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**SYSTEMATICS OF THE NEW ZEALAND
FRESHWATER CRAYFISH *PARANEPHROPS*
(CRUSTACEA: DECAPODA: PARASTACIDAE)**

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**INVERTEBRATE
ZOOLOGY**
Crustacea

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**SYSTEMATICS OF THE NEW ZEALAND
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SUMMARY

The systematics of the endemic New Zealand genus *Paranephrops* (Family Parastacidae) are re-examined. Specific characters previously used to separate *P. zealandicus* and *P. setosus* are considered to be inadequate, and the two species are merged. The genus, as now proposed, contains only two species: *P. planifrons*, occupying the whole of the North Island and northern and western areas of the South Island, and *P. zealandicus*, occupying eastern and southern parts of the South Island and Stewart Island.

INTRODUCTION

Up to the present time it has generally been considered that three species of the endemic genus *Paranephrops* White occur in New Zealand. White (1842) described the type species, *P. planifrons*, which inhabits the whole of the North Island and the Marlborough, Nelson and West Coast districts of the South Island. He also (White 1847) described *Astacus zealandicus* from the South Island, its name being subsequently changed to *P. zealandicus* by Miers (1874). Finally, Hutton (1873) named a third species from the South Island as *P. setosus*.

The three species have been accepted by all authors except Chilton (1889) who advocated merging *P. zealandicus* and *P. setosus* under the name *P. neo-zealandicus*. He retracted, however, in a later paper (Chilton 1900) largely in deference to Faxon (1898), who had accepted the separate identities of these two species. Hutton himself, according to Chilton (1889), would not have advanced his new species (*P. setosus*) had he possessed White's description of *P. zealandicus*.

After examination of new collections and of material held by the Canterbury Museum, Christchurch, the present author believes that there is no justification for separating *P. zealandicus* and *P. setosus*, and evidence is presented below to justify merging the two species.

MATERIAL

A total of 320 specimens were examined from areas to which *P. zealandicus* and *P. setosus* have been attributed. Most came from the collection of crayfishes held by the Fisheries Research Division in

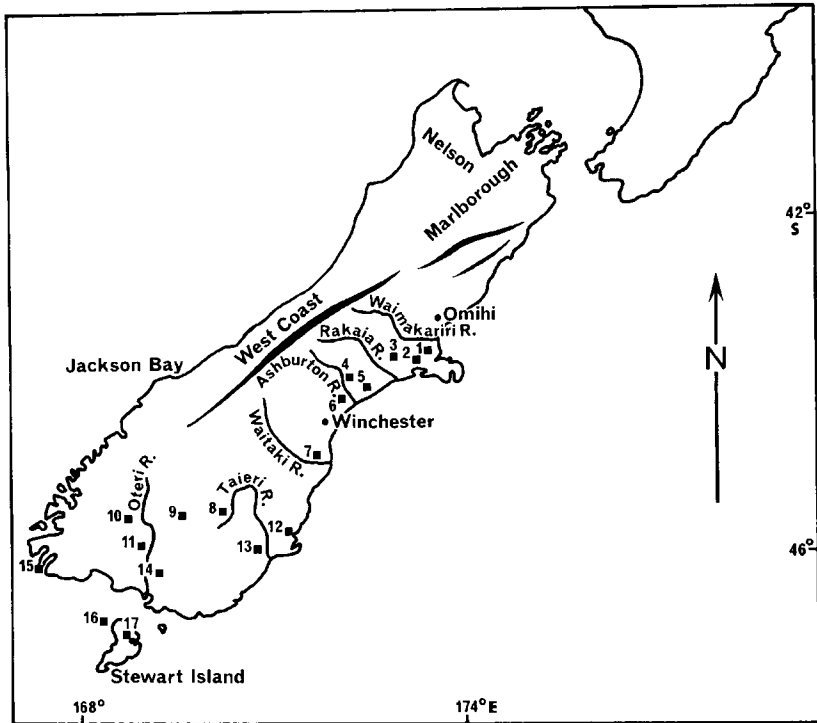


FIG. 1.—Sketch map of South Island, New Zealand, showing places and districts mentioned in the text and positions of samples of *Paranephrops* numbered in Table 1.

Wellington, but specimens from Stewart Island, Coal Island and the Avon River were borrowed from the Canterbury Museum collection. Figure 1 and Table 1 show the localities from which the samples originated.

A number of measurements were made with needle-pointed dividers. These are shown in Fig. 2. Analysis of linear measurements is graphed (Figs 3, 4) according to the method advocated by Hubbs and Hubbs (1953).

