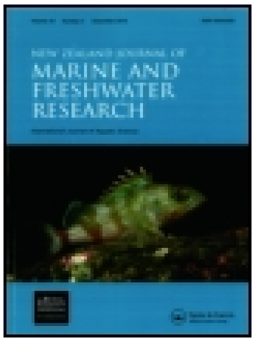

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DISTRIBUTION AND ECOLOGY OF THE CRABS *CYCLOGRAPSUS LAVAUXI* AND *C. INSULARUM* IN NORTHERN NEW ZEALAND

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ABSTRACT

The differences between the crabs *Cyclograpsus lavauxi* (Milne Edwards, 1853) and *C. insularum* (Campbell and Griffin, 1966) are outlined. *Cyclograpsus lavauxi* has long been known to be very common in New Zealand, but *C. insularum* was considered very rare and had been collected only six times since 1929.

In 1970, 60 spot surveys in the northern part of the North Island of New Zealand revealed 14 new populations of *Cyclograpsus insularum*.

Both species are found under boulders high on the beach. *Cyclograpsus lavauxi* occurs at maximum density higher on the shore than the maximum numbers of *C. insularum*, but the zones overlap widely. *Cyclograpsus insularum* occurs on substrates of smaller sand and silt content than those on which *C. lavauxi* is found.

INTRODUCTION

The New Zealand upper shore crabs *Cyclograpsus whitei* and *C. lavauxi* were inadequately described by Milne Edwards (1853), and later Chilton (1911) considered these forms to be the same species. Chilton and Bennett (1929) described two species of *Cyclograpsus* from New Zealand under the names of *C. lavauxi* (Milne Edwards) and *C. whitei* (Milne Edwards). As pointed out by Campbell and Griffin (1966), however, the characters attributed to *C. whitei* do not exist in the holotype of this species, but typify the new species *Cyclograpsus insularum* as described by them.

Cyclograpsus lavauxi has long been known as a very common crab throughout New Zealand. *Cyclograpsus insularum* has been recorded from Tom Bowling Bay (as *C. whitei*) by Bennett (1964); from Norfolk Island, Lord Howe Island, the Kermadec Islands and unnamed mainland New Zealand localities by Chilton and Bennett (1929); and from Lady Alice Island, of the Hen and Chickens group, by N.Z. Oceanographic Institute in 1968 (Wear 1970).

Dell and Marshall (1967) briefly described a population of both *Cyclograpsus insularum* and *C. lavauxi* at Otarawairere Bay (between Whakatane and Ohope Beach) and referred also to a record by Ponder from the east side of North Cape. They suggested that the two species occupy similar ecological niches, and for this reason *C. insularum* has had difficulty establishing itself after reaching New Zealand as larvae. This theory implies that *C. lavauxi* was the prior arrival to New Zealand shores.

Since this paper was submitted, Mr R. V. Grace reported to me thriving populations of *Cyclograpsus insularum* with *C. lavauxi* at localities east of Whakatane: Raukokore, Lottin Point, Hicks Bay and 7 miles west of East Cape. Thus *C. insularum* occurs on suitable boulder beaches from North Cape to East Cape.

MORPHOLOGICAL DIFFERENCES

The general appearance of the two species is shown in Fig. 1 and distinguishing features are listed in Table 1.

Although the colour pattern of the carapace varies within each species, it is a useful aid to quick identification in the field. A colour description was given by Campbell and Griffin (1966) for *Cyclograpsus lavauxi*, but not for their specimens of *C. insularum*, which were bleached by alcohol. *Cyclograpsus lavauxi* is distinctly speckled in dark reddish-brown on a ground varying through slate blue, bluish grey, fawn to yellowish brown. *Cyclograpsus insularum* has always a graded colour pattern, without speckling or spots, and the anterior half tends to be darker than the posterior half. Frequent shades at the front are orange-brown, or purple grading into paler brown, with tints of grey or purple towards the back. Fawn is occasionally found in large specimens of *C. insularum*.

Carapace size is also important; Table 1 gives the mean length and breadth of 80 specimens of each of the two species from Leigh. The ratios of length to breadth were approximately 1 : 1.2 for both species.

METHODS

At most shores visited in early 1970, the levels of *Cyclograpsus lavauxi* and *C. insularum* were referred to measured neap and spring tides at Goat Island Bay. At other localities adequate tidal data were not available and distribution was levelled to the upper limit of *C. insularum*.

