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**SEXUAL AND OTHER DIFFERENCES IN
COPEPODITE STAGES OF SOME NEW ZEALAND
CALAMOECIA AND BOECKELLA SPP.
(COPEPODA: CALANOIDA)**

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ABSTRACT

Differences between males and females in the morphology of the fifth legs were found in stage IV copepodites of *Boeckella hamata* and in stage V copepodites of *B. hamata*, *B. propinqua*, *B. dilatata*, *B. triarticulata*, and *Calamoecia lucasi*. There were also sexual differences in overall body size. In *B. hamata*, *B. triarticulata*, and *B. dilatata*, the differences were sufficiently obvious for stage V copepodites to be sexed at low magnifications. The diagnostic features of all stages are described.

INTRODUCTION

To calculate the biomass and production of copepod populations, the numbers and mean weights of each copepodite stage in samples of the population must be determined. Because of the often large differences in size between adult males and females, separate calculations are usually made for the adults (CVI) of each sex. We have observed, however, that sexual differences in size may also exist in pre-adult stages of some species of *Boeckella*, which ideally should also be taken into account in production and biomass estimates.

In Northern Hemisphere genera of freshwater calanoid copepods, the sexes can be distinguished, even at stage CIV, by slight differences in the morphology of the fifth legs (Wilson & Yeatman 1959). This is also true of the Australian species *Boeckella opaqua* (Fairbridge 1945). Bayly (1963) described the male and female fifth legs of stage CV copepodites of *B. propinqua*. We have examined five species of New Zealand freshwater calanoids to determine whether such morphological differences existed, and whether it was feasible to sex copepodites at the low magnifications of $\times 25-80$ used for routine enumeration of zooplankton.

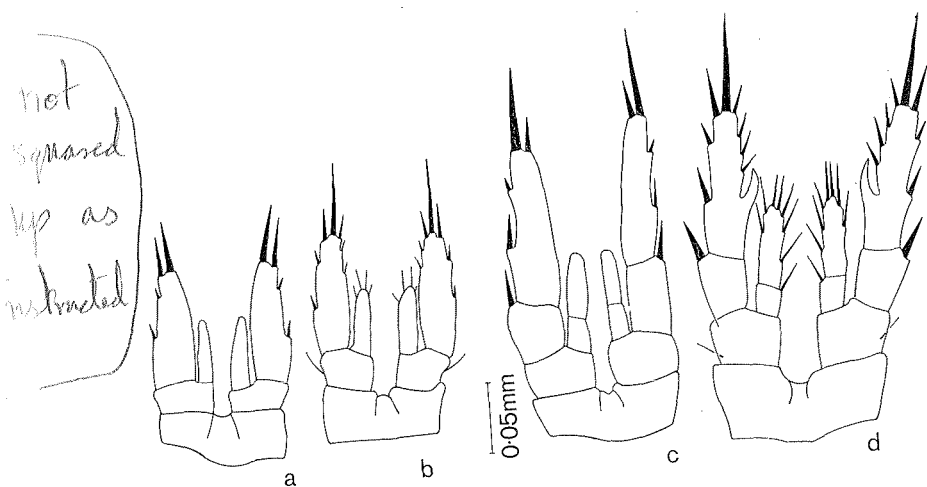


FIG. 1.—*Boeckella hamata*. Anterior views of fifth legs: a—CIV male; b—CIV female; c—CV male; d—CV female. All to same scale.

METHODS

The species examined are listed in Table 1. For each species mixed groups of copepodite (C) stages IV–VI were scanned under a dissecting microscope at magnifications ranging from $\times 10$ to $\times 80$, to establish possible criteria for distinguishing the sexes. To confirm sexual differences detected at these magnifications, and to examine dimorphism more fully, the fifth legs of several specimens of each copepodite stage were removed and mounted in polyvinyl alcohol on microscope slides. Drawings of the legs were made at magnifications of up to $\times 400$ with the aid of a camera lucida. Lengths were measured at $\times 80$ on preserved specimens from the front of the head, mid-dorsally, to the posterior dorsal edge of the metasome.