The presence or absence of a keel mid dorsal on the rostrum was noted and the spines on the rostral margins and keel were counted. Other non-measurable characters examined were the shape of the cephalothorax and the nature of projections on the surface of the cephalothorax and propod of the cheliped, i.e., whether spinous or tuberculate.

TABLE 1—Details of samples of *Paranehrops* taken in the South Island, New Zealand

| STATION AND SAMPLE NO. | LOCALITY | n |
|------------------------|--|----|
| 1 | River Avon, near Christchurch | 12 |
| 2 | River Halswell, near Christchurch | 12 |
| 3 | Selwyn River: water race, near Hororata | 24 |
| 4 | Ashburton River: Stony Creek, near Mt. Somers | 66 |
| 5 | Ashburton River: Remington Creek, near Lagmhor | 6 |
| 6 | Orari River: tributary of Coopers Creek | 20 |
| 7 | Waitaki River: tributary of Waikakahi River | 29 |
| 8 | Taieri River: creek, near Ranfurly | 1 |
| 9 | Mataura River: creek, near Athol | 4 |
| 10 | Lake Thomas | 29 |
| 11 | Oreti River: water race, near Castle Rock | 21 |
| 12 | Waitati River: tributary at Waitati | 68 |
| 13 | Waipori River: Lake Mahinerangi | 14 |
| 14 | Oreti River: Otapiri Stream | 4 |
| 15 | Coal Island, Preservation Inlet | 2 |
| 16 | Codfish Island, off Stewart Island | 6 |
| 17 | Paterson Inlet, Stewart Island | 2 |

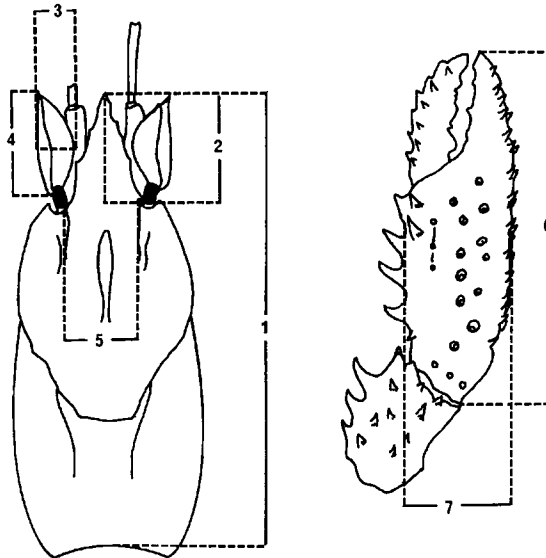


FIG. 2—Measurements made on all samples of *Paranehrops*: left—cephalothorax measurements, 1 = total length of cephalothorax, 2 = length of rostrum, 3 = width of squame, 4 = length of squame, 5 = width of rostrum; right—cheliped measurements, 6 = length of propod, 7 = width of propod.