The type of substrate was invariably boulders resting on finer particles, arbitrarily classified as small boulders, pebbles, gravel, sand and silt. From seven beaches forming a series from exposed to sheltered, samples were taken of gravel, sand and silt. Particles smaller than 0.062 mm (4 ϕ) were washed out, filtered and their dry weight determined. The remaining sediment was oven dried, placed in a series of sieves of approximately 1 ϕ interval and sieved for 10 minutes in a Rotap shaker. Particles larger than 4.96 mm ($-$ 2.25 ϕ) were discarded.

Where both species of crabs occurred together, the mean level of each species was calculated separately:

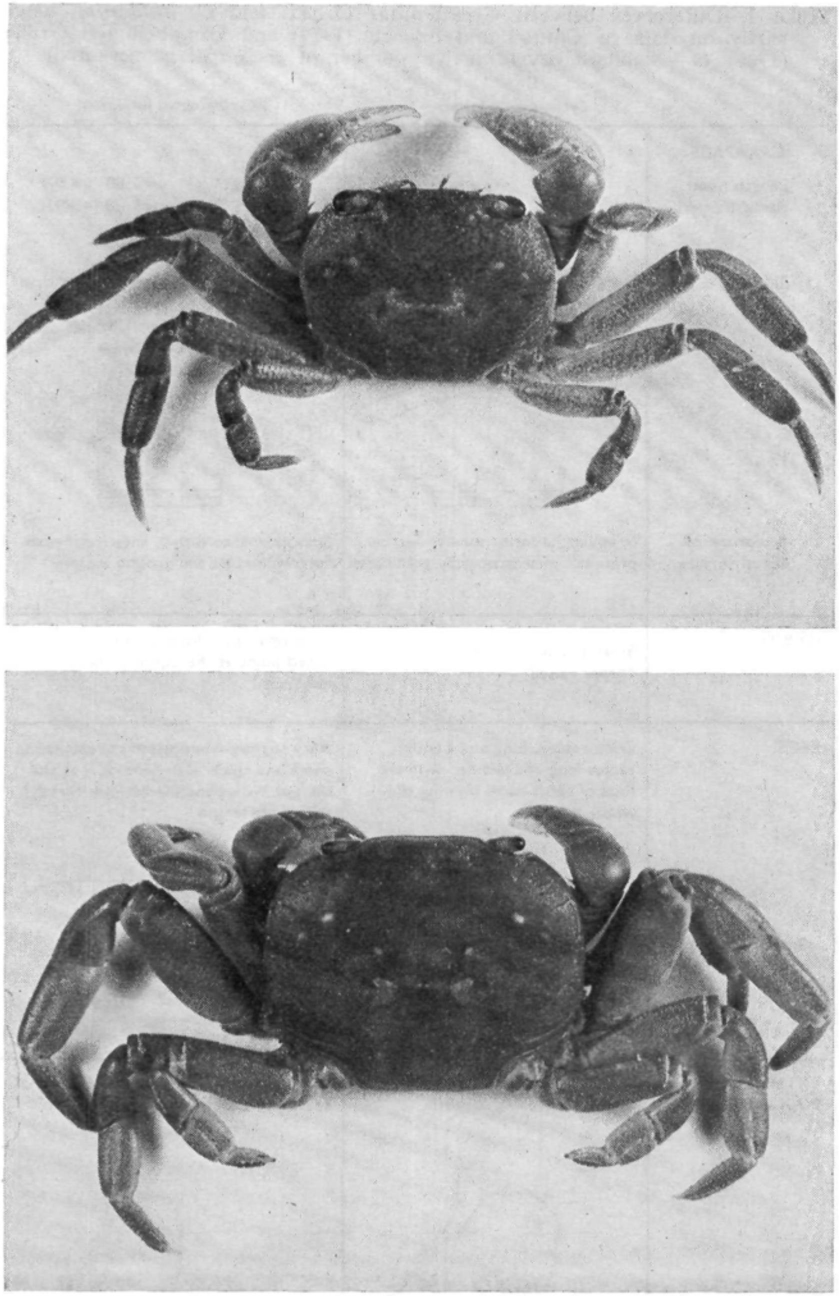
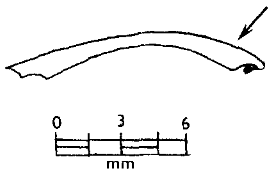
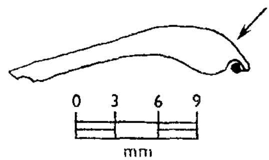
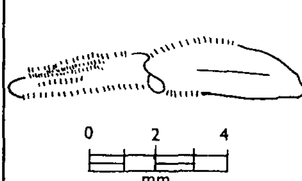
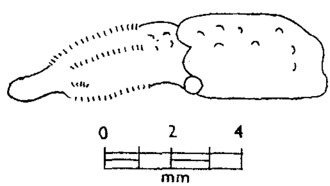
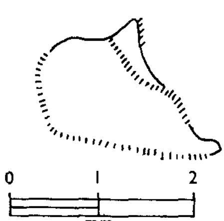
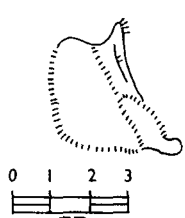


