Plankton Biol. Ecol. 52 (1): 27–32, 2005

plankton
biology & ecology

A new species of *Pseudodiaptomus* (Copepoda: Calanoida: Pseudodiaptomidae) from the coastal waters of Sulawesi, Indonesia

SHUHEI NISHIDA[1]* & INNEKE F. M. RUMENGAN[2]

[1] *Ocean Research Institute, University of Tokyo, 1–15–1 Minamidai, Nakano, Tokyo 164–8639, Japan*
[2] *Faculty of Fisheries and Marine Sciences, Sam Ratulangi University, Kampus Unsrat Bahu, Manado 95115, Indonesia*

Received 31 May 2004; Accepted 13 August 2004

Abstract: A new species of the demersal copepod genus *Pseudodiaptomus* is described from Sulawesi, Indonesia. The species is a member of the Ramosus species group sensu Walter (1986b) and distinguished from the most closely related species, *Pseudodiaptomus ishigakiensis* Nishida, 1985, from southern Japan by the morphology of the processes on the fifth pedigerous somite in both sexes, the female genital somite, and male leg 5. The relationship and zoogeography among these and other related species are discussed.

Key words: new species, *Pseudodiaptomus*, Copepoda, Sulawesi, Indonesia, demersal

Introduction

The genus *Pseudodiaptomus* Herrick, 1884 is a group of demersal copepods mostly occurring in shallow, coastal, freshwater to hypersaline conditions and presently comprising 74 species (Walter 1986a, b, 1987, 1989; Soh et al. 2001; Walter et al. 2002). During the course of a study on the biodiversity of zooplankton in coastal Southeast Asian waters, a species of *Pseudodiaptomus* so far unknown to science was collected. This species is described herein and the morphological and geographical relationships between the present and other related species are discussed.

Materials and Methods

Zooplankton samples were collected in the northern coastal waters of Sulawesi, Indonesia, using a hand net (0.33 mm mesh). The net was towed vertically from near the bottom (muddy substrate) to the surface (depth: 5–7 m) in the nighttime from a boat without a light. All samples were fixed and preserved in 2% formaldehyde/seawater. *Pseudodiaptomus* specimens were sorted from the original samples, stained with methyl blue, dissected with needles in 10% glycerol/distilled water, and the body and appendages observed under a compound microscope equipped with a drawing tube. The morphological terminology follows Huys & Boxshall (1991). Prosome length (distance between the anterior to mid-posterior margin) and width, urosome length (distance between the mid-posterior margin of the prosome to the posterior margin of the caudal ramus excluding the distal setae), and lengths and widths of urosomites were measured with a calibrated ocular micrometer. Types are deposited in the National Science Museum, Tokyo (NSMT) and the National Museum of Natural History, Smithsonian Institution (USNM). Other specimens are deposited in the Faculty of Fisheries and Marine Sciences, Sam Ratulangi University and the Ocean Research Institute, University of Tokyo.

* Corresponding author: Shuhei Nishida; e-mail, nishida@ori.u-tokyo.ac.jp; Fax: +81-3-5351-6481

Description

Pseudodiaptomus sulawesiensis, new species

Material: Collected on 25 Oct. 2003 at Likupang (1°40′48″N, 125°04′12″E) located on the northeastern most coast of Sulawesi, Indonesia. Holotype, 1 female (dissected: NSMT-Cr 16019); paratypes, 1 male (dissected) and 10 females and 4 males (intact) (NSMT-Cr 16020), 10 females and 3 males (intact: USNM 1026973). All specimens are preserved in vials in 2% formaldehyde/seawater with a drop of glycerol added.

Female: Total length 1.19–1.33 mm (mean±SD= 1.26±0.03, N=21; holotype, 1.25 mm). Prosome length

0.76–0.84 mm (holotype, 0.81 mm), width 0.36–0.39 mm (holotype, 0.36 mm).