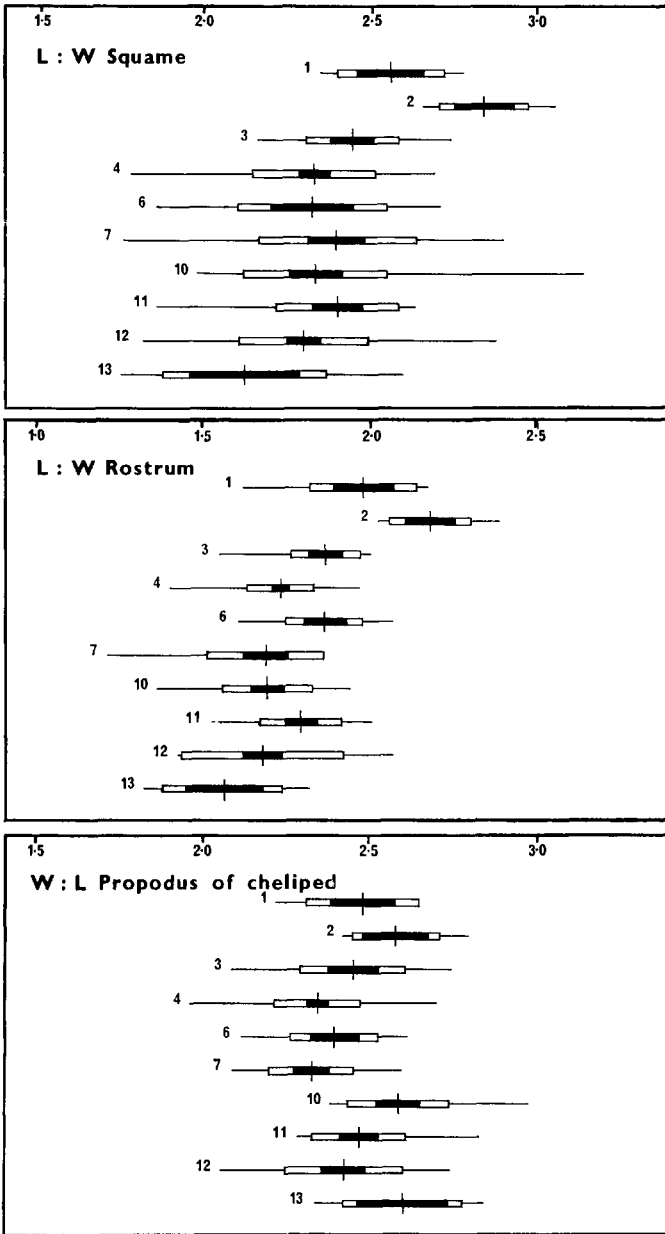


FIG. 3.—Analysis of linear measurements from 10 samples of *Paranephrops* numbered as in Table 1, after the method of Hubbs and Hubbs (1953): upper—ratio of length to width of squame; middle—ratio of length to width of rostrum; lower—ratio of length to width of propodus of cheliped. In each trace, vertical line = mean, black bar = two standard errors on each side of mean, white bar = one standard deviation on each side of mean, and horizontal line = range.

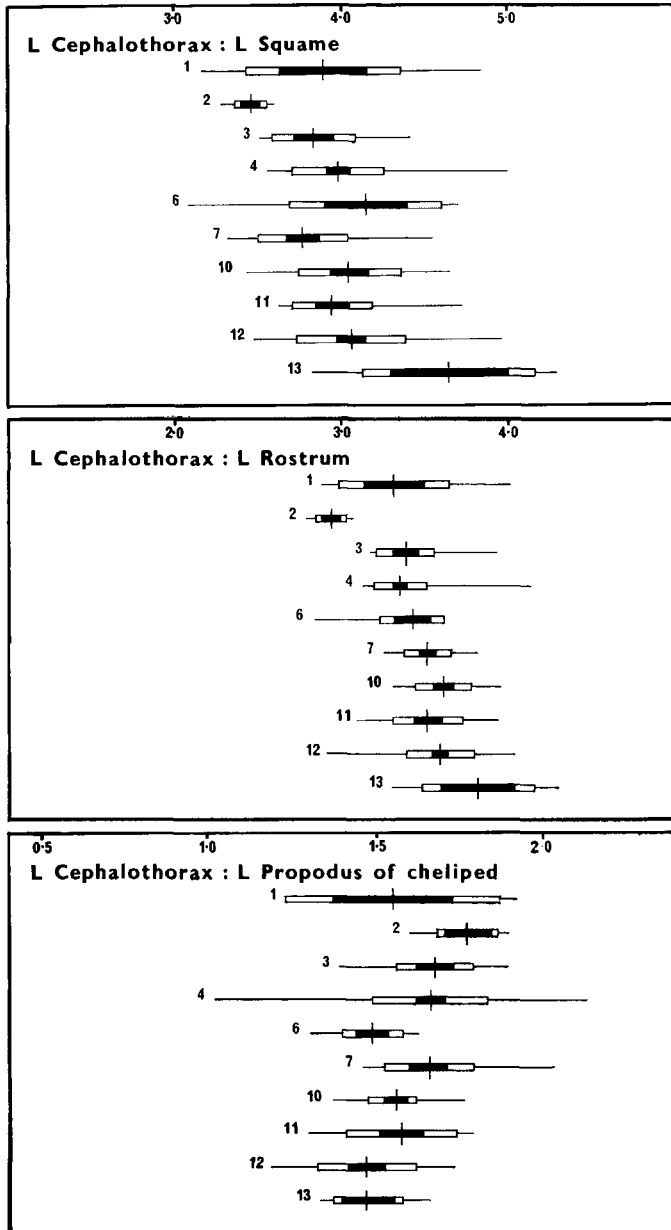


FIG. 4—Analysis of linear measurements from 10 samples of *Paranephrops* numbered as in Table 1, after the method of Hubbs and Hubbs (1953): upper—ratio of length of cephalothorax to length of squame; middle—ratio of length of cephalothorax to length of rostrum; lower—ratio of length of cephalothorax to length of propodus of cheliped. In each trace, vertical line = mean, black bar = two standard errors on each side of mean, white bar = one standard deviation on each side of mean and horizontal line = range.