FIG. 1—(Upper) *Cyclograpsus lavauxi*, carapace width approximately 9 mm; (lower) *Cyclograpsus insularum*, carapace width approximately 21 mm.

TABLE 1—Differences between *Cyclograpsus lavauxi* and *C. insularum*, based partly on data of Chilton and Bennett (1929) and Campbell and Griffin (1966). (s = standard deviation, n = number of each species measured)

	Cyclograpsus lavauxi	*Cyclograpsus insularum*
CARAPACE		
Length (mm)	9·1 s = 1·59 (n = 80)	13·4 s = 2·80 (n = 80)
Breadth (mm)	11·1 s = 3·07 (n = 80)	15·8 s = 3·30 (n = 80)
Shape	Dorsal surface sometimes broader in front than behind; front of carapace depressed in lateral view 	Dorsal surface narrower in front than behind; front of carapace more depressed, almost at right angles to dorsal surface in lateral view 
Sculpture of dorsal surface	Irregular; anterior median furrow present; microscopically granulated	Smoother anteriorly; anterior median furrow absent; rim around margins
ORBITS	Small but well incised, outer corner raised	Very small and shallow, not forming a raised point at the outer corner; eyes very small
LEGS	Compressed, long and slender; tarsus long and slender with six lines of short hairs running the whole length 	Very slightly compressed robust; tarsus short and thick with hairs only at the tip, but with punctulated lines through the whole length 
EXTERNAL MAXILLIPED	Third joint subquadrate, length scarely exceeding breadth 	Third joint elongate, length nearly one and a half times breadth 

If X = the height (cm) above the lower limit of the species, at which a set of samples was taken,
Y = the number of crabs per square metre at each sampling level
ΣY = the total number of crabs found in all samples

Then, the mean height of occurrence on the shore ($\bar{x}$) is given by multiplying X by Y for each shore level sampled and dividing the sum of these products by ΣY, i.e.,

$$\bar{x} = \frac{\Sigma X.Y}{\Sigma Y}$$

For example,

X	Y	X.Y
5	2	10
10	6	60
15	4	60
20	3	60
25	2	50
-	17	240

Then, $\bar{x} = \frac{\Sigma X.Y}{\Sigma Y}$

$= \frac{240}{17}$

$\bar{x}$ = 14.1 cm above lower limit of the species.