Habitus (Fig. 1A, B). Anterior margin of cephalosome rounded in dorsal view. Rostrum with paired filaments. Cephalosome and first pedigerous somite separate; fourth and fifth pedigerous somites fused. Fifth pedigerous somite symmetrical, with paired rows of fine hairs along posteromedial margin; posterior corners produced into triangular processes in dorsal view, tip of which directed posterolaterally and extending posteriorly to mid-length of genital double-somite. Proportional lengths of urosomites and caudal ramus 25 : 17 : 19 : 16 : 23 (=100); length to width ratios 1.0, 1.2, 1.4, 1.0 and 3.8, respectively. Genital double-somite and first and second abdominal somites with row of triangular spinules on dorsoposterior margin; size of spinules on second abdominal somite much larger than those on other somites. Genital double-somite produced ventrally, swollen laterally in anterior third with irregularly rounded margin in dorsal view; both anterolateral sides with dorsoventrally oriented row of spinules; left posterolateral corner slightly produced; ventral surface (Fig. 1C) with anterior, transverse row of spinules; paired gonopores covered by broad genital operculum bearing a pair of short, posteriorly directed processes. First abdominal somite with left margin slightly concave in dorsal view.

Antennule (Fig. 1D) symmetrical, 22-segmented; each segment except segments 6, 15, 16, 18–20 with aesthetasc; segments 6–7 incompletely fused, the former with short spine; segment 20 having modified seta with small teeth on medial margin.