SYSTEMATICS

Family PARASTACIDAE

Genus **Paranephrops** White, 1842

Paranephrops White, 1842, *Zool. Misc.* 2, 78-9; Miers, 1874, "Zool. Voy. *Erebus* and *Terror*", p. 4; Faxon, 1898, *Proc. U.S. natn. Mus.* 20, 677.

Astacus White, 1847 (in part), *Proc. zool. Soc. Lond.* 15, 123.

TYPE SPECIES: *Paranephrops planifrons* White, 1842.

DIAGNOSIS: The following is my diagnosis of the genus.

Cephalothorax (including rostrum) twice as long as its greatest breadth, spinous or tuberculate in its cephalic region and in thoracic region close to cervical groove, tuberculate in remainder of thoracic region. Median cephalic carina present. Rostrum elongate, triangular, pointed, the margins raised and bearing spines; ventral keel toothed. A small spinous, ventro-lateral cephalic ridge just forward of cervical groove. Areola broad, open posteriorly. Sternal keel sharp; lateral processes on each side of keel pointed. Antero-lateral extension of branchio-cardiac groove short and converging on cervical groove.

Abdomen slightly narrower and shorter than cephalothorax; smooth dorsally except for a few scattered setae on the posterior margins of each somite; lightly setiferous on sides of pleura. First somite with pleural lobes very small, partly covered by a forward projection from the second somite. Anterior margins of pleural lobes convex, carrying a row of short setae; posterior margins almost straight, naked.

Eyes large. Antennae long, reaching back well beyond posterior border of cephalothorax; inner margin of antennal peduncle with a row of long, close-set setae. Antennal squame large, projecting slightly beyond rostrum. Cheliped about $1\frac{1}{2}$ times as long as cephalothorax; strongly spinous on the mesial (inner) surface of carpus and propod; small spines or tubercles on dorsal and ventral surfaces; opposable margins of propod and dactyl each with a few small tubercles; propod and dactyl opening and closing in the horizontal plane. Male genital papilla on walking leg 4 broad and projecting, uncalcified. Telson entire, rectangular except for rounded posterior margin; membranous distally; spines on each lateral margin. Outer ramus of uropod with transverse suture carrying a row of fine spines, membranous distal to the suture; inner ramus entire with a spine on outer margin and with a median carina ending distally in a small spine near posterior margin; membranous distally. Stem of each podobranch with a narrow membranous wing carrying hooked filaments.

Gill formula (20 + rudimentary + epipodite) made up as follows:

| | Podobranch | Anterior Arthrobranch | Posterior Arthrobranch | Pleurobranch |
|---------------|------------|--------------------------|---------------------------|--------------|
| Maxilliped 1 | Epipodite | 0 | 0 | 0 |
| Maxilliped 2 | 1 | 1 | 0 | 0 |
| Maxilliped 3 | 1 | 1 | 1 | 0 |
| Cheliped | 1 | 1 | 1 | 0 |
| Walking leg 1 | 1 | 1 | 1 | 1 |
| Walking leg 2 | 1 | 1 | 1 | 1 |
| Walking leg 3 | 1 | 1 | Rudimentary | 1 |
| Walking leg 4 | 0 | 0 | 0 | 1 |

DISCUSSION: *Paranephrops* appears to be related to a group of Australian genera containing *Euastacus* Clark, *Euastacoides* Riek, *Astacopsis* Huxley, and *Cherax* Erichson. The key characters of this group have been defined by Riek (1967) as: antero-lateral extension of branchiocardiac groove fused to cervical groove; cheliped propod and dactyl moving in a horizontal plane; pleural lobe of abdominal somite 1 partly covered by a forward extension of the pleural lobe of the abdominal somite 2. These characters are found in *Paranephrops* with the exception that the antero-lateral extension of the branchiocardiac groove does not quite meet the cervical groove but fades out before junction. Within this group *Cherax* is most similar to *Paranephrops*. Both genera have the male genital papilla large, fleshy, and uncalcified. The rudimentary condition of the posterior arthrobranch of walking leg 3 in *Paranephrops* is also found in most species of *Cherax*. The general external appearance of both genera is similar, but *Cherax* lacks the spinous or tuberculate armature of cephalothorax and propod of the cheliped found in *Paranephrops*.

