Morphological variation in *Bradyidius pacificus* (Brodsky, 1950) (Copepoda: Aetideidae) in the eastern part of the Sea of Okhotsk

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This study deals with individual variation in *Bradyidius pacificus* (Brodsky, 1950) which is one of the most common aetideid copepods of the waters near Kamchatka. Material was collected during spring-summer 2001 in the eastern part of the Sea of Okhotsk. Only data on females of V-VI copepodite stages are presented. Studied was the structure (setation in particular) of individual limbs, rostrum, cephalothorax and abdomen in more than 50 specimens. There were observed 12 variants of the rostrum, up to 5 variants of the structure of individual segments of the antennules, 8 variants of the protopodites of the maxillipedes and up to 3 variants of the structure of the basipodites of the periopods. The rostrum, antennules and maxillipedes were the most variable parts. There were no variability observed of the structure in the maxillules and the antennae. It is shown that the maxillipedes are more variable than it was considered earlier.

Key words: Copepods, *Bradyidius pacificus,* morphology, infraspecific variation, Sea of Okhotsk

INTRODUCTION

This study deals with individual variation in *Bradyidius pacificus* (Brodsky, 1950) which is one of the most common aetideid copepods of the waters near Kamchatka. Comprehensive studies of planktonic organisms inhabiting the Ocean is one of the most important objectives of modern biological oceanology. In literature, there are not sufficient data on geographic and seasonal variability of copepods, including marine ones. Species of the Calanidae and Oithonidae were substantially studied, and there are also sporadic data on the Mertridinidae and Heterorhabdidae (Ferrari & Saltzman, 1998; Yamaguchi, 1999; Yamaguchi & Ikeda, 2000; Sedova, 2006). There is some information on the variability of rostrum and spinules of the last thoracic segment of some aetideid species (Markhaseva, 1996). There has been no special research on other families.

MATERIALS AND METHODS

Material was collected during spring-summer 2001 at the eastern part of the Sea of Okhotsk. There were no adult males found therefore only data on females (more than 50 specimens) of V-VI copepodite stages are presented. Studied was the structure of individual limbs, rostrum, cephalothorax and abdomen. Terminology follows Markhaseva (1996). Measured were lengths of the body (L), the cephalothorax (C), the abdomen (a) and the antennules (A). Ratios A/L, C/L, C/A and C/a were calculated. More than 50 specimens were studied.

RESULTS

Body lengths. Body lengths of adult females varied in range 3.2 through 4.9 mm. Body proportions varied insignificantly. A/L was in range between 0.82 and 0.90;

