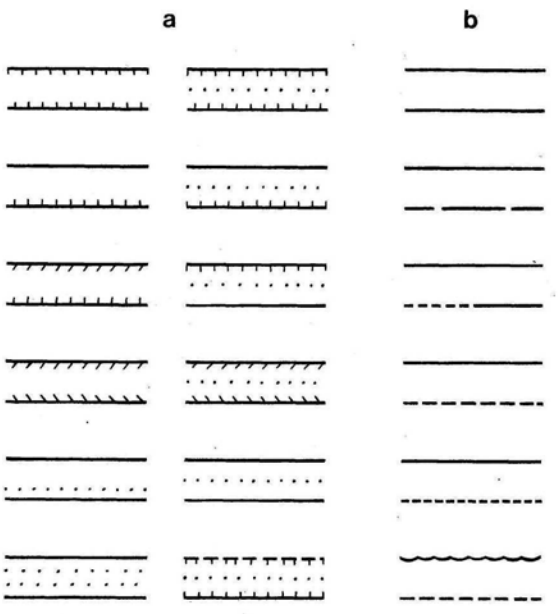

Fig. 5. Diagrammatic representation of variations in pattern of dorsolateral stripe, upper lateral band, and lateral stripe (considered as 1 unit) of **a,** *Leiolopisma* sp.; **b,** *L. zelandicum*.

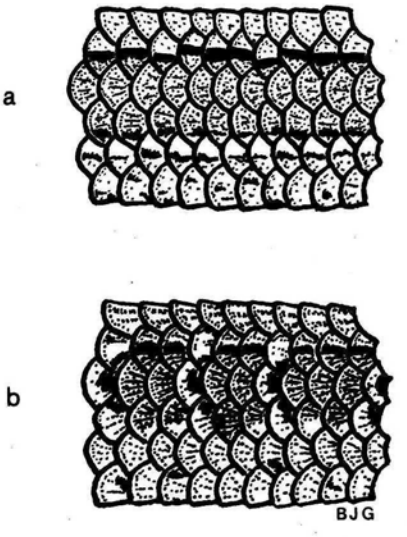

Fig. 6. Pattern laterally at base of tail of: **a,** *L. zelandicum*; **b,** *Leiolopisma* sp.

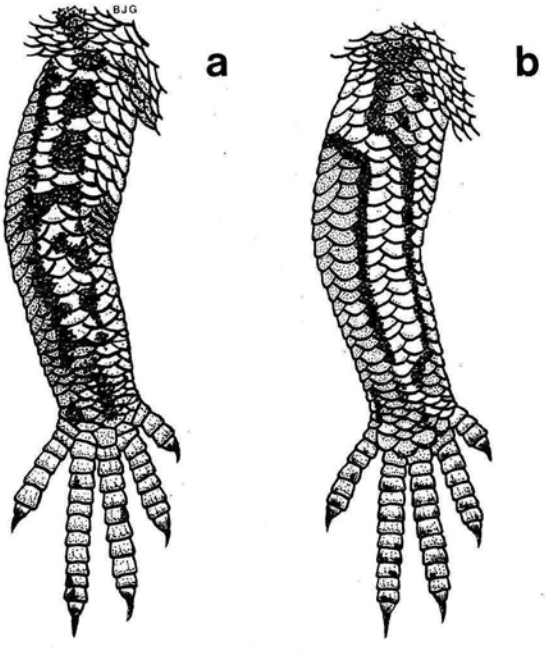

Fig. 7. Pattern on outer surface of forelimbs of: **a,** *Leiolopisma* sp.; **b,** *L. zelandicum*.

The analysis of pattern and colour presented above is based on specimens from the coastal Manawatu, and serves to diagnose the 2 species from that area. However, it is important to recognise the species throughout their ranges, and to this end I have examined a selection of specimens from the collection of Ecology Division, DSIR (22 *L. zelandicum* from most of the localities shown in Fig. 1a; 18 *Leiolopisma* sp. from Hawkes Bay, the Wairarapa, the Rangitikei, Wellington, Marlborough, Motunau Island, and Codfish Island).

Both species show pronounced geographic variation, and exceptions can be found to most of the individual statements about pattern established for the populations of the coastal Manawatu. For example, some specimens of *L. zelandicum* from Stephens Island have dorsolateral stripes which are toothed on their lower margin along the body. The lizards also have a highly speckled pattern, in which respect they are similar to *Leiolopisma* sp. from the coastal Manawatu. However, these and all other specimens are immediately recognisable as one species or the other, and can be separated on paper by combinations of characters.

Table 2 gives a summary of the useful characters of pattern and colour which distinguish the 2 species. The table is arranged to show how generalisations applicable to lizards from the coastal Manawatu are modified to account for specimens of wider distribution. One further point to note from this preliminary analysis of extra material is that although specimens of both species have unspotted bellies in the coastal Manawatu, black-spotted bellies can be a feature of both species elsewhere (*Leiolopisma* sp. from Marlborough; *L. zelandicum* from Maud and Stephens Islands).