KEY TO SPECIES

- Propod of cheliped densely pubescent; antenna when reflexed reaching no further than abdominal somite 3. *Paranephrops zealandicus*
- Propod of cheliped naked except for a few scattered setae; antenna when reflexed reaching well beyond abdominal somite 4. *P. planifrons*

Paranephrops planifrons White, 1842 (Fig. 5)

Paranephrops planifrons White, 1842, *Zool. Misc.* 2, 79 (Holotype: Brit. Mus. (Nat. Hist.); Type locality, Waihou River, North Island, New Zealand); Miers, 1874, "Zool. Voy. *Erebus* and *Terror*," p. 4; Chilton, 1889, *Trans. Proc. N.Z. Inst.* 21, 249; Faxon, 1898, *Proc. U.S. natn. Mus.* 20, 678; Chilton, 1900, *Trans. Proc. N.Z. Inst.* 32, 14-15; Archey, 1915, *Trans. Proc. N.Z. Inst.* 47, 311.
Paranephrops tenuicornis Dana, 1852, "U.S. Explor. Exped." 13 (1), 527.

Rostrum with raised lateral margins bearing 2-6 teeth; no dorsal rostral carina; ventral rostral keel with 1-2 teeth. Sides of carapace almost parallel; sharp, curved spines on cephalic region; usually a line of spines extending down anterior edge of carapace below orbit, frequently a patch of spines posterior to orbit; small specimens almost smooth except for 1-2 spines on ventro-lateral cephalic ridge; thoracic region smooth or tuberculated, with spines in larger specimens close to cervical groove; lateral borders of areola weakly outlined by cardiac grooves. Inner margin of antennal peduncle with single row of close-set setae.

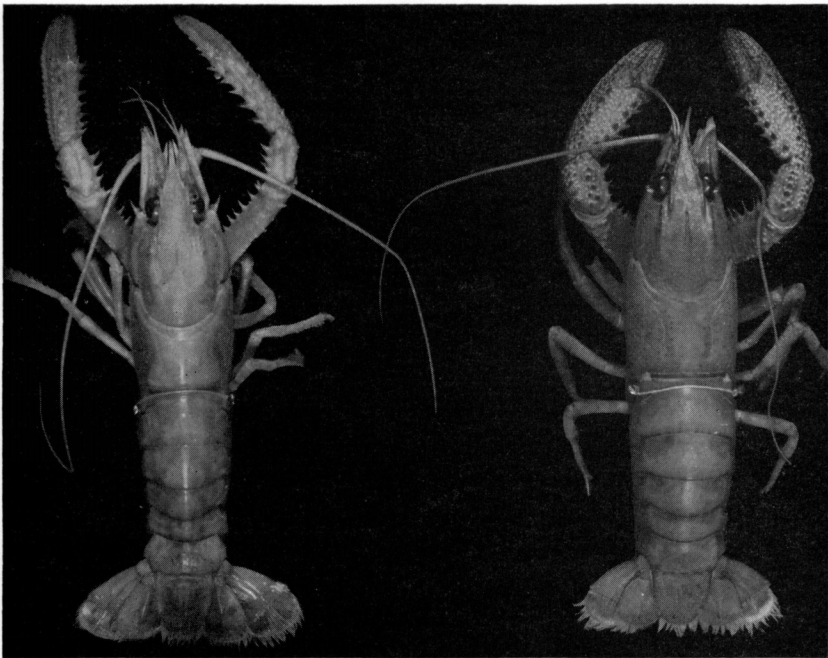


FIG. 5—*Paranephrops planifrons*: left, specimen from Naike Stream, tributary of the lower Waikato River, North Island; right, specimen from a sub-tributary of the Mokau River system, North Island. Both specimens held by Fisheries Research Division.

Cheliped propod approximately three times as long as broad, carrying a few isolated setae; two rows of large spines on mesial edge of propod and two rows of small spines on outer edge; one row of large spines on ventral surface with scattered small spines on both ventral and dorsal surfaces. Colour in life variable, usually mottled red-brown, sometimes almost black, occasionally red. Largest specimen recorded (by the author) 72.1 mm carapace length.

DISCUSSION: *Paranephrops planifrons* shows considerable variation in the ratio of length to width of antennal squame, rostrum, and propod of the cheliped. In crayfish from the north of the North Island these parts are generally more slender than they are in crayfish from further south (Fig. 5).

The geographic range of *P. planifrons* extends from the far north of New Zealand, south to the Marlborough, Nelson, and West Coast districts of the South Island. The most southern record is from Jackson Bay (latitude 40°S) (see Fig. 1). The species is found in a wide variety of habitats: lakes and ponds, large and small running waters, swamps, and on gravel and mud substrates. Eldon (1968) has described it as inhabiting swamps (Pakihi bogs) near Kumara, west coast of the South Island, where surface mud is at times completely dry. The species commonly burrows, but may also live beneath stones where the banks are not suitable for burrowing.