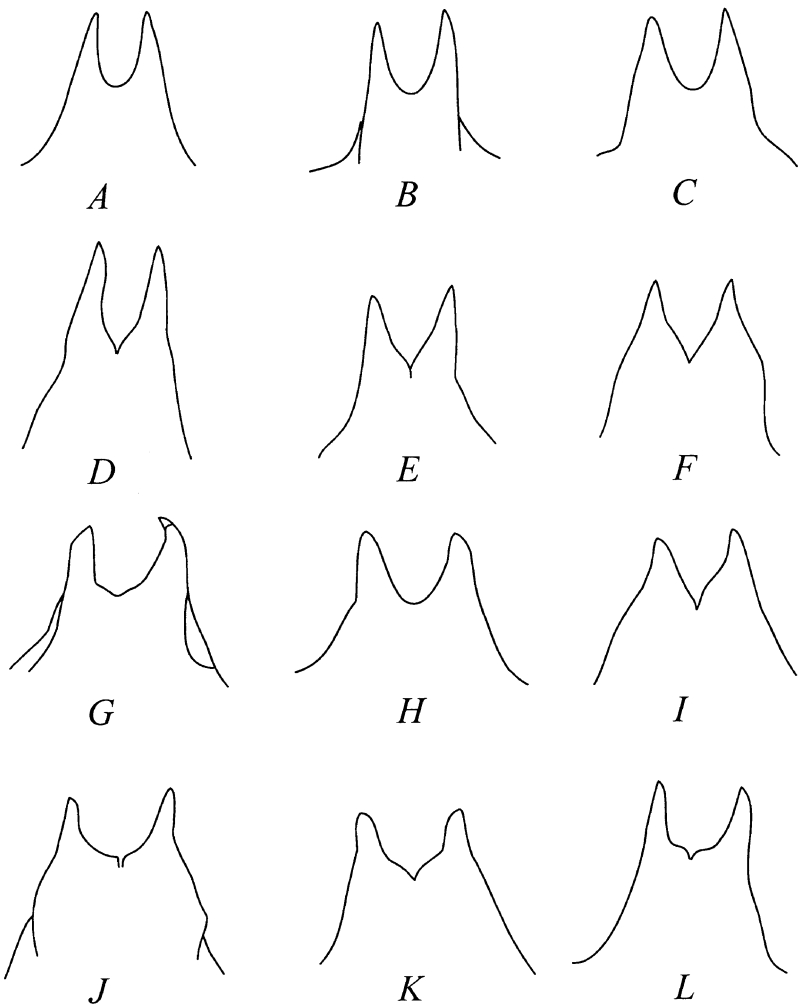

Fig. 1. Shape of rostrum of *Bradyidius pacificus*.

the C/A ratio was nearly constant and usually was 0.80-0.82. Only largest females had this index to be slightly different (0.77). Abdomen is shorter than cephalothorax in 2.9-3.4 times, the largest specimens having relatively long abdomen.

Rostrum. *Bradyidius pacificus* has heavily sclerotized bifurcated rostrum. Non-bifurcated part usually amounts to half of the length, rarely more. Sometimes tips of the rami are bent. There is individual variation of these features. The most common cases are presented in Fig. 1 (a, b, i, l) and rare ones are in Fig. 1 (d, g, j). Other variants in Fig. 1 are intermediate ones between these extremes.

Antennae. The first antennae are 24-segmented, shape and relative lengths of the segments being constant features. The variables are found to be number and structure of setae on the majority of segments. Following structural changes were observed: change in length of a particular seta (seg. 2, 8, 9, 18); addition of a seta or a spinule (seg. 8, 17); transformation of seta into thin spinule (seg. 2, 9, 12, 14-16, 22); feathering of a seta (seg. 5); reduction of a seta (seg. 5, 9, 11, 18); various changes in shape (seg.

21-24). The setation of segments No. 1, 3, 4, 6, 7, 10, 13, 19, and 20 proved to be invariable. Overall view of typical antennule is in Fig. 3a.

A detailed description of variation of individual segments follows. The *2nd* segment normally has 2 lateral setae, 1 distal aesthetask (a ribbon-like seta) and 2 distal setae (Fig. 2, *2a*). Two specimens had anomalies here: one had one of the distal setae significantly shortened (Fig. 2, *2b*); the other had the second lateral seta to be shortened and the 3rd transformed into a spinule (Fig. 2, *2c*). The *5th* segment normally has 2 ordinary and 1 ribbon setae (Fig. 2, *5c*); rarely middle seta was short-feathered (Fig. 2, *5b*); one female had no ribbon seta (Fig. 2, *5a*). The *8th* segment showed 4 variants of structure: normal, where it has 2 ordinary lateral setae, 1 ordinary distal seta and 1 thick distal seta (Fig. 2, *8d*); rare, where lengths of all setae were similar, i.e. distal seta