In some specimens of *L. zelandicum* the belly and the underside of the tail are bright red, the colour sometimes extending over the underparts of the hind limbs, the lateral and dorsolateral areas of the tail, and above the hind limbs. Such red coloration is never found in undamaged *Leiolopisma* sp., the only parts of the body ever appearing red being regenerated portions of the tail. It is not clear whether the red coloration of *L. zelandicum* has any behavioural significance. The males of some species of skink outside New Zealand are known to assume breeding colours in early spring (Barwick 1959). However, the red coloration in *L. zelandicum* seems unlikely to be related to breeding because it occurs throughout the year. Bright ventral colours are not seen in lizards less than about 40 mm from snout to vent. In a sample of 18 adult *L. zelandicum* sexed by dissection the colours, present in only 12, were pinkish or orangeish in 3 males and 3 females, but reddish in 6 females. The sample included brightly coloured lizards taken in January, February, April, May, August, September, and October. Towns (1975) found that females of the black shore skink (*L. suteri*) develop bright orange or pink ventral colours from August to November. Although any seasonal trends remain obscure for *L. zelandicum*, the colours involved and their predominance in females suggest some accord with *L. suteri*.

After some weeks of preservation in 70% ethanol the ventral surface of specimens of *Leiolopisma* sp. takes on a distinct bluish tinge. Although any reddish coloration tends to be lost in specimens of *L. zelandicum*, the underparts remain pale straw-coloured in the preservative. This suggests a difference in the biochemistry of the tissues between the 2 species.

Measurements and Counts

Table 3 summarises the results of a statistical analysis of certain bodily proportions. There is no significant difference between the 2 species with regard to the distance from snout to vent, although the mean and maximum of this measurement is slightly higher for *L. zelandicum*. However, the length of the intact tail is on average 13.3 mm less in *Leiolopisma* sp., and this difference is highly significant ($P < 0.001$). *L. zelandicum* is on average 17.7 mm longer in total length, the maximum recorded being 146.9 mm compared with 134.1 mm for *Leiolopisma* sp. The difference in the ratio intact tail length: snout-to-vent length is highly significant ($P < 0.001$). The range of 1.1–1.4 for *Leiolopisma* sp. is slightly higher than the 1.0–1.2 obtained by Barwick (1959), possibly owing to different techniques of measurement.

The distance from snout to fore limb is significantly longer in *L. zelandicum* ($P < 0.02$), but there is no significant difference in length from axilla to groin. The ratio axilla-to-groin length : snout-to-fore-limb length is higher in *Leiolopisma* sp., and the difference is highly significant ($P < 0.001$). However, Barwick's range of 1.0–2.0+ for *Leiolopisma* sp. in Wellington is no closer to that for *Leiolopisma* sp. in the Manawatu than to that for *L. zelandicum*.

The distance dorsally from the snout to the posterior apex of the interparietal head shield is a convenient measure of the length of the lizard's head. This distance is significantly longer in *L. zelandicum* ($P < 0.02$).

The counts of subdigital lamellae for the 4th toe of the hind foot did not differ between the 2 species. The range was 17–22 (mode 20) for *L. zelandicum* and 17–23 (mode 20) for *Leiolopisma* sp. Barwick's range for *Leiolopisma* sp. was 20–24 (mode 21), and McCann's was 20–28. However, neither author states his method of counting scales, and because the lamellae tend to merge imperceptibly with the granular scales of the soles, arbitrary decisions must be made in counting, and comparisons between authors become less meaningful. I considered as lamellae all scales which, being of even width, formed a continuous row. Sometimes this row extended a few mm into the sole of the foot.

Counts of scales at mid body partially separate the species (Fig. 8). It is interesting that no odd numbers were scored. Irregularities in scalation caused problems in 3 specimens: different counts at different points near mid body gave varying results (35 or 36; 30, 31, or 32; 31, 32, or 33). These specimens were omitted from Fig. 8, but are included in Table 1. Barwick's range of scale counts for *Leiolopisma* sp. was 28–34 (mode 29) and McCann's was 28–32. These match closely the range of 28–32 established for *Leiolopisma* sp. in the coastal Manawatu.

Of lizards examined with snout-vent length >30 mm, 63% of *L. zelandicum* ($n=41$) and 62% of *Leiolopisma* sp. ($n=60$) had regenerated tails. Barwick's figure for *Leiolopisma* sp. was 65.8%.

ECOLOGY

Distribution

The distribution of *L. zelandicum* is relatively restricted. The available evidence (A. H. Whitaker, pers. comm.; Fig. 1a) indicates that it occurs in the south-western sector of the North Island (from the Eltham area east to Taihape and south to Wellington), on Kapiti Island and Ward Island, and on 10 islands in the Marlborough Sounds (Chetwode and Outer Chetwode, D'Urville and Paddock, Trio and South Trio, one of The Twins, Long, Stephens, and Maud). Recently the species has been found at Cable Bay near Nelson (G. S. Hardy, pers. comm.), and it is likely to occur elsewhere on the South Island mainland. *Leiolopisma* sp. is found throughout the southern North Island (Fig. 1a) and extends

Table 2. Separation of *Leiolopisma* sp. and *L. zelandicum* according to pattern and colour, both in general and for Manawatu populations only

Character	*L. zelandicum* Manawatu	*L. zelandicum* Generally	*Leiolopisma* sp. Manawatu	*Leiolopisma* sp. Generally
Dorsal stripe along body	Broken: often prominent, or only present, anteriorly		Continuous Not prominent anteriorly	Broken or continuous
Dorsal stripe along tail	Broken or absent		Broken or continuous	
Scales of dorsal band	Faintly striate		Markedly striate	
Width at mid body of dorsal band plus dorsolateral stripe	4 scales ($\frac{1}{2}$.1.1.1.$\frac{1}{2}$)	Often 4 scales ($\frac{1}{2}$.1.1.1.$\frac{1}{2}$)	3 scales ($\frac{1}{2}$.1.1.$\frac{1}{2}$)	Often 3 scales ($\frac{1}{2}$.1.1.$\frac{1}{2}$)
Lower margin of dorsolateral stripe along body	Linear Usually prominent anteriorly	Linear or (rarely) toothed below	Usually toothed below; rarely prominent anteriorly	
Upper lateral band along body	Without median spots		Sometimes with median spots	
Upper lateral band along tail	Continuous	Usually continuous	Reduced to crescentic blotches	Usually reduced to crescentic blotches
Lateral stripe along body	Usually broken Never toothed above	Usually broken or absent	Continuous; usually toothed above	
Lateral stripe along tail	Continuous	Continuous, broken, or absent	Absent	Usually absent
Throat	Dark-spotted entirely or at edges		Usually unspotted	
Outer surface of fore limbs	Striped	Usually striped	Blotched	Usually blotched
Soles and palms	Black		Yellow	