Paranephrops zealandicus (White, 1847) (Fig. 6)

- Astacus zealandicus* White, 1847, *Proc. zool. Soc. Lond.* 15, 123 (Holotype: Brit. Mus. (Nat. Hist.); Type locality, New Zealand, no further locality data).
Astacoides tridentatus Wood-Mason, 1876, *Proc. Asiat. Soc. Beng.*, p. 4.
Paranephrops zealandicus: Miers, 1874, "Zool. Voy. *Erebus* and *Terror*," p. 4; Faxon, 1898, *Proc. U.S. natn. Mus.* 20, 680-1; Chilton, 1900, *Trans. Proc. N.Z. Inst.* 32, 15; Archey, 1915, *Trans. Proc. N.Z. Inst.* 47, 312.
Paranephrops setosus Hutton, 1873, *Ann. Mag. nat. Hist.* 71, 402; Faxon, 1898, *Proc. U.S. natn. Mus.* 20, 680-1; Chilton, 1900, *Trans. Proc. N.Z. Inst.* 32, 16; Archey, 1915, *Trans. Proc. N.Z. Inst.* 47, 312.
Paranephrops neo-zealanicus Chilton 1889, *Trans. Proc. N.Z. Inst.* 21, 249-50.

Rostrum with raised lateral margins bearing 3-6 teeth; dorsal rostral keel sometimes present; ventral rostral keel with 0-2 teeth. Sides of carapace nearly parallel or bulging in the thoracic region, carrying numerous scattered spines or tubercles which increase in number with age; lateral borders of areola strongly marked by the cardiac grooves. Propod of the cheliped about $2\frac{1}{2}$ times as long as broad, densely pubescent; one row of large spines on mesial edge of propod and two rows of small spines on outer edge; two rows of large spines or tubercles on ventral surface of propod and one row on dorsal, with an irregular scattering of smaller projections on both surfaces. Colour in life variable, usually shades of red-brown. Largest specimen recorded by the author 80.0 mm carapace length.

DISCUSSION: The characters used by Archey (1915) and earlier authors to distinguish *Paranephrops* from *P. zealandicus* were:

| <i>Paranephrops setosus</i> | <i>P. zealandicus</i> |
|---|---|
| Cephalothorax spinous | Cephalothorax tuberculate |
| Dorsal and ventral surfaces of propod of the cheliped spinous | Dorsal and ventral surfaces of propod of the cheliped tuberculate |
| Thoracic region rounded laterally | Thoracic region parallel sided |
| Antennal squame long and narrow | Antennal squame short and broad |
| Rostrum long and narrow | Rostrum short and broad |
| Dorsal keel on rostrum present | Dorsal keel on rostrum absent |

According to Archey, *Paranephrops setosus* is found from Winchester (in the Opihi basin) northward to Omihi (Waipara River basin), and *P. zealandicus* ranges from Winchester southward to Stewart Island. Archey also identified specimens from Tinwald (Ashburton River basin) as *P. zealandicus*, thus implying an overlap in this region (Opihi to Ashburton Rivers). It seems, therefore, that in Fig. 1 and Table 1, *P. setosus* would occupy stations 1-6 and *P. zealandicus* the remainder. The diagnostic features tabulated above will now be discussed:

ARMATURE OF CEPHALOTHORAX: All adult specimens from stations 1-3 (Avon, Halswell and Selwyn basins) were strongly spinous (as in Fig. 7A) and this condition occurred again in station 14 (Otapiri Stream in the Oreti basin). Stations 4-7, 12 and 13 (Ashburton, Orari, Waitaki, Waitati basins, and Lake Mahinerangi) contained both spinous and tuberculate specimens. All specimens from the remaining stations had a tuberculate cephalothorax (Fig 7B). The spinous condition of cephalothorax can therefore occur through most of the range from which the samples came, although it is more common in the north.