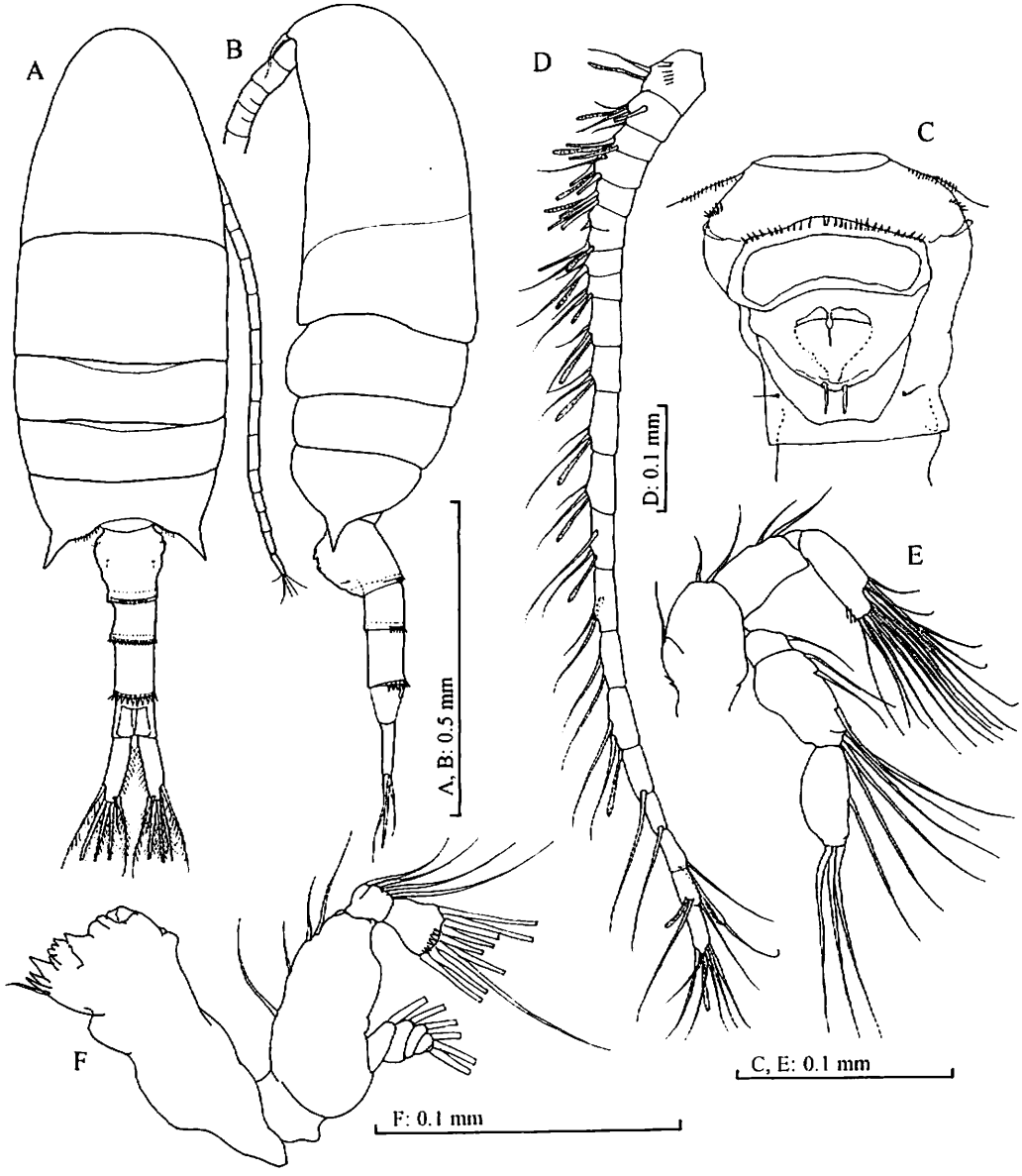

Fig. 1. *Pseudodiaptomus sulawesiensis*, n. sp., female (holotype). A: habitus, dorsal view. B: habitus, lateral view. C: genital double-somite, ventral view. D: antennule. E: antenna. F: mandible.

Antenna (Fig. 1E) coxa with 1 seta, basis with 2 setae; endopod 2-segmented, first segment with 2 setae, second segment with 7 terminal and 8 subterminal setae, and with lateral fringe of fine hairs. Exopod 4-segmented with third segment inconspicuous and looking like membrane connecting second and fourth segments; first segment with 1 seta, second segment with 1 proximal, 2 medial and 1 terminal setae; third segment with 3 setae; fourth segment with 1 medial and 3 terminal setae.

Mandible (Fig. 1F) basis with 4 medial setae; endopod 2-segmented, first segment with 4, second with 9 setae and row of spinules on surface; exopod with 6 setae; gnathobase well chitinized, cutting edge with seta on dorsal margin, 3 cuspidate teeth, smaller cuspidate teeth medially, and blunt molar-like processes ventrally.

Maxillule (Fig. 2A) praecoxal arthrite with 9 strong and 6 finer setae; coxa with 4 setae on endite and 9 setae on epipodite; basis with 4 and 5 setae on proximal and distal endites, and with 1 seta on exite; endopod 3-segmented with 4, 4 and 6 setae from first to third segments; exopod with 10 setae.

Maxilla (Fig. 2B) first praecoxal endite with 4 setae, second praecoxal and 2 coxal endites each with 3 setae; basis with 1 stout seta and 3 thinner setae; endopod with 9 setae.

Maxilliped (Fig. 2C) praecoxa and coxa completely fused, endites with 0, 2, 3, 4 setae; basis and first endopodal segment nearly fused, with 3 and 2 setae; second to sixth endopodal segments with 2, 2, 2, 3, 4 setae from proximal to distal; 2 setae on second segment bifurcated with modified branch.

Legs 1–4 (Fig. 2D–F) biramous with 3-segmented rami; first and second segments of both rami of legs 1–3, except