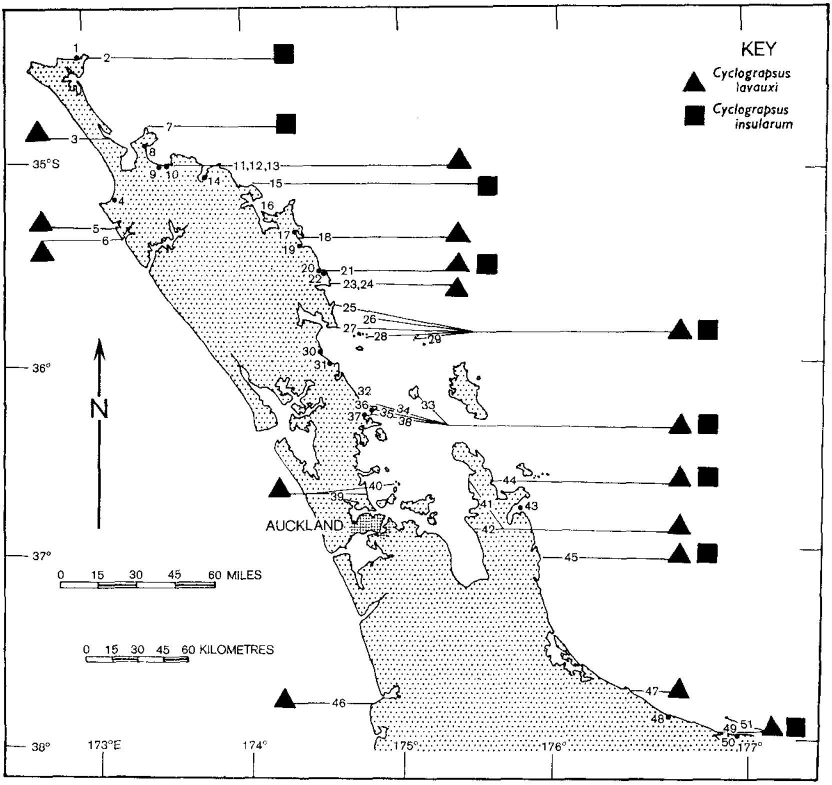
RESULTS

The presence/absence of each species is shown in Fig. 2. The localities and substrate types are listed in Table 2 according to whether one or both species was present.

Neither species was found beneath boulders of less than 15 cm diameter. *Cyclograpsus insularum* was found on boulder beaches of open coasts where direct wave attack was mitigated by offshore islands or extensive reefs. *Cyclograpsus lavauxi*, however, was found on boulder beaches ranging from open, wave-exposed coasts to sheltered harbours.

The vertical shore distribution of the species on shores where both occurred together is shown in Fig. 3. By comparing the mean level of vertical distribution of each species it is clear that although both species may widely overlap in distribution the *C. insularum* populations are centred lower on the shore.

From correlation of the sediment analyses with the presence of the species of crabs (Fig. 4), *Cyclograpsus insularum* was present where not more than 18% sand and silt occurred in the substrate beneath the



1. Tom Bowling Bay
2. North Cape
3. Houhora
4. Ahipara
5. Owhata
6. Whangape
7. Cape Karikari
8. Tokerau
9. Taipa
10. Coopers Beach
11. Mangonui
12. Hihi Stm
13. Tauranga Bay
14. Whangaroa
15. Lion Rock
16. Bay of Islands
17. Whangaruru
18. Oakura
19. Helena Bay
20. Woolleys Bay
21. Rangitapu
22. Matapouri
*23. Kawharewa Bay
*24. Pacific Bay
25. Taiharuru
26. Bream Head
27. Smugglers Bay
28. Hen & Chickens Is
29. Mokohinau Is
30. Waipu Cove
31. Langs Beach
32. Pakiri Beach
33. Little Barrier I
34. Goat I
35. Cape Rodney
36. Leigh
37. Whangateau
38. Ti Point
39. Milford
40. The Noises
41. Amodeo Bay
42. Wilson Bay
43. Mercury Bay
44. Waihirere Stm
45. Slipper Island
46. Raglan
47. Maketu
48. Matata
49. Whakatane
50. Ohope
51. Whale I

FIG. 2—Sketch map of the beach localities in the northern part of the North Island, New Zealand, searched in early 1970 for colonies of the two grapsid crabs *Cyclograpsus insularum* and *C. lavauxi*. Since then, *C. insularum* has been found also at Poor Knights Islands, Tairua, Aldermen Islands, and Mayor Island (* = names in local use but not yet approved by N.Z. Geographic Place Names Board.)

TABLE 2—Localities in the northern part of the North Island of New Zealand searched in 1970 for colonies of *Cyclograpsus insularum* and *C. lavauxi*. The situation and types of sediment are indicated by crosses. (Whale Island population reported to me by B. A. Marshall)