TABLE 1—Locality and date of collection of the copepod species examined

Species	Locality	Grid reference NZMS1	Date of Collection
North Island			
<i>Calamoecia lucasi</i>	Lake Rotoiti	N76/830516	13 March 1968
<i>Boeckella propinqua</i>	Lake Taupo	N94/530034	2 February 1970
South Island			
<i>Boeckella hamata</i>	Tomahawk Lagoon, Dunedin	S164/188568	19 March 1970
<i>Boeckella dilatata</i>	Lake Hayes	S132/68007	10 February 1973
<i>Boeckella triarticulata</i>	Ardlui Dam, Sutton	S154/814063	19 March 1962

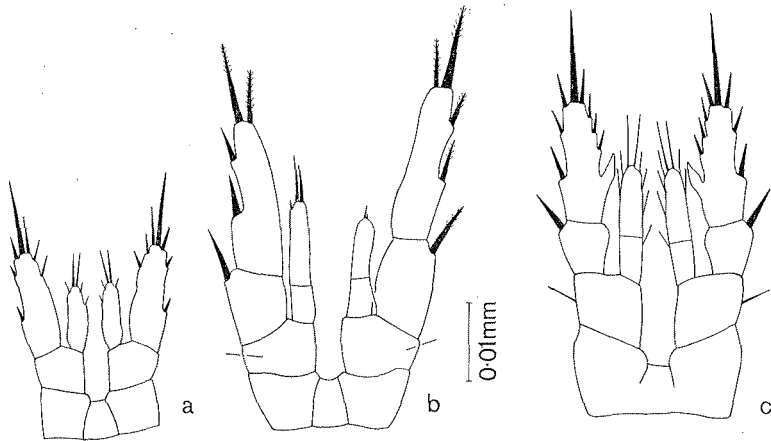


FIG. 2—*Boeckella dilatata*. Anterior views of fifth legs: a—CIV; b—CV male; c—CV female. All to same scale.

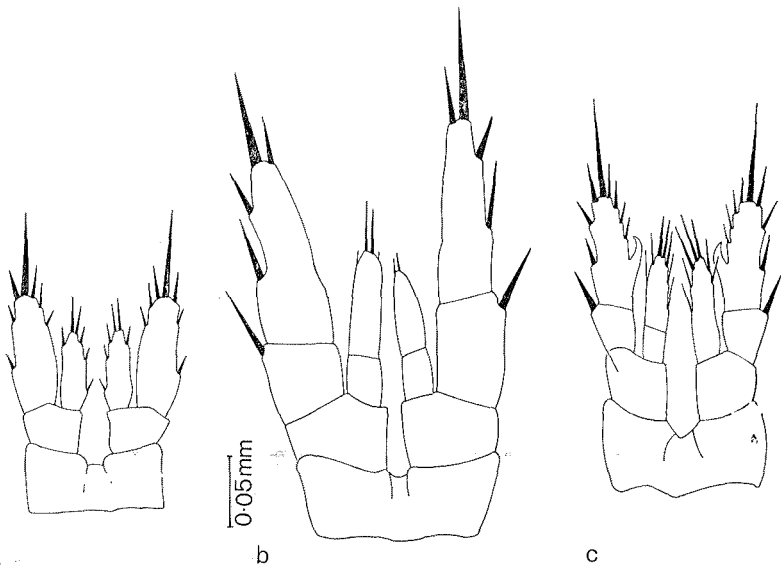


FIG. 3—*Boeckella triarticulata*. Anterior views of fifth legs: a—CIV; b—CV male; c—CV female. All to same scale.

MORPHOLOGY OF THE FIFTH LEGS

The form of the fifth legs of stages CIV and CV is shown in Figs 1-5.