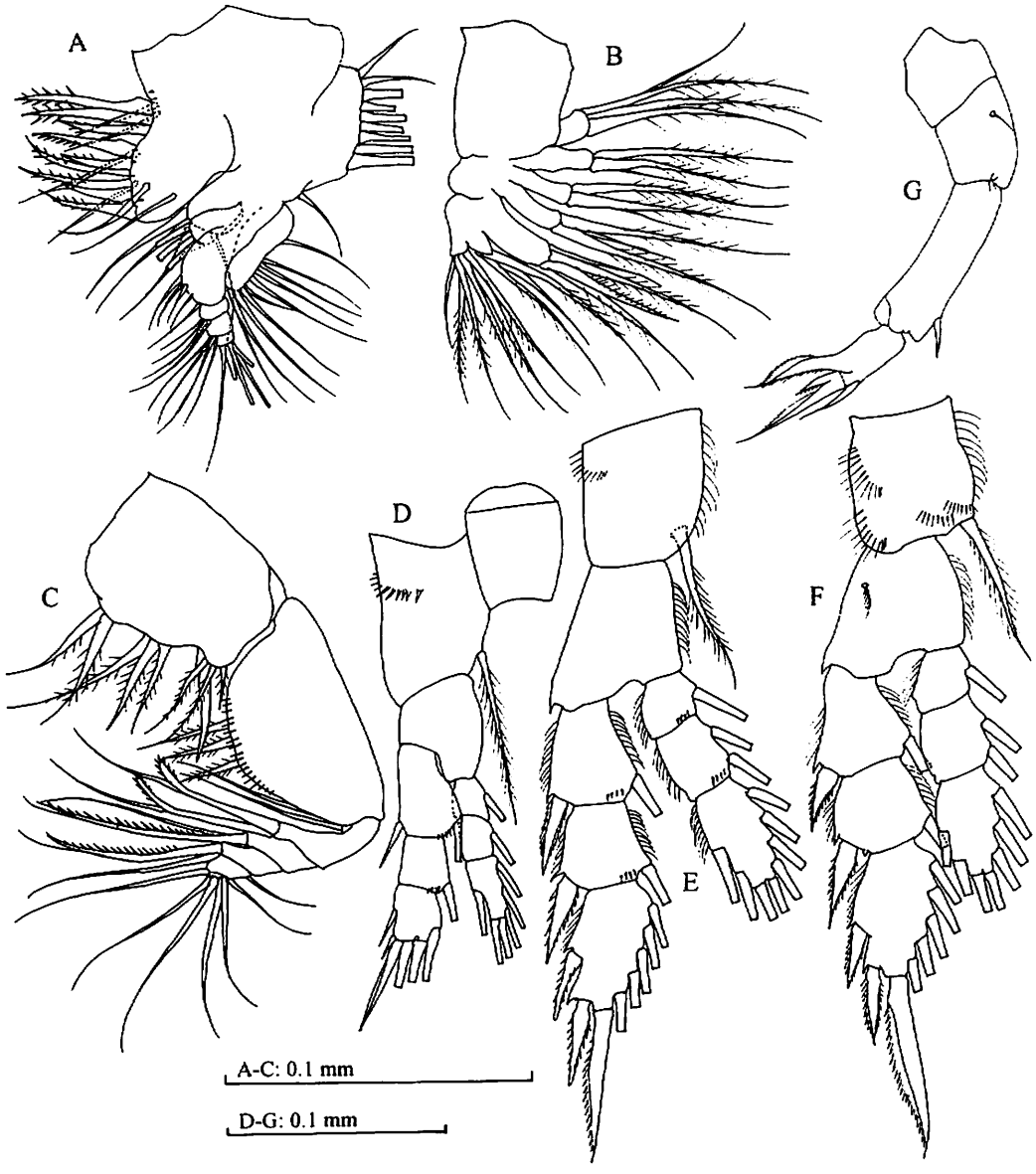

Fig. 2. *Pseudodiaptomus sulawesiensis*, n. sp., female (holotype). A: maxillule. B: maxilla. C: maxilliped. D: leg 1, posterior view. E: leg 3, posterior view. F: leg 4, posterior view. G: leg 5, posterior view.

leg 1 endopod, with spinules on inner distal margin. Seta and spine formula as follows:

	Coxa	Basis	Exopodal segment	Endopodal segment
Leg 1	0–1	0–0	I-1; 0–1; II, I, 3	0–1; 0–1; 1, 2, 3
Leg 2	0–1	0–0	I-1; I-1; II, I, 5	0–1, 0–2; 2, 2, 4
Leg 3	0–1	0–0	I-1; I-1; II, I, 5	0–1; 0–2; 2, 2, 4
Leg 4	0–1	1–0	I-1; I-1; II, I, 5	0–1; 0–2; 2, 2, 3

Leg 5 (Fig. 2G) uniramous and symmetrical; basis with 1 seta, without spinules on distolateral margin; exopod 3-segmented, first segment length ca. 3.0 times width, with distolateral seta; second segment with distolateral seta and distomedial process with serrate membrane on both margins; third segment spine-like with medial teeth and short proximomedial process.

Male: Total length 0.98–1.06 mm (mean±SD=1.02±0.03, N=8). Prosome length 0.67–0.72 mm, width 0.29–0.31 mm.