was shortened (Fig. 2, *8b*); very rare, where it has a small spinule near the base of long distal seta (Fig. 2, *8c*). There was one anomal specimen having an additional distal seta (Fig. 2, *8a*). The *9th* segment normally has 2 distal setae of different lengths (Fig. 2, *9d*). There were 3 rare variants: with one seta significantly shortened (Fig. 2, *9a*); without one distal seta (Fig. 2, *9b*); with one seta transformed into a spinule (Fig. 2, *9c*). The *11th* segment carries 2 setae (1 long distal ribbon-like, 1 lateral) with distal dens (Fig. 2, *11c*); quite a few specimens had no lateral seta, and the dens was shifted towards the base of long distal seta (Fig. 2, *11a*). Rarely there were no dens and distal seta was of simple structure and shorter than the other. The *12th* segment had two similar structure variants: the majority had one lateral seta and one (shorter) distal one (Fig. 2, *12b*); a quarter of all specimens had distal seta transformed into a spinule (Fig. 2, *12a*). The *14-16th* segments are alike and have two distal setae (Fig. 2, *14-16a*). Rarely the short seta of each pair on these segments was transformed into a small spinule (Fig. 2, *14-16b*). The *17th* segment normally has 1 lateral and 1 distal seta, the latter being longer (Fig. 2, *17b*); rarely there was additional distal seta of medium length (Fig. 2, *17a*). The *18th* segment in most cases had 2 lateral and one thick or ribbon-like distal seta (Fig. 2, *18a*), which very rarely might be shorter (Fig. 2, *18e*); sometimes there was long thin additional distal seta (Fig. 2, *18b*). There were 2 specimens with anomalies in this segment: one had only one lateral seta (Fig. 2, *18d*), and the other had no distal seta as well (Fig. 2, *18c*). The *21st* segment normally has 2 setae on different sides (Fig. 2, *21a*), one of which often had different structure, more often on only one antennule (Fig. 2, *21c*; Fig. 3*f*). Rarely the structure of setae was similar, but one was significantly shorter (Fig. 2, *21b*); there was one specimen with very different structure of one seta (Fig. 2, *21d*; Fig. 3*d*). The *22nd* segment has 2 long setae (Fig. 2, *22b*); one rarely may be short (Fig. 2, *22a*).