Table 3. Comparison of bodily dimensions (in mm) of *Leiolopisma* sp. ('sp.') and *L. zelandicum* ('*z.*'); the first 4 dimensions are from live animals >30 mm s–v, the last 4 are from preserved specimens >50 mm s–v

Dimension	Species	*n*	Mean	Range	S.D.	C.V.	t-test
Snout to vent (s–v)	*z.*	41	54.1	31.6–72.1	8.1	14.9	t =1.33
	sp.	60	51.4	31.2–69.3	11.6	22.5	P >0.10
Intact tail	*z.*	15	66.7	40.9–85.0	10.8	16.2	t =3.97
	sp.	23	53.4	37.8–75.2	9.8	18.3	P <0.001
Total length*	*z.*	15	113.8	72.5–146.9	24.1	21.2	t =2.57
	sp.	23	96.1	69.0–134.1	18.4	19.1	P <0.02
Intact tail/s–v	*z.*	15	1.4	1.3–1.5	0.1	8.6	t =4.33
	sp.	23	1.3	1.1–1.4	0.3	23.0	P <0.001
Snout to fore limb (s–f)	*z.*	22	20.2	18.1–23.8	1.5	7.4	t =2.62
	sp.	20	19.1	16.0–21.6	1.3	7.0	P <0.02
Axilla to groin	*z.*	22	31.9	26.9–38.7	3.5	10.8	t =1.24
	sp.	20	33.4	27.4–38.1	3.9	11.8	P >0.10
Axilla–groin/s–f	*z.*	22	1.6	1.4–1.8	0.1	6.3	t =4.25
	sp.	20	1.8	1.4–2.3	0.2	11.4	P <0.001
Snout to interparietal	*z.*	22	9.0	8.0–10.4	0.7	7.3	t =2.47
	sp.	20	8.6	7.5–9.7	0.5	5.8	P <0.02

*Length s–v plus tail length, for lizards with intact tails

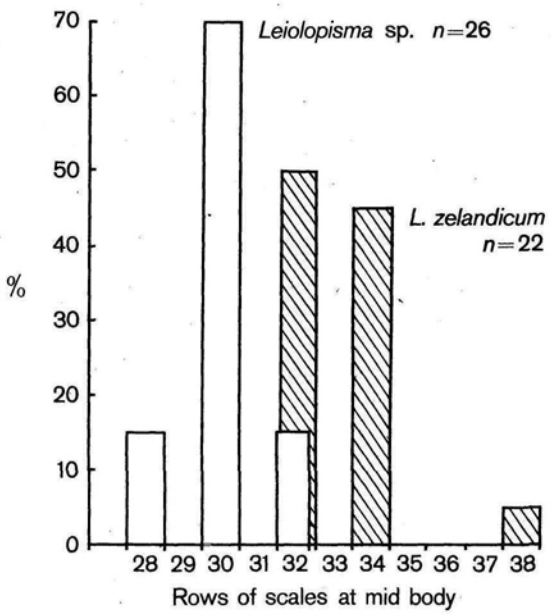

Fig. 8. Partial separation in scale counts at mid body between *L. zelandicum* and *Leiolopisma* sp.

through the South Island to Stewart Island (A. H. Whitaker, pers. comm.).

Fig. 1b shows the localities from which specimens were collected in the Manawatu, and Fig. 1c shows points of capture for the Borough of Foxton, where collecting was intensive. Although the maps for the Manawatu area tend to show the distribution of effort in collecting rather than the true distribution of the lizards, it is clear that the species are sympatric, i.e., individuals of both species are within range of each other during the breeding season.

It also emerges that skinks are more common towards the coast than inland. I have questioned many residents of Palmerston North, especially biologists from Massey University, yet obtained only 1 record of skinks from that area: Dr J. Skipworth has seen them occasionally during the past 15 years on river terraces of the Tiritea Stream. Ecology Division (DSIR) has in its herpetological collections a specimen of *L. zelandicum* from near Linton, and several years ago I was shown specimens of the same species by residents of Shannon and Levin. These records (Fig. 1b) are all that are available for the inland Manawatu.

Habitat

L. zelandicum and *Leiolopisma* sp. are ground-dwellers which normally neither burrow nor climb. They are diurnal and associated with comparatively open areas; they are never found in dense forest. I found both species to be avid baskers in captivity. Free-living skinks are often seen basking during the warmer months, but owing to their wariness it is usually impossible to identify or catch them. The lizards are most readily located by removing the cover beneath which they shelter and forage.

The habitats of the 2 species differ in terms of shade and moisture, and with some experience it becomes possible to predict with accuracy the species to be found at any particular site. Skinks were found at 55 individual sites, all but 2 sites yielding just 1 species. Furthermore, all but 2 areas remained populated by a single species. Hence the skinks exist separately, even though in many instances they are only a few hundred metres or less apart. These observations alone strongly suggest that the 2 species are distinct, with separate habitat requirements or realised niches (niches occupied in the face of interspecific competition; see Jaeger 1974). They also indicate that the lizards are 'neighbouringly sympatric' at the level of the microhabitat.