Habitus (Fig. 3A, B). Prosome as in female, but triangular processes on posterior corners of fifth pedigerous somite much smaller than in female and with tip directed posteriorly extending beyond posterior margin of genital somite. Proportional lengths of urosomites and caudal ramus 13 : 22 : 17 : 17 : 13 : 18 (=100); length to width ratios 0.7, 1.3, 1.1, 1.2, 0.8 and 2.9. Genital somite with genital aperture on left posterolateral margin. First abdominal somite with ventral row of spinules. First to third abdominal somites with row of triangular spinules on whole of posterior margins, spinules on third somite larger than those on other somites.

Appendages similar to those of female except right antennule and leg 5.

Right antennule (Fig. 3C) geniculate and 21-segmented; each segment except segments 5–8, 10, 12, 17–20 with aesthetasc; segments 6 and 7 incompletely fused; segment 10 with curved spine.

Leg 5 (Fig. 3D, E) asymmetrical and biramous, with two 1-segmented endopods, 2-segmented left exopod and 3-segmented right exopod. Coxa with row of spinules on both surfaces. Basis with distolateral row of spinules. Right leg: First segment of exopod with patch of spinules on medial

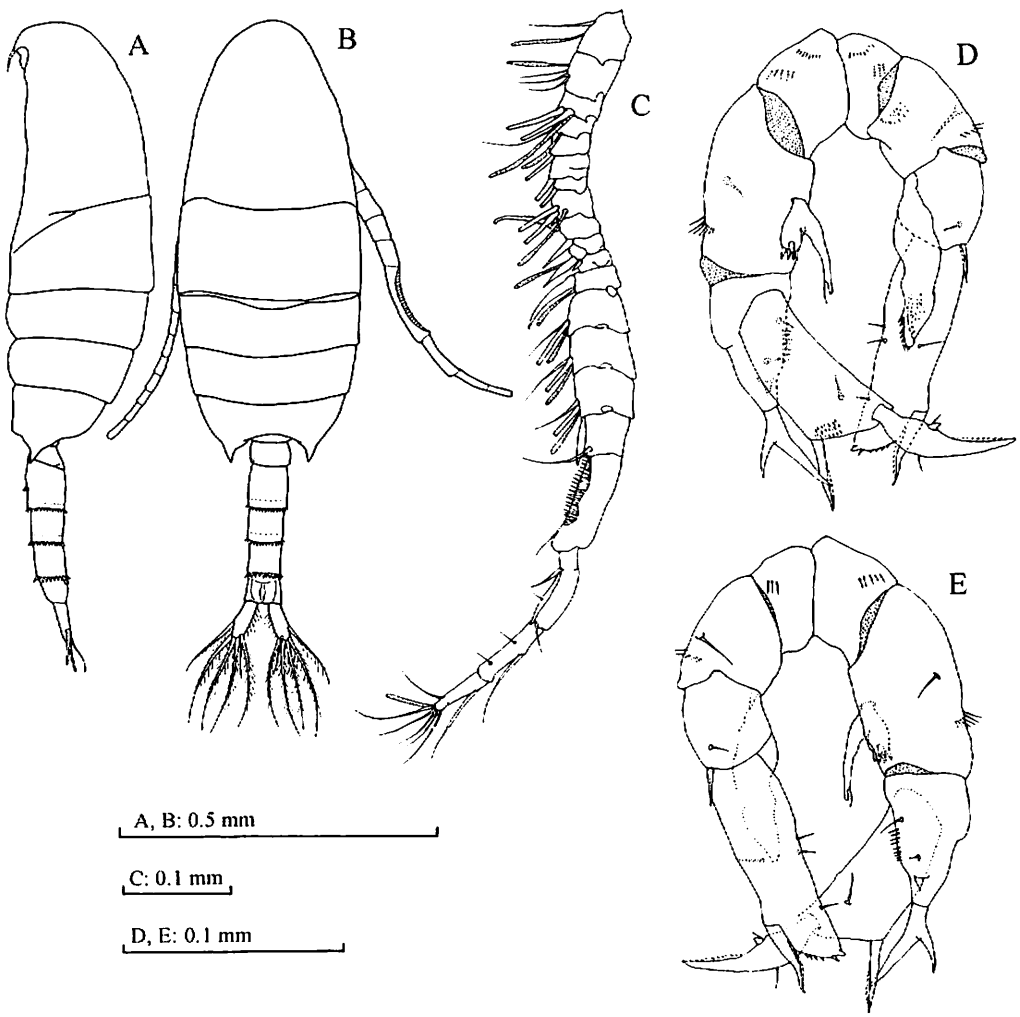

Fig. 3. *Pseudodiaptomus sulawesiensis*, n. sp., male (paratype). A: habitus, lateral view. B: habitus, dorsal view. C: right antennule. D: leg 5, anterior view. E: leg 5, posterior view.

