

**A new species of *Pseudodiaptomus* (Crustacea: Copepoda: Calanoida)
from the Philippines, with a key to pseudodiaptomids from the Philippines
and comments on the status of the genus *Schmackeria***

T. Chad Walter, Susumu Ohtsuka, and Lourdes V. Castillo

(TCW) National Museum of Natural History, Smithsonian Institution, P.O. Box 37012,
Washington, D.C., 20013-7012, U.S.A., e-mail: walterc@si.edu;

(SO) Takehara Marine Science Station, Graduate School of Biosphere Science,
Hiroshima University, 5-8-1 Minato-machi, Takehara, Hiroshima 725-0024, Japan,
e-mail: ohtsuka@hiroshima-u.ac.jp;

(LC) Institute of Biological Science, University of the Philippines, Los Banyos, College,
Laguna 4031, Philippines, e-mail: lvacastillo@yahoo.com

Abstract.—Four species of the demersal calanoid copepod genus *Pseudodiaptomus* were collected from Panay Island, Philippines in September 2003. They represented three species groups (sensu Walter 1986a): *P. terazakii*, a new species, and *P. annandalei* (Lobus group), *P. bispinosus* (Hyalinus group), and *P. clevei* (Nudus group). The female of the new species differs from its congeners in the possession of 3 pairs of anterolateral spines on the genital double-somite. The male is distinguished by the fifth leg right endopod, which is bifid at its apex, and the left non-bifid endopod. A key to the 14 pseudodiaptomid species known from the Philippines is provided herein. A review of the genus *Schmackeria* Poppe & Richard (1890) is presented, and all species attributed to this genus are merged into the genus *Pseudodiaptomus*. Because many new species of *Pseudodiaptomus* have been described recently, a revised key to the species-groups of Walter (1986a) is presented.

The taxonomy of marine planktonic copepods in southeastern Asia is generally accepted to have been initiated by A. Scott (1909), and subsequently has been elaborated by many copepodologists (e.g., Mulyadi 1997, 1998, 2002a, 2002b; Mulyadi & Ueda 1996; Nishida & Rumengan 2005; Ohtsuka et al. 1998, 1999, 2003; Walter 1984, 1986a; Walter et al. 2002). The species of the demersal calanoid family Pseudodiaptomidae G. O. Sars, 1902 are typically found in coastal environments and are highly diversified in the Indo-Pacific region. A preliminary survey of coastal copepods conducted off Panay Island, Philippines, in September 2003 resulted in the collection of four species of the genus *Pseudodiaptomus*, one

of which is new to science. *Pseudodiaptomus bispinosus* (the first record after the original description), *P. annandalei*, and *P. clevei* were also collected from this locality. The present study describes the new pseudodiaptomid, with notes on the other three species from Panay Island. The 77 currently recognized species of the genus are presented in Table 1, following an alphabetical arrangement of the species within their designated species groups as established by Walter (1986a).

Materials and Methods

Copepods were collected from three localities (Leganes, Culasi Ajuy, and Iloilo at the International Port, Fort San

Table 1.—List of the 77 species of *Pseudodiaptomus*. Arrangement is alphabetical by species within their assigned species groups and subgroups.

Americanus species group:

(*acutus*—subgroup)

1. *P. acutus* (F. Dahl, 1894)
 2. *P. cristobalensis* Marsh, 1913
 3. *P. galapagensis* Grice, 1964
 4. *P. richardi* (F. Dahl, 1894)
 5. *P. wrighti* Johnson, 1964
- (*pelagicus*—subgroup)
6. *P. cokeri* González & Bowman, 1965
 7. *P. culebrensis* Marsh, 1913
 8. *P. euryhalinus* Johnson, 1939
 9. *P. longispinosus* Walter, 1989
 10. *P. marshi* Wright, 1936
 11. *P. panamensis* Walter, 1989
 12. *P. pelagicus* Herrick, 1884

Burckhardt species group

13. *P. burckhardti* Sewell, 1932

Hyalinus species group

(*aurivilli*—subgroup)