One seta in some cases was short-feathered (Fig. 3*g*). The *23rd* segment has one distal seta on each side (Fig. 2, *23a*), one of which very rarely was feathered and bifurcated (Fig. 2, *23b*; Fig. 3*h*). The last, *24th* segment, usually has 3 long distal and 1 short lateral setae (Fig. 2, *24a*); two females had one distal seta trifurcated (Fig. 2, *24b*; Fig. 3*i*), and two had this segment of abnormal structure (Fig. 2, *24c*; Fig. 3*d*).

The structure of antennas was typical in most cases. Normally proximal part of the first segment of the basipodite has small projection carrying long bent non-feathered seta. One female had an anomaly there – a double projection and additional hairs on the second basipodite segment (Fig. 3*b*).

Mouth parts. The basipodite of mandible normally had 2 non-feathery setae of different lengths, the proximal being longer and the distal one being shorter. In 15% cases there was only one small seta on both limbs.

The presence of spinules on the first proximal lobe of maxillae is a variable feature. 60% of specimens had spinules only on three middle lobes, and others had them

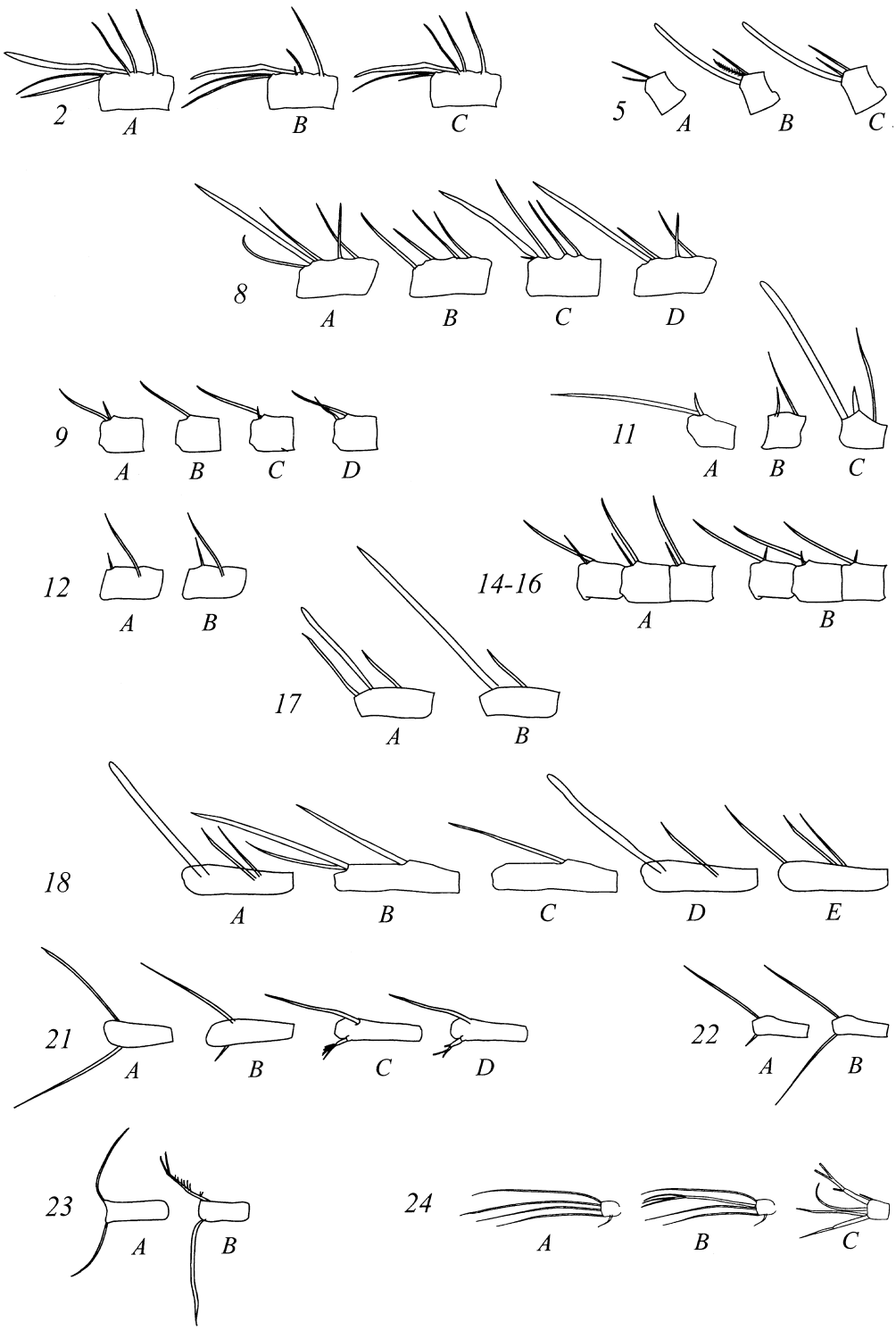

Fig. 2. Structure variants of individual segments of antennules. Numbers denote segments, letters denote variants.