margin and 2 setae on anterior surface, Y-shaped distal spine with medial fork about two times longer than lateral, and short thick subdistal spinule. Second exopod segment with distolateral serrate spine, with distolateral patch of spinules at base of spine, and posterior-surface seta. Third segment with 1 medial and 1 lateral setae. Endopod bifurcate; medial branch slender and much longer than lateral, with fine subdistal seta; lateral branch thick with 5–6 blunt distal spinules, one of which with teeth on tip. Left leg: First segment of exopod with short distolateral spine. Second segment with 3 medial and 1 anterior-surface setae, and with small distomedial process and thick distolateral spine extending well beyond distal tip of second segment and curved laterally near tip; lateral margin distal to this spine fringed with spinules. Endopod with distomedial rows of spinules.

Remarks: *Pseudodiaptomus sulawesiensis* is a member of the *hickmani* subgroup of the Ramosus species group (Walter 1986a, b, 1987), and is distinguished from the most closely allied species, *P. ishigakiensis* Nishida, 1985 in the following characters (the characters of the latter in parentheses). In both sexes, (1) the processes on the fifth pedigerous somite are triangular and well developed (spine-like, much smaller processes). In females, (2) the genital doublesomite is swollen in anterior third (nearly rectangular in dorsal view, with the left margin slightly produced), and (3) the first abdominal somite is concave on left margin in dorsal view (left margin straight in dorsal view). In the male leg 5, (4) the Y-shaped distal spine on the right first exopod has the medial folk conspicuously longer than the lateral (the spine is nearly V-shaped and the forks are of similar lengths), (5) the medial branch of right endopod is conspicuously longer than the lateral (the medial branch is only slightly longer than the lateral), and (6) the distolateral spine on left second exopod segment extends well beyond the segment and curved laterally near the tip (the spine reaches only the tip of the segment and is straighter).

Other closely related species *P. marinus* Sato, 1913, *P. philippinensis* Walter, 1986, and *P. australiensis* Walter, 1987 are easily distinguishable from *P. sulawesiensis* by various characters, e.g., the presence of distolateral spinules on the basis in the female fifth leg (spinules absent in *P. sulawesiensis*), and in the male fifth leg: the forks in the Y-shaped distal spine on the first segment of right exopod, which are short relative to the total length of the spine (the forks are relatively longer in *P. sulawesiensis*), an acute medial process on left basis (such a process absent in *P. sulawesiensis*), and the short, and straight distolateral spine on second segment of left exopod (the spine is much longer, curved laterally, and extends beyond the tip of the segment in *P. sulawesiensis*).

Discussion

According to Walter et al. (2002) who summarized the distributional patterns of the Indo-West Pacific species of *Pseudodiaptomus*, the four species most closely related to *P. sulawesiensis*, i.e. *P. ishigakiensis*, *P. marinus*, *P. philippinensis* and *P. australiensis*, all exhibit the Type-III geographic pattern: a confined distribution mainly restricted to the West Pacific. The other known species of the *hickmani* subgroup, i.e. *P. ardjuna* Brehm, *P. hickmani* Sewell, *P. hypersalinus* Walter, and *P. jonesi* Pillai, exhibit the Type-II pattern and are confined mainly to the Indian Ocean (Walter 1987, Walter et al. 2002). On the basis of the known occurrence records, *P. sulawesiensis* and the four close relatives appear to be more-or-less endemic to their respective ranges within the West Pacific: from north to south, the neritic waters of Japan (*P. marinus*, excluding records of assumed synanthropic introduction and those lacking definitive information in species identification: Sato 1913; Nishida 1985; Walter 1986a), Ryukyu Islands (*P. ishigakiensis*: Nishida 1985), Philippines (*P. philippinensis*: Walter 1986a), Sulawesi (*P. sulawesiensis*: this study), and Australia (*P. australiensis*: Walter 1986a, 1987). In addition, there is another species occurring in the coastal waters of the Gulf of Thailand which is similar to but slightly differs from *P. sulawesiensis* (Nishida & Ohtsuka, unpublished observation) whose characterization, including morphological variability of the populations in the Gulf, is now in progress. In view of the present discovery of *P. sulawesiensis* from Sulawesi wherein detailed comprehensive research into the *Pseudodiaptomus* fauna has been lacking, and the apparent patterns of geographically disjunct distribution in the *hickmani* subgroup, it is highly possible that more species of this group will be found from less-well investigated waters of the western Pacific.