	Situation			Substrate				Presence		
	Reefs or Islands	Open Coast	In harbour	Sand	Boulders	Gravel	Silt	*C. insularum* present	*C. lavauxi* present	*Cyclograpsus* absent
Mayor Island	×	×	–	–	×	×	–	×	–	–
Poor Knights Islands	×	×	–	–	×	×	–	×	–	–
Cape Karikari	×	×	–	–	×	×	–	×	–	–
Lion Rock (Bay of Islands)	×	×	–	–	×	×	–	×	–	–
Rangitapu	×	×	–	–	×	×	–	×	×	–
Taiharuru	×	×	–	–	×	×	–	×	×	–
Bream Head	×	×	–	–	×	×	–	×	×	–
Smugglers Bay	×	×	–	–	×	×	–	×	×	–
Flax I. (Mokohinau Group)	×	×	–	–	×	×	–	×	×	–
Lady Alice I. (Hen and Chickens Group)	×	×	–	–	×	×	–	×	×	–
Goat Island Bay (Leigh)	×	×	–	–	×	×	–	×	×	–
Goat Island (Leigh)	×	×	–	–	×	×	–	×	×	–
Cape Rodney	×	×	–	–	×	×	–	×	×	–
Ti Point	×	×	–	×	×	×	–	×	×	–
Little Barrier Island	×	×	–	–	×	×	–	×	×	–
Waihirere	×	×	–	–	×	×	–	×	×	–
Aldermen Islands	×	×	–	–	×	×	–	×	–	–
Tairua	×	×	–	–	×	×	–	×	–	–
Slipper Island	×	×	–	–	×	×	–	×	–	–
Maketu	×	×	–	–	×	×	–	–	×	–
Whale Island	×	×	–	–	×	×	–	×	–	–
Otarawairere	×	×	–	–	×	×	–	×	×	–
Houhora Heads	–	–	×	–	×	–	×	–	×	–
Mangonui	–	–	×	–	×	×	×	–	×	–
Hihi	–	–	×	–	×	×	×	–	×	–
Oakura	–	–	×	–	×	×	–	–	×	–
Owhata	–	–	×	–	×	–	×	–	×	–
Whangape	–	–	×	–	×	×	×	–	×	–
Kawharewa Bay	–	–	×	–	×	×	–	–	×	–
Pacific Bay	–	–	×	–	×	×	–	–	×	–
Urquhart Bay	–	–	×	–	×	×	×	–	×	–
Home Point (Whangarei)	–	–	×	–	×	×	×	–	×	–
Leigh Harbour	–	–	×	–	×	×	×	–	×	–
Nordic Bay (Leigh)	–	–	×	×	×	×	×	–	×	–
Whangateau Harbour	–	–	×	–	×	–	×	–	×	–
Campbells Bay	–	–	×	×	×	–	×	–	×	–
Castor Bay	–	–	×	×	×	–	×	–	×	–
Milford Beach	–	–	×	×	×	–	×	–	×	–
Amodeo Bay	–	–	×	–	×	×	×	–	×	–
Wilson Bay	–	–	×	–	×	×	×	–	×	–
Raglan	–	–	×	×	×	×	×	.	×	–
Noises	–	–	×	×	×	×	×	–	×	–

Continued on next page

TABLE 2—*continued*

	Situation			Substrate				Presence		
	Reefs or Islands	Open Coast	In harbour	Sand	Boulders	Gravel	Silt	*C. insularum* present	*C. lavauxi* present	*Cyclograpsus* absent
Tokerau Beach	–	×	–	×	–	–	–	–	–	×
Ahipara	–	×	–	×	–	–	–	–	–	×
Taipa	–	×	–	×	–	–	–	–	–	×
Coopers Beach	–	×	–	×	–	–	–	–	–	×
Tauranga Bay	–	×	–	×	–	–	–	–	–	×
Woolleys Bay	–	×	–	×	–	–	–	–	–	×
Matapouri	–	×	–	×	–	–	–	–	–	×
Ocean Beach (Whangarei)	–	×	–	×	–	–	–	–	–	×
Waipu Cove	–	×	–	×	–	–	–	–	–	×
Langs Beach	–	×	–	×	–	–	–	–	–	×
Pakiri	–	×	–	×	–	–	–	–	–	×
Matata	–	×	–	×	–	–	–	–	–	×
Ohope	–	×	–	×	–	–	–	–	–	×
Whangaroa	–	–	×	–	–	–	×	–	–	×
Kerikeri	–	–	×	–	–	×	–	–	–	×
Russell	–	–	×	–	–	×	–	–	–	×
Opua	–	–	×	–	–	×	×	–	–	×
Paihia	–	–	×	–	–	–	×	–	–	×
Rawhiti	–	–	×	×	–	–	–	–	–	×
Whangaruru	–	–	×	–	–	–	×	–	–	×
Helena Bay	–	×	–	–	–	×	–	–	–	×
Tamaterau Bay	–	–	×	×	–	–	×	–	–	×
Parua Bay	–	–	×	–	–	–	×	–	–	×

boulders, but *C. lavauxi* tolerated up to 63% sand and silt (i.e., sand and silt = particles smaller than 1.00 mm, from 0 to 5 ϕ).