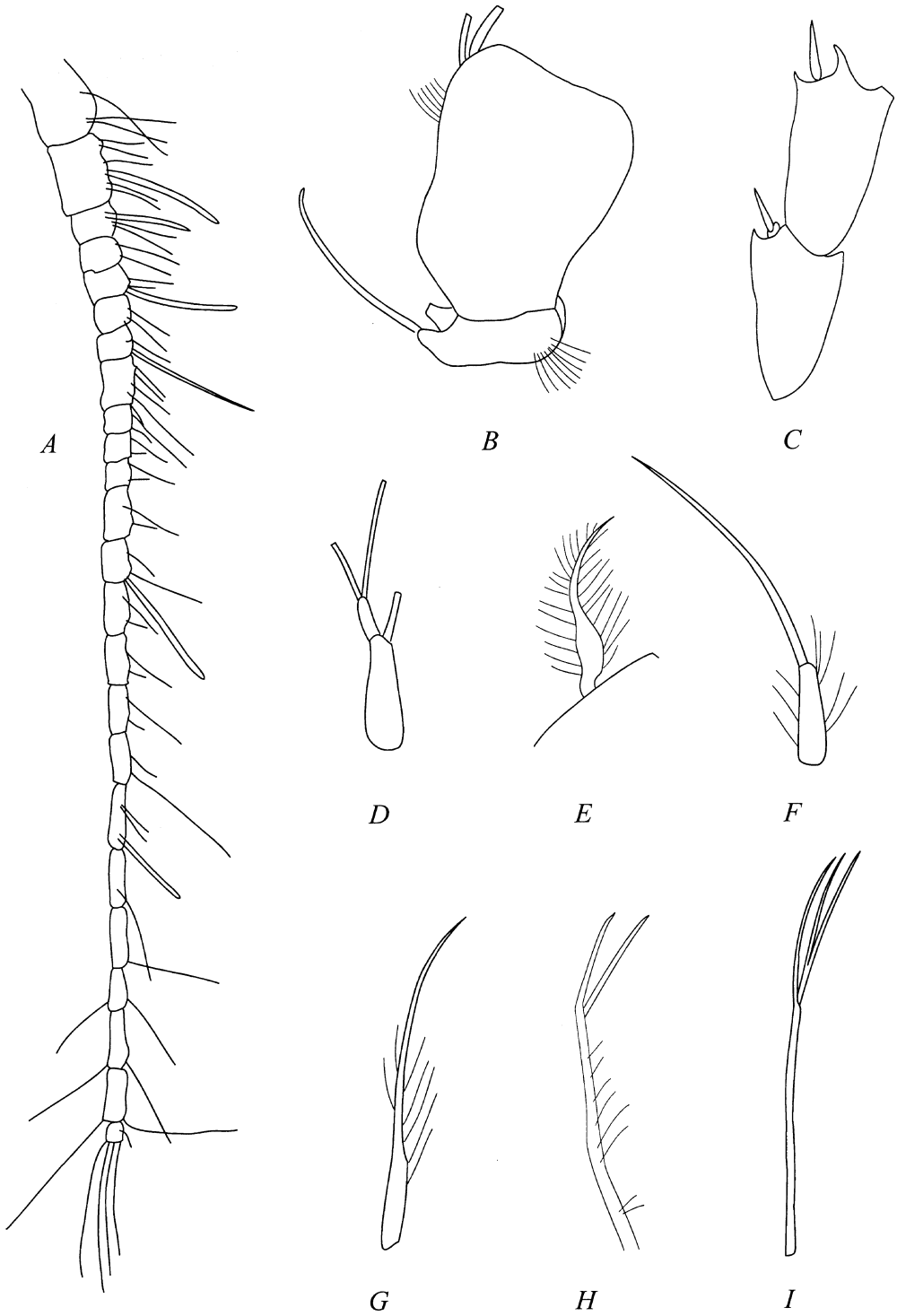

Fig. 3. Structure of legs and individual setae: *a,* antennules, overall view; *b,* basipodite of antenna; *c,* two first segments of basipodite P4; *d-i,* various malformed setae.