14. *P. aurivilli* Cleve, 1901
 15. *P. bowmani* Walter, 1984
 16. *P. compactus* Walter, 1984
 17. *P. mertoni* Früchtl, 1923
- (*trihamatus*—subgroup)
18. *P. baylyi* Walter, 1984
 19. *P. bispinosus* Walter, 1984
 20. *P. daughlihi* Sewell, 1932
 21. *P. griggae* Walter, 1987
 22. *P. incisus* Shen & Lee, 1963
 23. *P. occidentalis* Walter, 1987
 24. *P. sewelli* Walter, 1984
 25. *P. trihamatus* Wright, 1937 (syn. *P. penicillus* Li & Huang, 1984)

Improcerus species group

26. *P. andamanensis* Pillai, 1980
27. *P. batillipes* Brehm, 1954
28. *P. hessei* (Mrázek, 1895)
29. *P. ornatus* (Rose, 1957)
30. *P. pankajus* Madhupratap & Haridas, 1992
31. *P. pauliani* Brehm, 1951
32. *P. stuhlmanni* (Poppe & Mrázek, 1895)
33. *P. trispinosus* Walter, 1986a

Lobus species group

(*forbesi*—subgroup)

34. *P. annandalei* Sewell, 1919
 35. *P. binghami* Sewell, 1912
 36. *P. brehmi* Kiefer, 1938
 37. *P. bulbosus* (Shen & Tai, 1964)
 38. *P. forbesi* (Poppe & Richard, 1890)
 39. *P. inflatus* (Shen & Tai, 1964)
 40. *P. inopinus* Burckhardt, 1913
-

Table 1.—Continued.

-
41. *P. inopinus gordiodes* Brehm, 1952
 42. *P. inopinus saccupodus* (Shen & Tai, 1962)
 43. *P. lobipes* Gurney, 1907
 44. *P. malayalus* Wellershaus, 1969
 45. *P. mixtus* Walter, 1994
 46. *P. poplesia* (Shen, 1955)
 47. *P. spatulatus* (Shen & Tai, 1964)
 48. *P. terazakii*, new species
- (*poppei*—subgroup)
49. *P. poppei* Stingelin, 1900
 50. *P. smithi* Wright, 1928
 51. *P. tollingeriae* Sewell, 1919

Ramosus species group

(*hickmani*—subgroup)

52. *P. ardjuna* Brehm, 1953
 53. *P. australiensis* Walter, 1987
 54. *P. hickmani* Sewell, 1912
 55. *P. hypersalinus* Walter, 1987
 56. *P. ishigakiensis* Nishida, 1985
 57. *P. jonesi* Pillai, 1970
 58. *P. marinus* Sato, 1913
 59. *P. philippinensis* Walter, 1986a
 60. *P. sulawesensis* Nishida & Rumengan, 2005
- (*serricaudatus*—subgroup)
61. *P. arabicus* Walter, 1998
 62. *P. caritus* Walter, 1986a
 63. *P. colefaxi* Bayly, 1966
 64. *P. cornutus* Nicholls, 1944
 65. *P. diadelus* Walter, 1986a
 66. *P. galleti* (Rose, 1957)
 67. *P. inflexus* Walter, 1987
 68. *P. nihonkaiensis* Hirakawa, 1983
 69. *P. pacificus* Walter, 1986a
 70. *P. salinus* (Giesbrecht, 1896)
 71. *P. serricaudatus* (T. Scott, 1894)

Nudus species group

72. *P. clevei* A. Scott, 1909
73. *P. gracilis* (F. Dahl, 1894).

Unassigned species (These species were inadequately described or based on only one sex, thus making the species-group determination difficult.)