Walter et al. (2002) ascribed the speciation of the present tropical pseudodiaptomids in the Indo-Malayan region (belonging to Types II and III) primarily to the sea-level changes around the Indo-Australian region during glacial periods, which could have acted as a distinct barrier between the Indian and the West Pacific populations (Walter et al. 2002). While this mechanism may also be partly applicable to the speciation of the above-mentioned species "within" the western Pacific, our present knowledge is still too incomplete to identify any specific mechanism, particularly with respect to the geologic history of the region including changes in the sea-level, salinity, and circulation patterns. It should be noted, however, that since pseudodiaptomids are mostly neritic and demersal, their dispersal may be limited significantly by the presence of open, deep water, as observed in terrestrial or inter-tidal populations, in addition to the mechanisms applicable to purely marine pelagic populations. Hence the decreases in sea level during the glacial periods could have resulted in the formation of geographical barriers on one hand, but enhanced dispersal on the other, and vice versa for increases in sea level. More detailed research into the geographic distribution and analyses of their phylogenetic relationships by using both morphological and molecular genetics approaches is necessary for a better understanding of the evolutionary history of

these copepods.

Acknowledgements

We express our sincere thanks to the two anonymous reviewers for their useful comments. We also thank Ms. Devie S.N. Limpong and other members of the Faculty of Fisheries and Marine Sciences, Sam Ratulangi University, for their help during the field sampling. This study was supported by a grant from the Japanese Society for Promotion of Science (Multilateral Cooperative Research Program: Coastal Oceanography).

Literature Cited

Huys, R. & G. A. Boxshall 1991. *Copepod Evolution*. The Ray Society, London, 468 pp.

Nishida, S. 1985. Pelagic copepods from Kabira Bay, Ishigaki Island, southwestern Japan, with the description of a new species of the Genus *Pseudodiaptomus*. *Publ. Seto Mar. Biol. Lab.* **30**: 125–144.

Sato, C. 1913. Free swimming Copepoda (1). *Hokkaido Fish. Res. Lab., Invest. Rep.* **1**: 1–82, 8 pls.

Soh, H. Y., H.-L. Suh, O. H. Yu & S. Ohtsuka 2001. The first record of two demersal calanoid copepods, *Pseudodiaptomus poplesia* and *P. nihonkaiensis* in Korea, with remarks on morphology of the genital area. *Hydrobiologia* **448**: 203–215.

Walter, T. C. 1986a. New and poorly known Indo-Pacific species of *Pseudodiaptomus* (Copepoda: Calanoida) with a key to the species groups. *J. Plankton Res.* **8**: 129–168.

Walter, T. C. 1986b. The zoogeography of the genus *Pseudodiaptomus* (Calanoida: Pseudodiaptomidae). *Syllogeus* **58**: 502–508.

Walter, T. C. 1987. Review of the taxonomy and distribution of the demersal copepod genus *Pseudodiaptomus* (Calanoida: Pseudodiaptomidae) from southern Indo-West Pacific waters. *Aust. J. Mar. Freshw. Res.* **38**: 363–396.

Walter, T. C. 1989. Review of the New World species of *Pseudodiaptomus* (Copepoda: Calanoida), with a key to the species. *Bull. Mar. Sci.* **45**: 590–628.

Walter, T. C., S. Ohtsuka, S. Putchakarn, K. Pinkaew & S. Chullasorn 2002. Redescription of two species of *Pseudodiaptomus* from Asia and Australia (Crustecea: Copepoda: Calanoida: Pseudodiaptomidae) with discussion of the female genital structure and zoogeography of Indo-West Pacific species. *Proc. Biol. Soc. Wash.* **115**: 650-669.