In general, *Leiolopisma* sp. is found in situations which are open, exposed, and rather dry. This lizard is often found near the sea, and Fig. 9a,b shows littoral sites representing extremes in open and exposed habitats. Here, near the mouth of the Manawatu River, individuals were found to within 1 m of high tide level. In summer diurnal temperatures are high, and throughout the year winds are strong. Skinks were seen basking in mat-forming vegetation and on pieces of wood. Farmland in the Manawatu comprises mainly open expanses of pasture. *Leiolopisma* sp. is found in these areas where fallen objects such as logs provide cover (Fig. 9c). In residential areas the species occurs in newly established gardens with few mature trees. Characteristic of all these sites (Fig. 9a–c) are the presence of low, open vegetation (grasses, herbs, and small shrubs) and the temporary or recently changed nature of the inanimate objects (fence posts, driftwood, and other debris).

L. zelandicum, in contrast, is often associated with habitats that are shady and moist and that incorporate vegetation or buildings of considerable age. Fig. 9d depicts open farmland, but lizards were found beneath debris in and around the derelict shed that has stood for perhaps 30 years. Note the close proximity to mature trees. The association of *L. zelandicum* with old or dilapidated wooden buildings is marked, and in Foxton the species tends to coincide with the distribution of mature houses and gardens. Several times I found lizards actually inside earthen-floored woodsheds which, although supporting numerous invertebrates, lacked living vegetation. Fig. 9e shows the site of a recently demolished house. *L. zelandicum* was found under wooden planks and sheets of galvanised iron which littered the area, and beneath the floorboards of the