Where *Cyclograpsus lavauxi* was found, the substrate below mid-tide level varied from solid rock through boulders and gravel to mud. The crab can occur in a restricted and sparse upper shore fringe. The larger grapsids, *Leptograpsus variegatus* (Fabricius) and *Plagusia capensis* (Linnaeus), which occur in the eulittoral and sublittoral respectively, were seldom found on shores where *C. lavauxi* (and not *C. insularum*) was present but were usually found on shores where *C. insularum* occurred, i.e., where there is typically a substrate of base-rock below mid-eulittoral.

Cyclograpsus lavauxi may be excluded by the effects of severe wave attack on exposed shores. At Lion Rock, north of the Bay of Islands (*see* Fig. 2) where *C. insularum* alone was found, the boulder beach is very narrow, and the gravel beneath the boulders at the top of the beach remains as wet at low tide as the mid-eulittoral gravel does at most other *C. insularum* localities. There was no higher fringe of well drained boulders and gravel, the usual habitat of *C. lavauxi*.

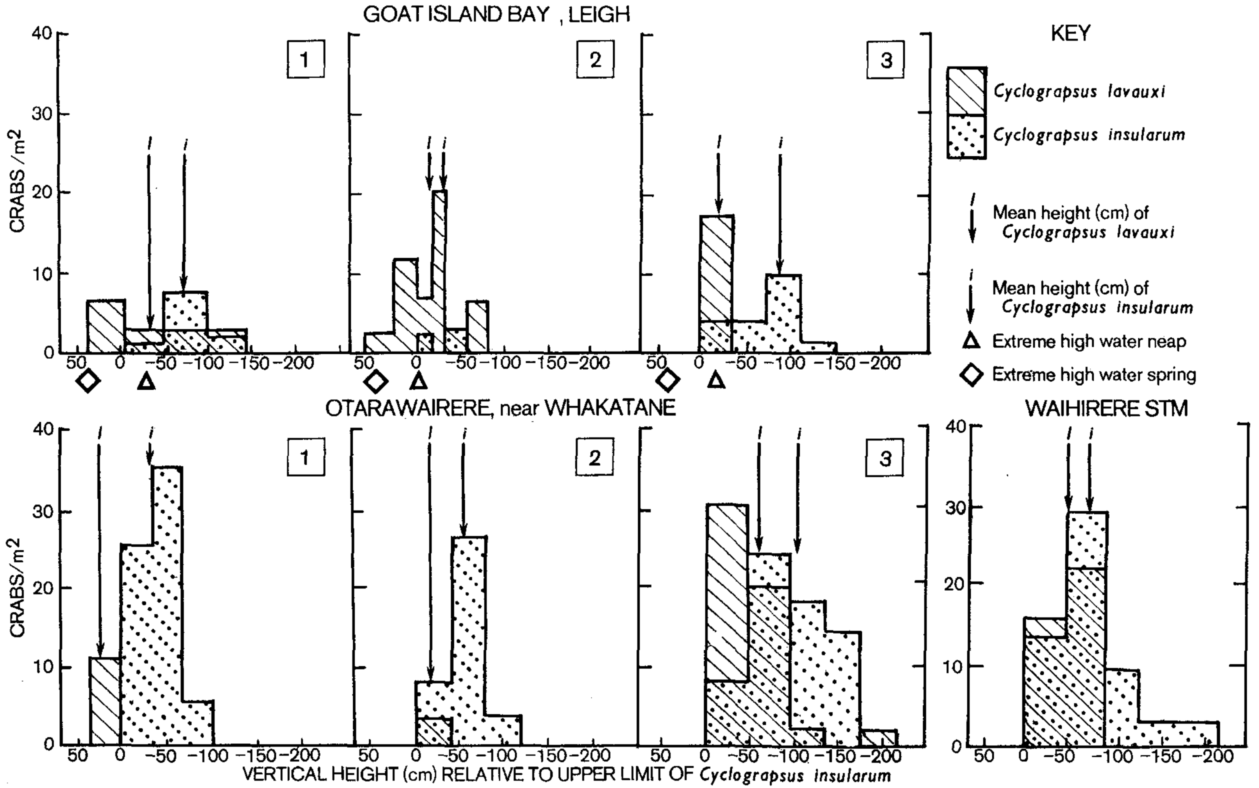


FIG. 3—Histograms showing the distribution of the grapsid crabs *Cyclograpsus insularum* and *C. lavauxi* vertically on the shore in seven separate colonies. On the horizontal axis, 0 is the upper limit of *C. insularum* on the shore and the vertical height above and below this limit is given in centimetres. Mean levels, as indicated by arrows, were calculated from the formula given in the methods section.