74. *P. bulbiferus* (Rose, 1957) [probably Ramosus group]
 75. *P. heterothrix* Brehm, 1953 [probably Lobus group]
 76. *P. masoni* Sewell, 1932 [probably Ramosus group]
 77. *P. nankauriensis* Roy, 1977 [probably Hyalinus group]
-

Pedro) at 10°45'N, 122°30'E along the southeastern coast of Panay Island, Philippines, on September 27, 2003, by means of towing a conical plankton net

(diameter 30 cm, mesh size 0.1 mm) near the surface. Samples were collected at night at Iloilo, and during the day at the other two localities. All samples were fixed by 10% neutralized formalin/sea-water immediately after collection. Specimens were dissected and mounted in CMC-10 (Masters Company, Ltd.) or gum-chloral. Copepods were examined with a differential interference contrast microscope (Nikon Optiphot), and illustrated with the aid of a camera lucida. One adult female of a new species, described below, and four specimens of *P. bispinosus* were dehydrated in ethanol series, critical-point-dried, ion-sputtered, and observed with a scanning electron microscope (Jeol T-20). Body and appendage terminology follows Huys & Boxshall (1991). Types of the new species are deposited in the National Museum of Natural History, Smithsonian Institution, U.S.A. All measurements were done with a calibrated ocular micrometer and are presented in millimeter(s). Abbreviations used in this work appear primarily in the keys and tables: ae, aesthetasc; Ba, basis; CR, caudal rami; P5, leg 5; Pdg, pedigerous somite; Re, exopod; Ri, endopod; SD, standard deviation; Ur, urosomite(s); USNM, United States National Museum.

Order Calanoida G. O. Sars, 1903

Family Pseudodiaptomidae G. O. Sars, 1902

Genus *Pseudodiaptomus* Herrick, 1884

Pseudodiaptomus terazakii, new species

Figs. 1–3

Material examined.—Holotype: female (USNM 291494). Allotype: male (USNM 291495). Paratypes: 5 males, 1 female, partly dissected and mounted on glass slides (USNM 291496); 4 females, 5 males, undissected specimens in ethanol (USNM 291497). All collected near the surface off Leganes, Panay Island, Philippines on September 27, 2003 by S. Ohtsuka.

Description.—Female: Body length 1.06–1.27 mm (mean $\pm$ SD = 1.20 ± 0.08 , N = 6). Prosome and urosome in approximate proportion 1.9:1, with both cephalosome and pedigerous somite 1 and pedigerous somites 4 and 5 completely fused (Fig. 1A, B), the latter ending in rounded posterolateral corners with sparsely distributed spinules anterolaterally, posterolateral margin with row of spinules. Urosome 4-segmented (Fig. 1C), slightly asymmetrical. Genital double-somite (= urosomite 1) (Figs. 1A–D, 3A, B) swollen anteriorly, with 3 pairs of long spines directed laterally, left posterolateral margin protruding posteriorly, almost covering left side of urosomite 2, right dorsolateral margin with oblique row of spinules. Genital double-somite with ventral paired genital flaps expanded laterally into rounded lamellar lobes, each with posteriorly pointed tip; paired gonopores located beneath flaps, egg-sacs paired. Urosomite 2 relatively small, with spinules along posterodorsal margin, urosomite 3 with incomplete posterior margin spinule row, urosomite 4 (anal somite) slightly asymmetrical. Caudal rami highly asymmetrical, with left ramus longer and thicker than right, fourth caudal spine longer and thicker at base than others. Urosomites and caudal rami with proportions 32:9:13:11:35(left) 30 (right) = 100. Antennule (Fig. 1E) reaching distal end of anal somite, indistinctly 22-segmented, segments 6–7 partly fused and counted separately. Armature elements as follows (segment number = setae + ae): 1 = 1 + ae, 2 = 3 + ae, 3 = 2 + ae, 4 = 3 + ae, 5 = 3 + ae, 6 = (1 spiniform element), 7 = 2 + ae, 8 = 1 + (1 spiniform element) + ae, 9 = 2 + ae, 10 = 1 (1 spine) + ae, 11–14 = 2 + ae, 15–17 = 2, 18–19 = 1, 20–21 = 2, 22 = 7 + ae.