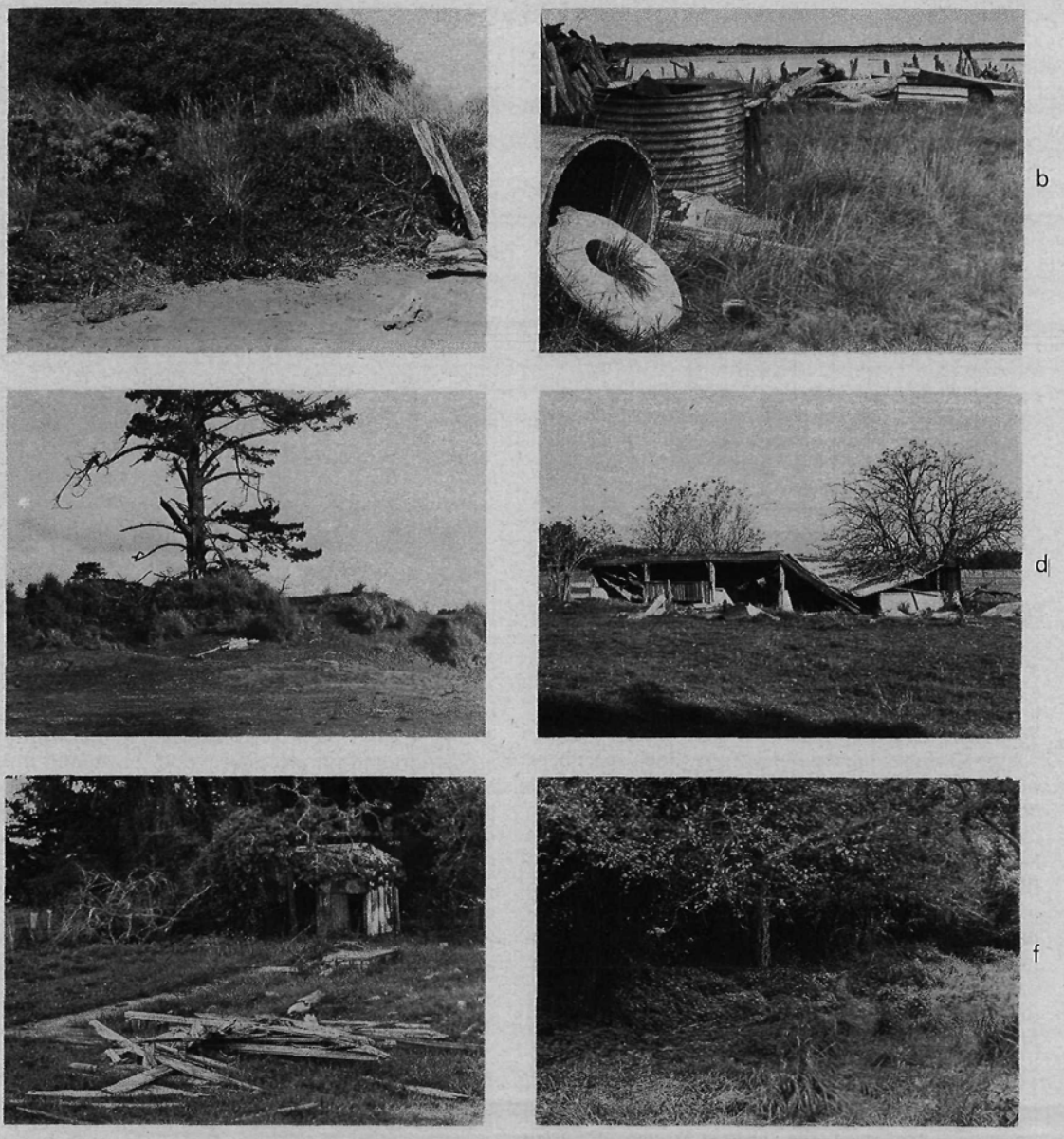

Fig. 9. Examples of habitat of *Leiolopisma* sp. and *L. zelandicum*: **a** Small sandy beach at estuary of Manawatu R. where *Leiolopisma* sp. occurred in litter and mat-forming vegetation (mainly ice-plant, *Carpobrotus edulis*) near high tide level. **b** Overgrown lot near mouth of Manawatu R. at Foxton Beach where *Leiolopisma* sp. occurred beneath pieces of wood, galvanised iron, and other debris. **c** Stabilised dune in sand-country farmland near Foxton — *Leiolopisma* sp. occurred beneath the pile of old fence posts; shrubby vegetation is boxthorn (*Lycium ferocissimum*). **d** Farmland near Foxton, open yet with shaded microhabitats — *L. zelandicum* occurred among debris close to the derelict building and mature trees. **e** Garden near Foxton shaded by trees at many sites — *L. zelandicum* was found beneath debris from the demolished house and close to, even under, the derelict shed. **f** Mature garden in Foxton and site of demolished wooden house — *L. zelandicum* occurred in shade of trees beneath damp, decaying boards, partially or completely overgrown with *Tradescantia fluminensis*.

derelict shed. Once again mature trees are present. Fig. 9f shows the extreme in moist and shady habitats for *L. zelandicum*. The site is a mature garden in Foxton, which was recently occupied by an old wooden house. Lizards were found in several places beneath planks of rotting wood, in some instances overgrown by *Tradescantia fluminensis*, which grew in the shade of the large trees. Many of the rotting boards were encrusted with saprophytic fungi, and were therefore probably always damp.

The photographs are arranged in sequence to show a spectrum of habitats, from an exposed littoral site for *Leiolopisma* sp. (Fig. 9a) to a moist, shady site occupied by *L. zelandicum* (Fig. 9f). Many areas occupied by skinks fall between these extremes, and analysis becomes more difficult. The exceptions to the rule whereby 1 site yields 1 species are areas of intermediate character. Nevertheless, the general applicability of the rule suggests that the differences in habitat, so obvious in extreme situations, are merely subtly replicated where the 2 extremes begin to intergrade.

Certain types of vegetation were noted in association with only 1 of the 2 species of skink. Only *L. zelandicum* was ever found close to the moisture- and shade-tolerant plants *Tradescantia fluminensis* and *Selaginella*. Conversely, numerous plants characteristic of coastal or open areas were associated only with *Leiolopisma* sp. — *Spinifex hirsutus*, *Calystegia soldanella*, *Lagurus ovatus*, *Artemisia absinthium*, *Alyssum alyssoides*, *Carpobrotus edulis*, and various cultivated succulent plants.

Because most lizards in this study were caught by hand, it was necessary to locate them by turning over objects lying close to the ground. Both species were collected readily beneath logs, fence posts, sheets or drums of galvanised iron, wooden planks, and pieces of hardboard or plywood. The sampling of habitats was therefore biased in a way which favoured particular sizes and types of cover. All 22 of the sites at which *L. zelandicum* was found and 27 (87%) of the 33 sites for *Leiolopisma* sp. were determined by deliberately seeking out items of cover. The remaining sites for *Leiolopisma* sp. were discovered by accident, and were the only situations where lizards were found in vegetation alone. I caught these lizards basking in mat-forming vegetation at the littoral site (Fig. 9a) or found them unexpectedly while weeding a garden.

A classification of sites according to the dominant type of cover beneath which the lizards were sheltering is given in Fig. 10. Both species utilises wood as cover, but *Leiolopisma* sp. is able to make greater use of metal, and presumably, therefore, can tolerate wider fluctuations in temperature. Metal has a higher thermal conductivity than wood, and is subject to heating to a greater maximum and cooling to a lower minimum. The preference of *L. zelandicum* for wood as cover (68.2% of sites) is striking, and suggests an intolerance of extreme temperatures. Concrete is uncommon as a cover, and nothing of significance can be inferred from the few records of lizards in vegetation.

All lizards were collected within the bounds of the Manawatu sand-country, and so any soil present was well drained sandy loam. Some specimens of *Leiolopisma* sp. caught close to the sea were associated with pure sand containing little, if any humus. Because most of the sites at which lizards were found comprised objects which had fallen to the ground, it was usual to find dead or aetiolated vegetation forming part or all of the substrate. Occasionally lizards were collected in heaps of wood or stacks of corrugated iron sheets, and in such instances the substrate and cover were homogeneous.

Particular attention was paid to the moisture content of the substrate, and each site was scored as dry, slightly damp, very damp, or wet. Fig. 10 shows the occurrence of both skinks according to the moisture of the substrate at each site. Some substrates were not uniformly moist, and were given 2 ratings; other sites were therefore scored twice to compensate. *Leiolopisma* sp. is most frequently associated with dry or slightly damp substrates, whereas *L. zelandicum* is most often found in very damp sites.

Food

The stomach contents of 11 *L. zelandicum* and 14 *Leiolopisma* sp. collected during the warmer months from September 1974 to April 1975 were analysed to assess diet. One of the stomachs from *Leiolopisma* sp. was empty, but is included in the calculations.

Both species are carnivores feeding exclusively on invertebrates, which were identified to ordinal level. Table 4 shows various computations based on the occurrence of invertebrates in the sample of stomachs: 61 items were obtained from *L. zelandicum* and 124 from *Leiolopisma* sp. The maximum number of items in any single stomach was 24 for *L. zelandicum* and 31 for *Leiolopisma* sp.