STAGE IV

In this stage, the endopodite and exopodite are characteristically one-segmented in all species (Figs 1a, b; 2a; 3a; 4a, b; 5a). In *Boeckella*

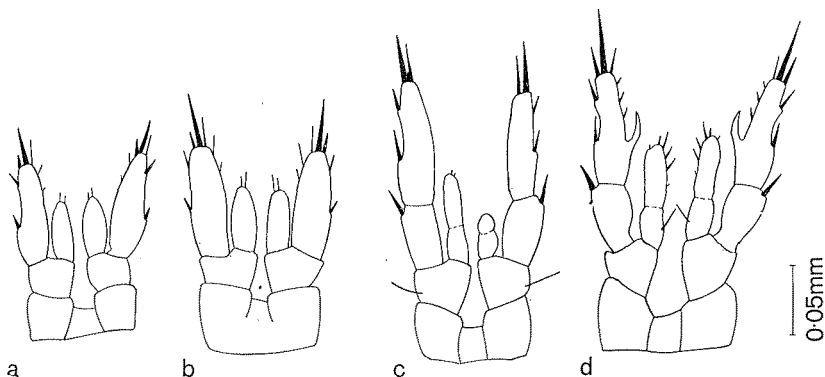


FIG. 4—*Boeckella propinqua*. Anterior views of fifth legs: a—CIV male; b—CIV female; c—CV male; d—CV female. All to same scale.

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not reduced as instructed
v

TABLE 2—Lengths (mm) of the cephalothorax of five species of freshwater calanoid copepods from New Zealand (M = mean; R = range; n = number of specimens)

Species		CIV	♀ CV	♂ CV	♀ CVI	♂ CVI
<i>Calamoecia lucasi</i> Lake Rotoiti 13 March 1968	M	0.48	0.54		0.63	0.58
	R	0.45–0.50	0.52–0.57		0.60–0.65	0.55–0.62
	n	20	20		20	20
<i>Boeckella dilatata</i> Lake Hayes 10 Feb. 1973	M	0.59	0.79	0.72	1.00	0.90
	R	0.55–0.62	0.75–0.82	0.67–0.75	0.95–1.05	0.85–0.95
	n	20	20	20	20	20
<i>B. hamata</i> Tomahawk lagoon 19 March 1970	M	♀ 0.67 ♂ 0.59	0.81	0.68	0.91	0.72
	R	♀ 0.64–0.69 ♂ 0.57–0.63	0.79–0.84	0.65–0.69	0.87–0.96	0.68–0.79
	n	♀ 15 ♂ 12	16	15	30	30
<i>B. propinqua</i> Lake Taupo 2 March 1970	M	0.57	0.68	0.65	0.78	0.70
	R	0.52–0.62	0.67–0.72	0.65–0.67	0.75–0.82	0.65–0.75
	n	20	10	10	20	20
<i>B. triarticulata</i> Ardlui Dam, Sutton 19 March 1962	M	0.84	1.06	0.99	1.40	1.32
	R	0.77–0.89	1.00–1.13	0.96–1.01	1.27–1.57	1.23–1.39
	n	15	19	15	30	16

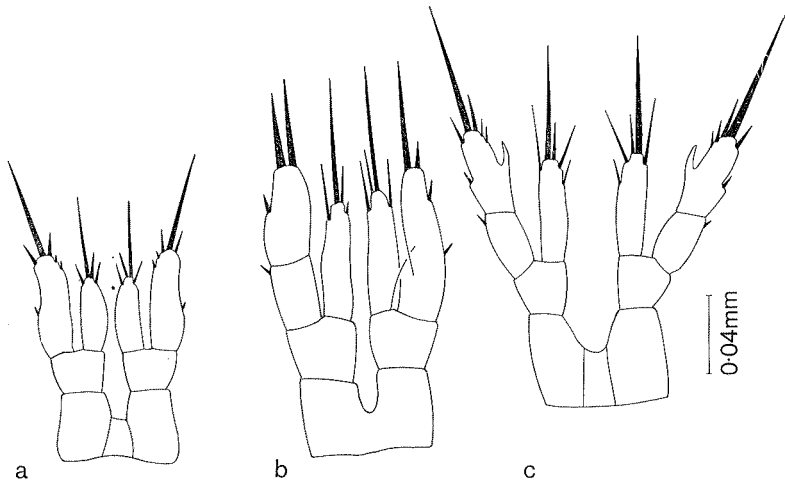


FIG. 5—*Calamoecia lucasi*. Anterior views of fifth legs: a—CIV; b—CV male; c—CV female. All to same scale.

hamata, the fifth legs of males can be distinguished from those of females by the presence of two nearly equal, long spines at the distal end of the exopodites, and the absence of spines on the inner margins of the exopodites (Fig. 1a, b). The other four species show no sexual differences in morphology of the fifth legs at this stage, although there are differences in size (e.g., *B. propinqua* in Fig. 4a, b).