Leg 5 uniramous (Fig. 1F), slightly asymmetrical, left leg slightly longer than right; coxae and intercoxal sclerite fused to form common base; inner margins of basis expanded medially, with lateral row

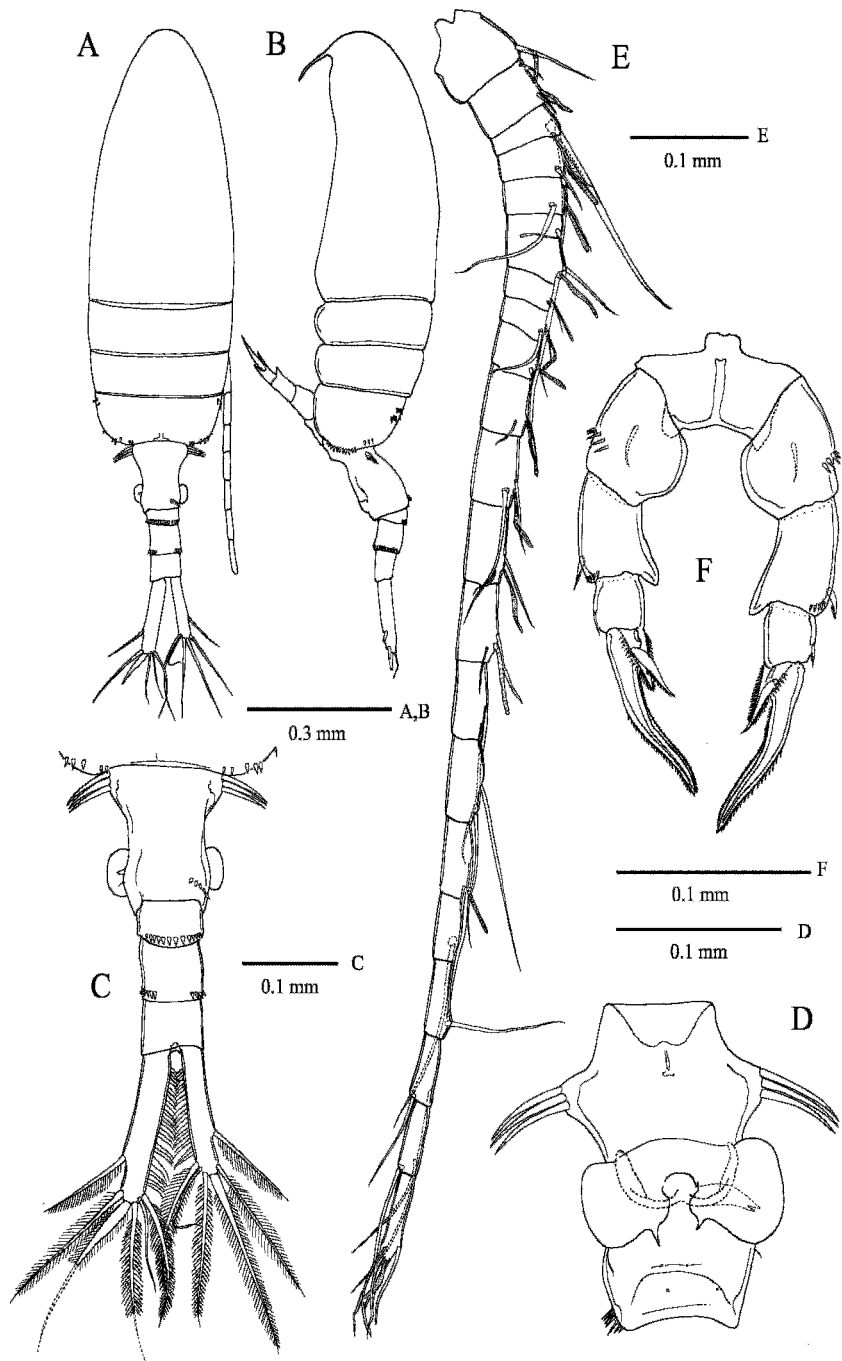


Fig. 1. *Pseudodiaptomus terazakii*, female, holotype. A, Habitus, dorsal view; B, Habitus, left lateral view; C, Prosomal end and urosome, dorsal view; D, Genital double-somite, ventral view; E, Antennule; F, Leg 5, anterior view.