The proportion of stomachs in which a category of food appears measures either selectivity or the availability of food (the latter reflecting habitat). In both species about 70% of stomachs contained arachnids and about 60% contained crustaceans, but the figure for insects in *Leiolopisma* sp. (79%) is higher than that for *L. zelandicum* (64%).

Of all the items of food ingested by the sample of *L. zelandicum*, 16% were insects (37% in *Leiolopisma* sp.), 52% were arachnids (cf. 39%) and 23% were crustacenas (cf. 14%). *L. zelandicum* therefore feeds mainly on arachnids, insects forming only a small fraction of the diet, whereas *Leiolopisma* sp.

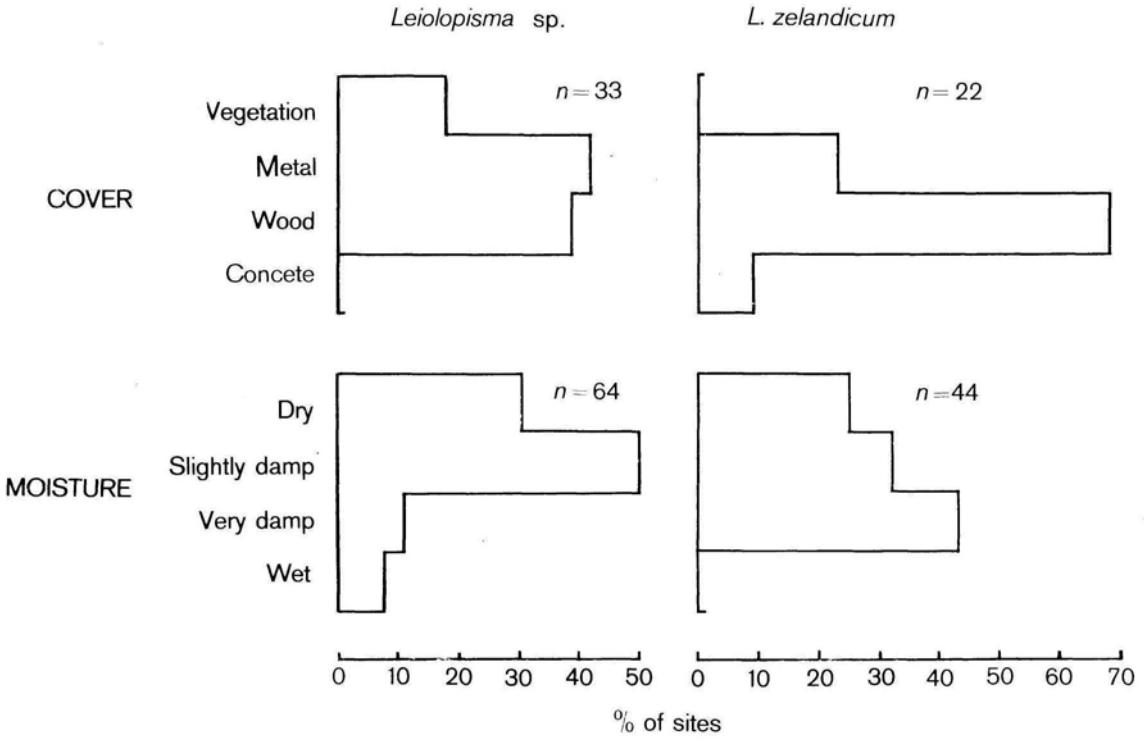

Fig. 10. Classification of sites at which lizards were found according to material providing cover and moisture content of substrate.

Table 4. Computations based on ordinal classification of invertebrates from stomachs of *L. zelandicum* ('*z.*'; $n=11$) and *Leiolopisma* sp. ('sp.'; $n=14$, but 1 stomach empty) (—, nil)

	No. of stomachs		% of stomachs		No. of items		% of items		Mean per stomach		Max. in any stomach	
	z.	sp.	*z.*	sp.	*z.*	sp.	*z.*	sp.	*z.*	sp.	*z.*	sp.
Collembola	1	3	9	21	1	17	2	14	0.1	1.2	1	8
Orthoptera	—	1	—	7	—	1	—	1	—	0.1	—	1
Dermaptera	—	1	—	7	—	1	—	1	—	0.1	—	1
Hemiptera	—	6	—	43	—	9	—	7	—	0.6	—	3
Neuroptera	—	2	—	14	—	2	—	1	—	0.1	—	1
Coleoptera	1	4	9	29	2	4	3	3	0.2	0.3	2	1
Lepidoptera	2	4	18	29	2	6	3	5	0.2	0.4	1	3
Diptera	2	4	18	29	3	5	5	4	0.3	0.4	2	2
Hymenoptera	2	1	18	7	3	1	5	1	0.3	0.1	2	1
INSECTA	7	11	64	79	11	46	16	37	1	3.3	3	16
Araneae	6	9	55	64	28	18	46	14	2.6	1.3	20	6
Opiliones	4	4	36	29	4	29	6	23	0.4	2.1	1	24
Acarina	—	2	—	14	—	2	—	2	—	0.1	—	1
ARACHNIDA	8	10	73	71	32	49	52	39	2.9	3.5	20	25
Isopoda	6	8	55	57	13	17	21	14	1.2	1.2	3	5
Amphipoda	1	—	9	—	1	—	2	—	0.1	—	1	—
CRUSTACEA	7	8	64	57	14	17	23	14	1.3	1.2	3	5
Unid. arthropods	2	5	18	36	4	6	7	5	0.4	0.4	3	2
ARTHROPODA	11	13	100	93	61	118	100	95	5.6	8.4	20	27
Stylommatophora	—	3	—	21	—	6	—	5	—	0.4	—	4
MOLLUSCA												
INVERTEBRATES	11	13	100	93	61	124	100	100	5.6	8.9	24	31