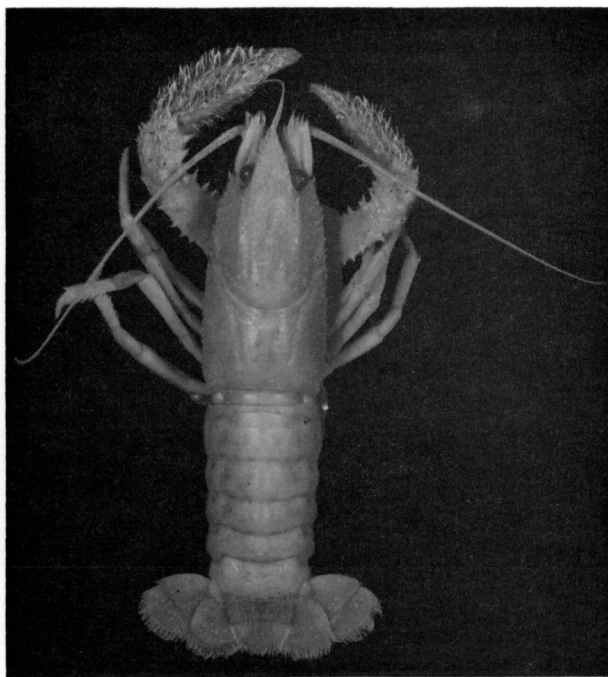


FIG. 6—*Paranephrops zealandicus*: specimen from a tributary of the Waikakahi River, Waitaki River system (Sample 7). Specimen held by Fisheries Research Division.

ARMATURE OF CHELIPED PROPOD: On the dorsal and ventral surfaces of the propod are rows of strong projections which may be spinous or tuberculate. The geographic distribution of the spinous and tuberculate condition was found to be the same as that described for armature of the cephalothorax. Some individuals had a spinous cephalothorax and tuberculate cheliped propods or vice versa. There appears to be no significant variation in the number of projections on the propod.

SHAPE OF CEPHALOTHORAX: A visual comparison of large specimens from every sample showed that the thoracic region was more rounded laterally in crayfish from stations 1-3 than it was in specimens from stations 8-17, in which the sides of the thoracic region were nearly parallel. In stations 4-7 both conditions occurred, though not systematically linked with variation in the other characters examined. In the most northern samples, therefore, crayfish showed a rounded or bulging cephalothorax and in the southern samples crayfish had the sides of the cephalothorax more nearly parallel. There is an area of overlap between these characters in the region between the Ashburton and the Waitaki river systems.

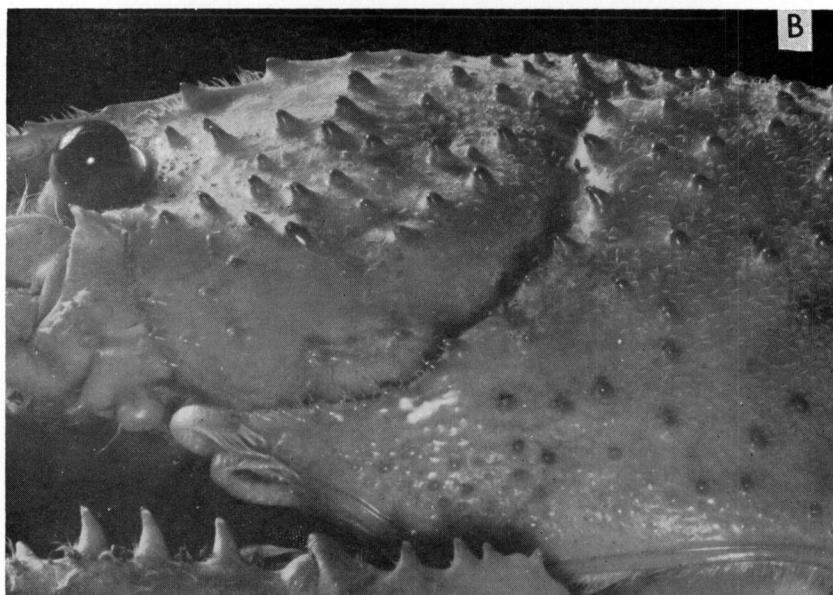
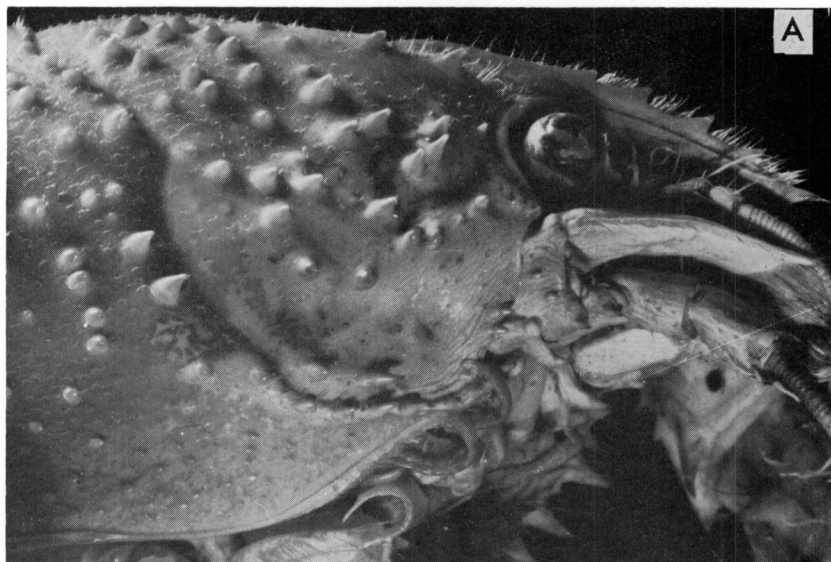