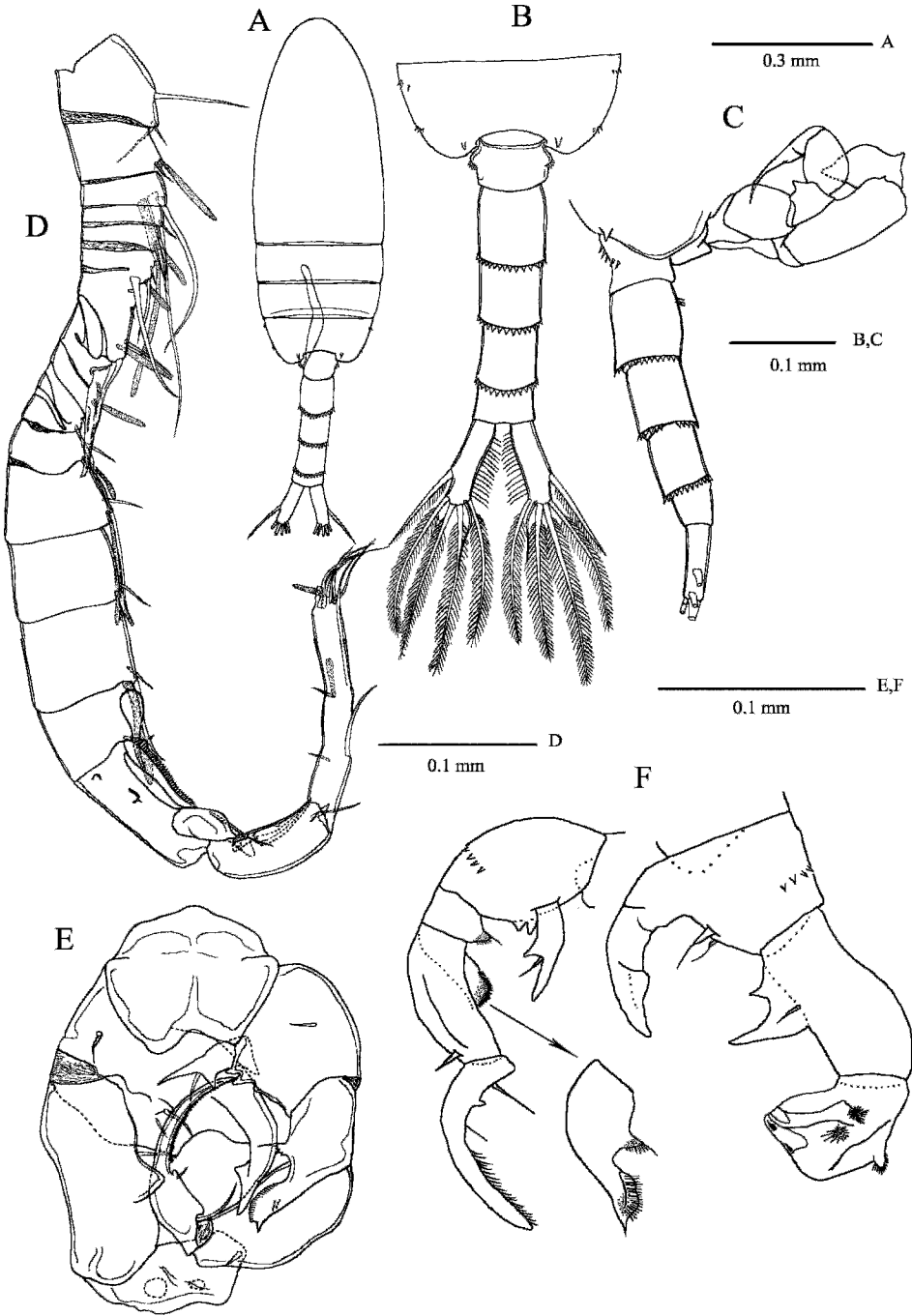


Fig. 2. *Pseudodiaptomus terazakii*, male, paratypes. A, Habitus, dorsal view; B, Prosomal end and urosome, dorsal view; C, Urosome, right lateral view; D, Right antennule; E, Leg 5, posterior view; F, Leg 5, anterior view (arrowed structure, posterior view of the right first exopod).