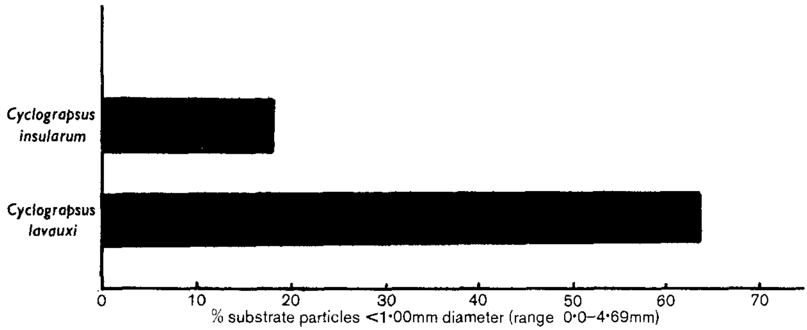


FIG. 4—Occurrence of *Cyclograpsus lavauxi* and *C. insularum* in relation to the presence of particles smaller than 1.00 mm (i.e., sand, silt, and clay) beneath boulders in the habitat.

The densest population of *Cyclograpsus insularum* was found at Lady Alice Island, Hen and Chickens Islands, in February 1970 (Fig. 5). Very large numbers of *C. insularum* (approximately $1000/m^2$) occurred beneath the boulders, which were covered with decaying algae, at the drift line. On a second visit a month later, there was no decaying algal drift, the beach had steepened, but *C. insularum* was still present in high densities at the top of the beach where the algae had been.

DISCUSSION

Dell and Marshall (1967) suggest that *Cyclograpsus insularum* evolved in isolation at Lord Howe Island, Norfolk Island and the Kermadec Islands, and that recent invasions by current borne larvae have resulted in isolated populations on New Zealand shores, previously the domain of the indigenous species *C. lavauxi*. They suggest that interspecific competition has proved an obstacle to colonisation by *C. insularum* because of similar ecological requirements. *Cyclograpsus insularum* is obviously more widely distributed than previously known, and it appears to have more restricted ecological preferences of substrate type and intertidal levels than does *C. lavauxi*.

Several questions may repay further enquiry. Firstly, what characteristics of a sheltered shore offer a suitable habitat for *Cyclograpsus lavauxi* but not for *C. insularum*? Secondly, what are the breeding seasons or other means of reproductive isolation between the two species? Wear (1970) gives the breeding periods at Otarawairere as mid-October to late December for *C. lavauxi* and mid-August to mid-October for *C. insularum*. The author has collected *C. insularum* in berry in early June from Ti Point near Leigh and in July from Bream Head and Taiharuru. *C. lavauxi* was found in berry at Goat Island Bay in March 1969. Further work will clearly be required upon the possible seasonal

FIG. 5—Boulder beach, Lady Alice Island, Hen and Chickens group, where *Cyclograpsus insularum* was found at densities of approximately 1000/m^2 beneath the belt of algae near the top of the shore.

separation of the breeding periods of these two crabs. Thirdly, what are the determining factors restricting each species to its own shore level and substrate type?

Further work, to be reported later, on physiological tolerances to temperature, salinity and desiccation will help to clarify the niche separation of these two species.

ACKNOWLEDGMENTS

I wish to thank Drs R. K. Dell and J. C. Yaldwyn of the Dominion Museum, Wellington, for their helpful advice and the positive identification of *Cyclograpsus insularum*. I am also indebted to my father Mr R. L. G. Bacon and especially Mr R. V. Grace for assistance in field work and photography. I thank Professor J. E. Morton and Dr B. A. Foster for critical reading of the manuscript. I am grateful for the use of facilities at the Marine Research Laboratory, Leigh.

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