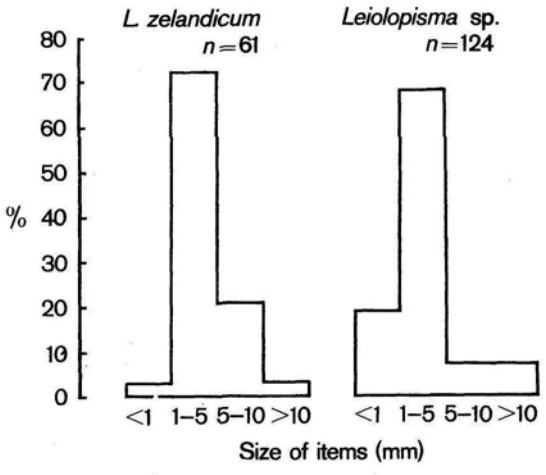

Fig. 11. Items from stomachs of lizards, classified according to size.

eats a more balanced range of invertebrates with insects relatively more important. Of the arachnids, *L. zelandicum* appears to feed more on spiders (46% of items) than on harvestmen (14% of items), and vice versa for *Leiolopisma* sp. (6% and 23% respectively). But these results are each affected by the contents of single stomachs with many items of a single type.

Orthopterans, dermapterans, hemipterans, neuropterans, mites, and molluscs occurred only in stomachs of *Leiolopisma* sp.; the single amphipod was found in *L. zelandicum*. Invertebrates from 14 orders were found in the stomachs of *Leiolopisma* sp., whereas the figure for *L. zelandicum* was only 9. Perhaps *Leiolopisma* sp. is an opportunistic feeder, and *L. zelandicum* is more selective.

On average there were considerably more invertebrates per stomach of *Leiolopisma* sp. (8.9, cf. 5.6 for *L. zelandicum*), and the maximum and total numbers of insects, arachnids, crustaceans, arthropods, and invertebrates were consistently higher in *Leiolopisma* sp.

In *Leiolopisma* sp. 21% of stomachs contained collembolans and 43% contained hemipterans (mainly aphids); these items are very small. To compare the sizes of invertebrates taken, the longest dimension of each item was measured. Fig. 11 shows the grouping of items into 4 categories of size. For both species 70% of items were 1–5 mm long, but 20% of items ingested by *L. zelandicum* were in the 5–10 mm range whereas for *Leiolopisma* sp. 20% of items were < 1 mm long.

Barwick (1959), studying the diet of *Leiolopisma* sp. in the Wellington area, found an average of 5.03 items per alimentary tract during the summer months. This is much lower than my value for the coastal Manawatu of 8.9 items per stomach. The percentages of items contributed by 3 main classes of invertebrate also show considerable differences between the 2 areas: the figures for Insecta, Arachnida, and Crustacea are respectively 73%, 27%, and 25% for Wellington and 37%, 39%, and 14% for the Manawatu. However, the type and range of food taken by the species is similarly wide in the 2 areas.

Competition

According to the principle of competitive exclusion 2 species cannot occupy identical niches. The information on habitat and food suggests that in the coastal Manawatu there is an ecological separation between the 2 species of skink, and it is quite possible that competition at certain times or in certain places has been, or is, the cause of this distinction. Although I have no direct evidence of competition, a discussion of possibilities past and present may be of some relevance.

As already mentioned, usually only a single species of lizard is found at any particular site, and each species tends to occur in a characteristic habitat. However, at 2 sites (Fig. 1c) I found both species beneath a single item of cover (5 *L. zelandicum* plus 1 *Leiolopisma* sp.; 1 *L. zelandicum* plus 1 *Leiolopisma* sp.), and on 2 occasions a single specimen of *Leiolopisma* sp. was collected in an area which had previously yielded *L. zelandicum*. The area shown in Fig. 9e yielded 9 *L. zelandicum* and 1 *Leiolopisma* sp. between May 1974 and April 1975. These observations suggest an overlap in habitat requirements, or perhaps a temporal change in habitat which alters its suitability in favour of the second species.

Habitats aside, it is clear from the stomach content analysis that the diets of the 2 species overlap considerably. Consequently, there exists in the coastal Manawatu a potential for competition between 2 sibling species. Possibly competition occurs, and restricts each species to a realised niche; or, by virtue of separate niches, competition is absent or rare.

Any discussion of the present distribution of the species must take account of 2 important factors. First, in view of the difficulties of sympatric speciation (Mayr 1969), the 2 skinks must have been allopatric before the establishment of sympatry. Among Australian leiolopismids, some species which evolved in geographic isolation have later invaded each other's range so that 2 similar species have come to exist in the same area (Clarke 1965). Second, the distribution of skinks up to 1000 years ago, when the plain between the Manawatu and Rangitikei Rivers probably comprised rain forest to within a few km of the coast (J. Skipworth, pers. comm.), must be considered. Note that the present habitats of both species are completely modified by man.

It is plausible that more than 1000 years ago *Leiolopisma* sp. was a skink of the dunes and the low scrub which must have been intermediate between forest and coast. It may, therefore, have been restricted to the coastal area, extending inland only where dense forest was absent, as on the stable longitudinal dunes which occur east to Rangiotu. *L. zelandicum*, on the other hand, may have exploited bush edges and shady clearings wherever they occurred on the Manawatu plain, both towards the coast and inland.