FIG. 7—*Paranephrops zealandicus*: specimens from a tributary of the Waitaki River (Sample 12) showing (A) mixed tubercles and spines on cephalothorax, (B) tuberculate cephalothorax. Specimens held by Fisheries Research Division.

SHAPE OF ANTENNAL SQUAME: The length and breadth of squame for every specimen were measured. The mean ratio of length to breadth is shown in Fig. 3 (upper) for each sample in which 10 or more specimens were measured. There was no systematic variation through the range over which samples were collected.

SHAPE OF ROSTRUM: The ratio of length to breadth of rostrum was measured in every specimen. The rostrum tended to become broader in the more southern populations (Fig. 3, middle).

DORSAL KEEL ON ROSTRUM: All specimens from stations 1-3 showed a pronounced dorsal keel. In stations 4-6 all specimens showed a weak keel. The crayfish in the remaining samples had no dorsal keel, except five of a total of eight specimens from stations 16 and 17 (Stewart Island), which had a weak keel. A dorsal keel is therefore present in the northern part of the range, but not usually in the south.

Some additional ratios have been calculated and are shown in Figs 3 and 4. In none of these ratios was there any systematic variation.

On the basis of the characters discussed there seems to be no reason for maintaining *Paranephrops setosus* and *P. zealandicus* as separate species and it is therefore proposed to merge them under the senior synonym of *P. zealandicus*.

The geographic range of *Paranephrops zealandicus* extends down the eastern side of the South Island from the Waipara River in North Canterbury (Archev's (1915) most northerly record), across the Canterbury Plains, Otago, and Southland, to Stewart Island. There are no records of crayfish from the mountain streams of the eastern slopes of the Southern Alps and the author could not find any crayfish in the streams of the Kaikoura Range between the Clarence and Waiiau Rivers. The species has been recorded from a variety of different habitats: gravel-bedded and muddy streams, small ponds, and lakes. Like the previous species, *P. zealandicus* burrows where the bed or the banks are suitable.

DISTRIBUTION OF THE GENUS *Paranephrops*

The two present allopatric species of *Paranephrops* must have been separated at least from Early Pliocene times, for the geographical barrier between them is the Kaikoura-Southern Alps divide, which, according to Fleming (1962), reached essentially its present configuration at the beginning of the Pliocene.

The presence of *P. planifrons* on both sides of Cook Strait and its failure to cross the Kaikoura-Southern Alps divide is paralleled by the distribution of several other members of the native fauna. Two freshwater fishes, *Galaxias divergens* Stokell and *Neochanna apoda* Günther, are found in southern North Island and the Nelson and West Coast districts of the South Island (McDowall 1966). The woodlice *Spherillo ambitiosus* Budde-Lund and *S. macmahoni* (Chilton) range from the North Island into the north-western part of the South Island, and the

former species extends down the western flanks of the Southern Alps (Hurley 1961). Similar patterns of distribution are found for the millipede *Procyliosoma tuberculatum* Silvestri (Holloway 1956), the terrestrial gastropods *Phenacohelix stokesi* (Smith) and *P. pilula* (Reeve) (Cumber 1961) and the genus *Paryphanta* (Te Punga 1953), and several species of harvestmen (Opiliones) (Forster 1954). A land connection existed across Cook Strait during the late Pleistocene (Fleming 1962), which thus provided access between the North and South Islands. Possibly the Kaikoura-Southern Alps divide is much more important as a boundary to distribution of many elements of the New Zealand fauna than is Cook Strait.

ACKNOWLEDGMENTS

The author thanks those members of the Fisheries Research Division who helped to collect the specimens and compile the statistics required for this paper, and the staff of the Canterbury Museum, who supplied some of the specimens from their collection.

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