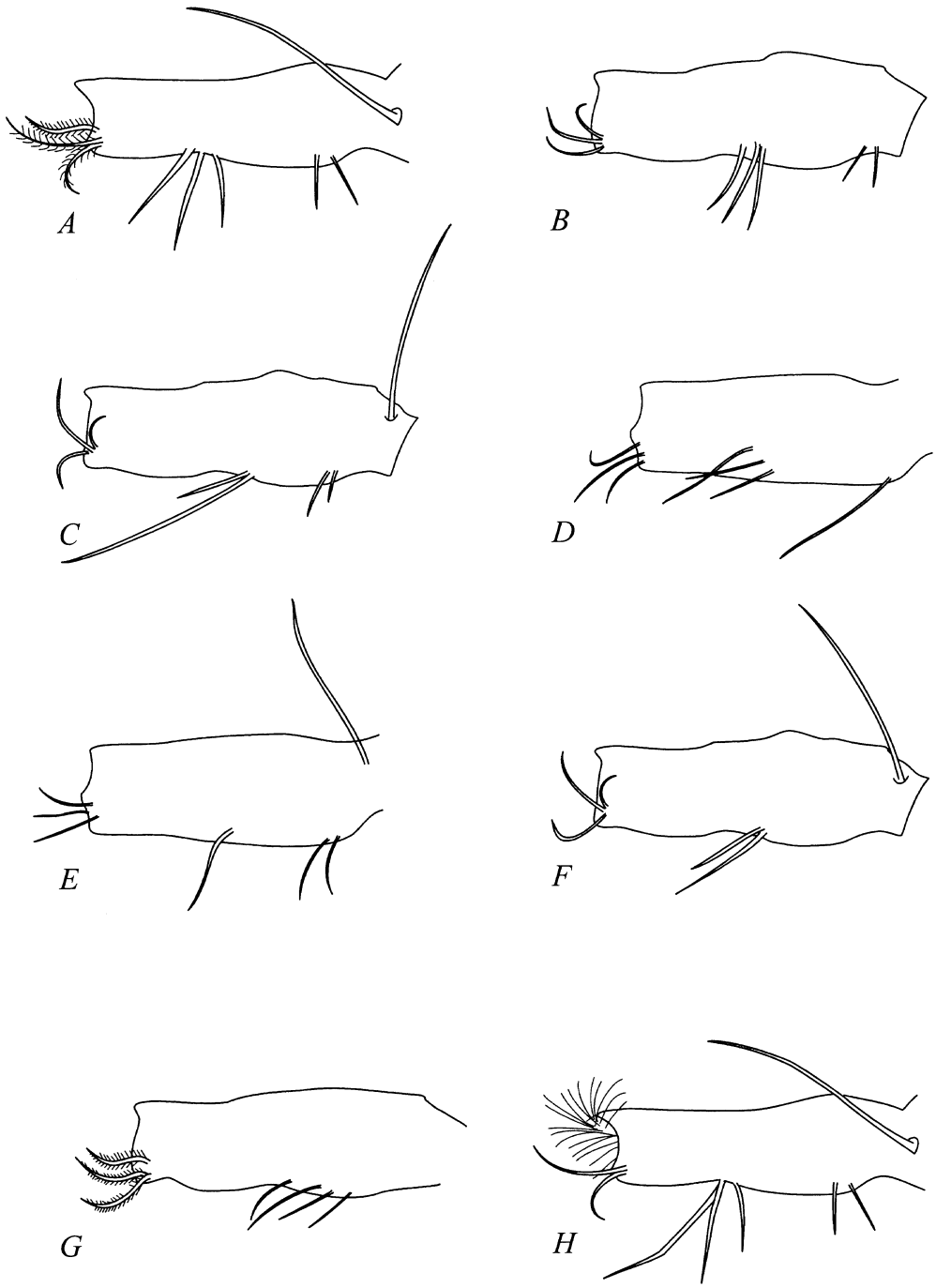

Fig. 4. Structure variants of protopodite of maxillipedes. Explanations are in the text.