Even before European settlement the forests of the coastal Manawatu were diminished by man-made fires. Since 1840 agricultural activity has led to further reduction of the forests and to draining of swamps, as part of a gradual conversion of the Manawatu to pasture. During this transformation of habitats the total area available to skinks presumably increased, because usually few species are found in dense forest or very wet sites. Competition or particular habitat requirements may have restricted *L. zelandicum* to remaining shady microhabitats such as the vicinity of derelict buildings and established gardens, while *Leiolopisma* sp. extended its range into the now dry and exposed farmland.

Breeding Cycle of the Female

Nine (43%) of the 21 specimens of *Leiolopisma* sp. dissected were males, as were 5 (25%) of 20 *L. zelandicum*; 34% of all specimens were males, as were 30% of the *Leiolopisma* sp. sexed by Barwick (1959). It is not clear whether the populations contain fewer males, or whether the techniques of capture are biased in favour of catching females.

The dry weights of ovaries from a sample of females (16 *L. zelandicum*, 11 *Leiolopisma* sp.) suggest that the general ovarian cycle is the same for both species, and no different from that recorded by Barwick. Ovaries are at minimal mass from October to March and reach a maximum in September. The maximum mean weight of the 2 ovaries obtained by Barwick for *Leiolopisma* sp. was just over 200 mg. No mature ovaries of *Leiolopisma* sp. from the Manawatu exceeded 200 mg, but the mean dry weights for both ovaries of 2 *L. zelandicum* were 250 mg and 300 mg (both caught 15.ix.1974).

In *L. zelandicum* ovulation occurs in late September (1 specimen had ovulated before 29.ix.1974) or October. The maximum numbers of mature eggs in ovaries were 7 for *L. zelandicum* and 9 for *Leiolopisma* sp. (the maxima were the same for eggs in oviducts). Barwick's maximum figure for *Leiolopisma* sp. was 8. Young of *L. zelandicum* are produced in January, as are those of *Leiolopisma* sp. (see Barwick 1959).

The mean dry weight of 34 early oviducal eggs from 6 *L. zelandicum* was 53.5 mg. A specimen caught on 1.i.1975 contained 3 embryos with pigmented eyes but little other pigment. The embryos were each associated with a roughly equal volume of yolky substance, and both embryo and yolk were enveloped in a series of membranes. The mean dry weight of the embryos was 79.3 mg, so it is clear that they must have received nutriment of maternal origin. Barwick claims placentation for *Leiolopisma* sp., on the basis of an observed disparity between ovarian and embryonic weights. This does not necessarily follow, because maternal substances may be absorbed by embryos via oviducal fluids (Balinsky 1970) rather than via a placenta. The skinks in question are viviparous in the sense that they produce live young, but they could well be ovoviviparous according to certain definitions, especially if it is shown that placentation is absent or poorly developed.

If the 2 kinds of skink are ever shown to occur as siblings then conspecificity is proved. However, several people who have kept these lizards in captivity report uniformity among progeny, and I have had the same indication from examining late embryos of 2 preserved female lizards (1 of each kind).

Parasites

For many years ticks and mites (considered by some authors to represent 3 orders) have been known to parasitise New Zealand reptiles, but this field has not been adequately researched (Hardy 1972). One species of mite (*Acomatacarus lygosomae*, order Acariformes) has been described from a skink in this country (Dumbleton 1947).

On one occasion small red mites were observed on lizards in captivity. The lizards involved were of both species, but because they were kept in the same cage in the same month it is possible that cross-infestation occurred. Samples of the mites were mounted and sent to Dr R. Emberson (Lincoln College, Canterbury), who confirmed that they were parasitic and identified them as a probably undescribed species close to the genus *Ophionyssus* Megnin (subfamily Macronyssinae, family Dermanyssidae, suborder Mesostigmata, order Parasitiformes). The mites from *L. zelandicum* were juvenile stages, and could not be compared specifically with the adult mites from *Leiolopisma* sp.

The Macronyssinae are a large group of ectoparasites of vertebrates, and the genus *Ophionyssus* parasitises lizards and snakes throughout the world. This is the first report of mites of this order as parasites of New Zealand lizards. Their incidence in the coastal Manawatu is low.

Two nematodes have been reported from skinks in New Zealand. Barwick (1959) found a species of *Pharyngodon* in the rectum of specimens of *Leiolopisma* sp., and Andrews (1974) described a new species, *Hedruris minuta*, from the stomach of

Leiolopisma smithi (a northern skink). In the sample of 25 lizards whose stomachs were examined, 1 specimen of *Leiolopisma* sp. from Foxton Beach was found to be infested with nematodes: 6 were firmly attached to the inside wall of the stomach. Dr J. Andrews (Victoria University, Wellington) examined the specimens and found them all to be females; although a male is required for confirmation, they are likely to be *H. minuta*.

CONCLUSIONS

It is reasonable to conclude from the morphological and ecological differences expounded above that the 2 kinds of skink present in the coastal Manawatu represent separate biological species. Their reproductive isolation may be on temporal, behavioural, or ecological grounds, rather than by genetic incompatability. Their subtle differences in appearance suggest that they are sibling species; the alternative, that they are morphs of a single species, seems unlikely. Morphs usually differ in only one or a few characters, whereas these skinks differ slightly in virtually every aspect of their morphology examined.

NOTE ADDED IN PRESS

Robb (1975; *Proc. Koninkl. Nederl. Akad. Wetensch., Ser. C, 78(5):* 477-84) has recently described *Leiolopisma pachysomaticum* and *L. macgregori*, to bring the number of species for New Zealand to 20.

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