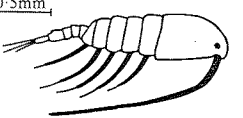
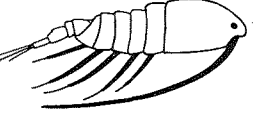
STAGE V

In the fifth legs of both sexes, the exopodites become two-segmented, and there are changes in both the length and the number of spines (Figs 1c, d; 2b, c; 3b, c; 4c, d; 5b, c). In males of both genera, the left and right exopodites are unequal in length, as are the endopodites also in *Boeckella*. The inequality in exopodite length is most noticeable in *B. triarticulata* and *B. dilatata*, in which species it can be detected at magnifications of $\times 25$ in intact animals. In females of both genera, there is a distinctive hook-shaped projection on the inner side of the distal segment of the exopodite which is retained in the adult.

LENGTH OF CEPHALOTHORAX

The cephalothoracic lengths of stages CIV–CVI of each species are given in Table 2. It is well established that food and temperature affect the size of adult copepods and presumably also of pre-adult stages. In an attempt to minimise differences in growth pattern due to seasonal changes in these environmental parameters, measurements were made on animals collected in late summer (Table 1). However, because habitats

TABLE 3—Diagnostic features of the copepodite stages of *Boeckella* and *Calamoecia*. The diagrams are of *Boeckella dilatata* with the mouthparts omitted, except in CIV.

Stage	Diagnostic Features	Appearance	Comments
CI	Number of pairs of well-developed legs : 2		Small rudiments of other limbs are present in these stages
CII	Number of pairs of well-developed legs : 3		
CIII	Number of pairs of well-developed legs : 4		
CIV	Number of pairs of well-developed legs : 5 Fifth legs short, approximately half the length of the fourth pair Abdomen 3-segmented Size: CIV ♀ larger than CIV ♂, approximately equal to CV ♂		Separation of the sexes is difficult to make, particularly in <i>B. propinqua</i> and <i>C. lucasi</i>
CV	Number of pairs of well-developed legs: 5		Separation of the sexes at low magnifications is feasible only for large species
CV ♂	Approximately equal in length to CIV ♀ Fifth legs nearly as long as fourth legs Left and right exopodites of the fifth leg not of same length Left endopodite of fifth leg shorter than right endopodite Abdomen 4-segmented		
CV ♀	Larger than CV ♂ No posterolateral metasomal lobes (present in adult <i>Boeckella</i>) Fifth legs shorter than fourth legs Exopodites of fifth legs equal in length Abdomen 3-segmented		

from which the species were collected differ in food and temperature regimes, these data cannot be used to compare patterns of copepodite growth between species.

DISTINGUISHING STAGES AND SEXES

The different stages of both *Calamoecia* and *Boeckella* can be distinguished at low magnifications by checking firstly the number of pairs of legs to separate stages I–III, and secondly by the overall body size, the number of abdominal segments, and the length of the fifth legs relative to the fourth pair, to distinguish stage IV from stage V (as summarised in Table 3). We found that sexual dimorphism in *B. dilatata*, *B. hamata*, and *B. triarticulata* was sufficiently obvious for body size and relative lengths of the fourth and fifth legs to also be used to distinguish between male and female stage V copepodites at low magnifications. *Boeckella propinqua* is smaller than these three species and none of these characters could be distinguished clearly enough, even at $\times 80$ magnification. However, in specimens which have the fifth legs projecting clear of both the body and of the other legs, CV males can sometimes be recognised by their unequal endopodites; in addition CV females have longer terminal spines on the exopodites than males.

In *Calamoecia lucasi*, which is the smallest species we studied, we were not able to distinguish between CV males and females at $\times 80$ magnification.

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