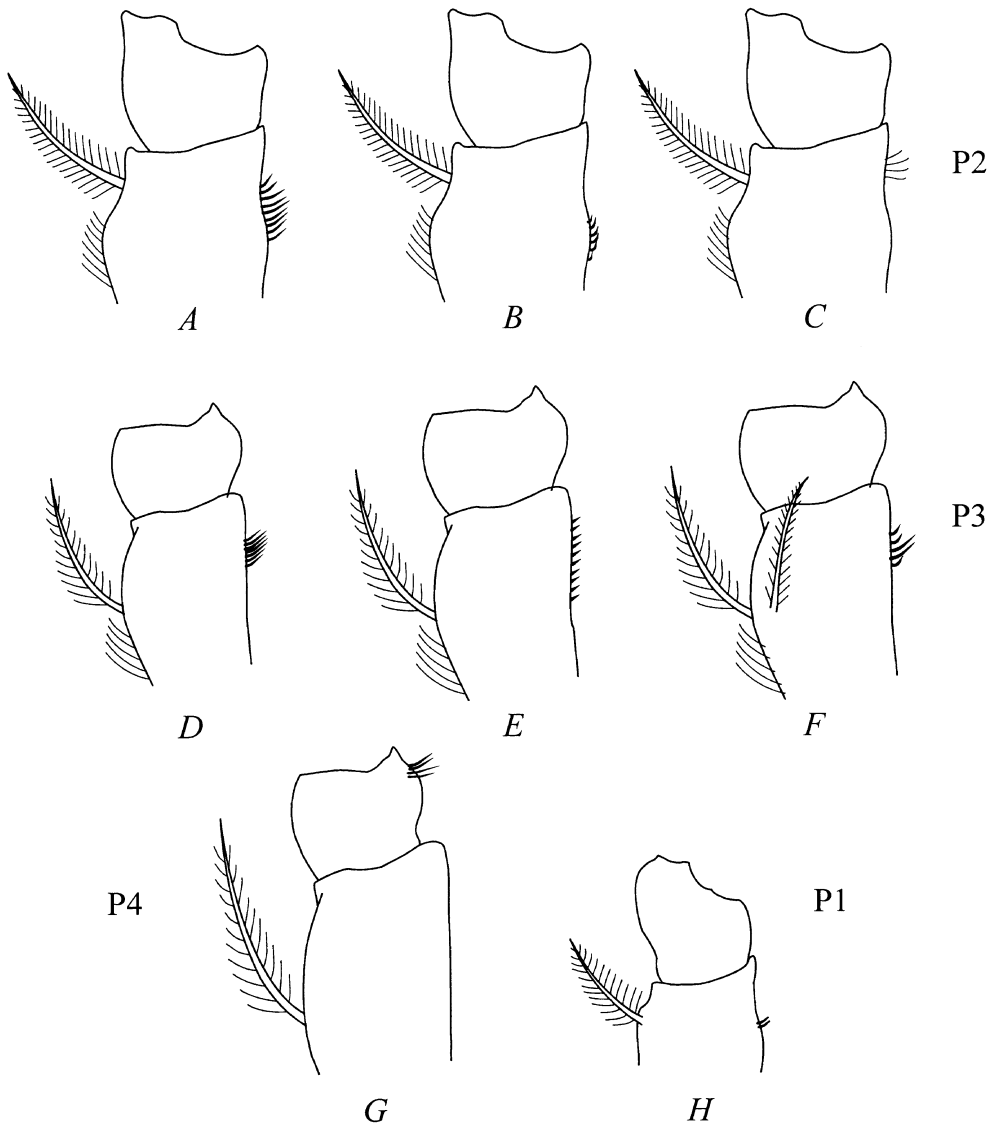

Fig. 5. Basipodites of periopods: *a-c,* P2, *d-f,* P3, *g* – P4, *h,* P1.

on the 1st through 4th lobes. Distal lobes never had spinules.

The variability of maxillipedes substantially involves the setation of the protopodite. Number, arrangement and lengths of setae on this segment may vary. There were 8 variants of structure of protopodite observed (Fig. 4*a-h*). In most cases there were 9 setae on this segment: long proximal seta, two short setae on the bottom, three medium ones (the middle being the longest), and three small setae on the distal edge. Distal setae were usually bent and short-feathered (Fig. 4*a*; 47% of specimens). 20% of specimens had almost the same setation, but the long proximal seta was absent (Fig. 4*b*). Another 20% had one proximal seta, two pairs of lateral setae of different lengths, and 3 distal setae (Fig. 4*c*). 10% of specimens had only one small proximal seta, 3 setae in the middle and 3 distal ones (Fig. 4*d*). Sporadically there were either

4 setae at the middle and 3 at the ending, without proximal one (Fig. 4*g*) or 1 proximal, 2 lateral and 3 distal (Fig. 4*f*), or proximal, 2 lateral near the proximal, 1 middle, and 3 distal setae (Fig. 4*e*). Sometimes setation on the left and the right limbs was different.

One female had anomal maxillipedes: 1 or 2 distal protopodite setae were absent, but the distal edge was covered with long hairs (Fig. 4*h*).

Periopods. The periopods of *B. pacificus* usually had structure typical of the specie. There were only sporadic cases of anomal structure of individual periopods, which should be considered as monstrosities. For example, one female had significantly curved interior seta on the coxopodite of P2 (only on one limb; Fig. 3*e*). Other specimen had 2 ordinary setae instead of 1 on interior surface of one of P3 (Fig. 5*f*). Another female had too thin lateral spines on Re1 and Re2, exopodite P4 (Fig. 3*c*). Usually, variable features were only number and structure of spines on the exterior surfaces of coxopodites of P2-P4. Usually there were no spinules on P1 except for two specimens having 2 thin spinules there (Fig. 5*h*). P4 normally has no spinules. Very rarely there were several spinules on its basipodite (Fig. 5*g*). The number of spinules on coxopodite of P2 and P3 varied in range between 2 and 10. Often middle spinules were significantly longer than others (Fig. 5*d*). Very rarely instead of spinules on coxopodite there were short thin hairs (Fig. 5*c*). About half of all females had long thin spinules on coxopodite of P2 and P3 (Fig. 5 *a, d*). Spinules were long and thin on P2, and thick and short on P3 (Fig. 5*e*), or vice versa (Fig. 5*b*). Spinules on the left and right limbs sometimes were different in length and thickness.

CONCLUSION

There were 12 variants of rostrum observed, up to 5 variants of structure of individual segments of antennules, 8 variants of protopodites of maxillipedes and up to 3 variants of structure of basipodites of periopods. Most variable parts turned out to be rostrum, antennules and maxillipedes. There were no variability of the structure of maxillules and antennae observed.

The number of setae in the middle of protopodite of maxillipedes is known to vary in genus of *Bradyidius*. Our results show that the number of proximal setae varies as well. Thus, this organ proved to be more variable than it was considered earlier.

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