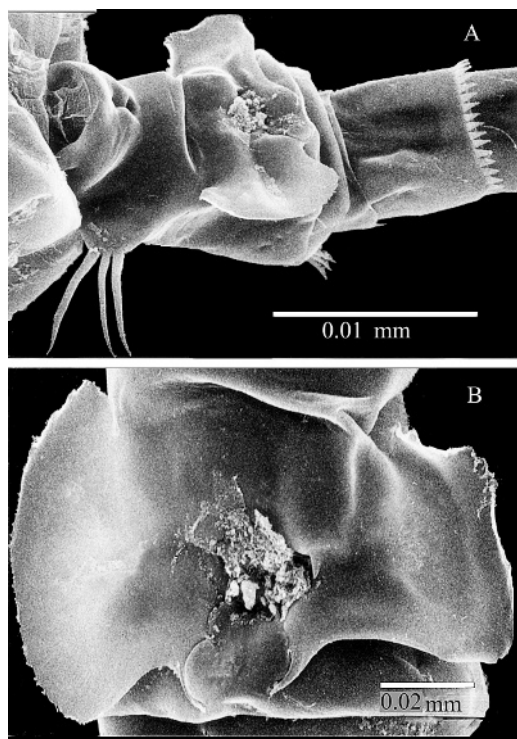


Fig. 3. SEM micrographs of *Pseudodiaptomus terazakii*, female. A, Urosome, ventrolateral view; B, Genital area, showing large expanded genital flaps, ventral view.

of minute spinules at midlength extending onto anterior surface, large seta on posterior surface. Exopods 3-segmented, first exopodal segment distomedial corner produced into triangular expansion, distolateral corner with row of small spinules plus lateral serrate subterminal spine. Second segment medial corner produced distally into large serrate process, distolateral corner with small medially serrate spine. Third segment proximally swollen, with small medial spine, and produced distally into long curved serrate process.

Male: Body length 0.94–1.09 mm (mean $\pm$ SD = 0.99 ± 0.04 , N = 10); (Fig. 2A) similar to female, but more slender, prosome to urosome ratio 1.8:1, terminal somite rounded, with pair of minute posterodorsal acute processes and 2 pairs of lateral spinules. Urosome 5-segmented (Fig. 2B, C), almost symmet-

rical. Genital somite (urosomite 1) slightly asymmetrical, moderately produced anterolaterally with lateral spinule row. Urosomites 2–4 with complete spinule rows along posterior margin, urosomite 2 with anteroventral row of spinules. Caudal rami symmetrical. Urosomites and caudal rami with proportions 16:21:17:16:8:22 = 100. Right antennule (Fig. 2D) geniculate and indistinctly 20-segmented, with only 2 distal segments after geniculation; armature elements as follows: 1 = 3, 2–3 = 2 + ae, 4 = 1, 5 = 2 + ae, 6 = 1, 7 = 2 + 4 + (1 spiniform element) + 2ae, 8 = process + ae, 9 = 2 + ae, 10 = 1, 11 = (1 spiniform element) + ae, 12 = 1 + (1 spiniform element) + ae, 13–16 = 2 + ae, 17 = process + 1, 18 = 2 processes (proximal and distal processes serrate and naked, respectively), 19 = 1 + (2 processes), 20 = 9 + 2ae. Left antennule 22-segmented, armature as in female.

Leg 5 (Fig. 2E, F) heavily chitinized, highly modified, details difficult to observe, because it is typically contracted and held close to body. Coxae and intercoxal sclerite fused to form common base. Right leg exopod 3-segmented, left leg 2-segmented. Posterior view, legs contracted (Fig. 2E). Right leg basis medially expanded, with 2 small knob-like processes, distal to short bifurcated endopod with setule between fork and lateral spinule row. First exopodal segment medially produced, apex acute, margin flared and hirsute, with distal process bearing spinule patch and apical seta (arrowed structure Fig. 2F). Second segment elongate, bearing outer subdistal lateral spine. Third segment medially curved, tapering distally, inner margin setulose along distal half, proximal half with 2 spinules and small knob-like process between them. Left leg massive, with basis and endopod completely fused, forming strong medially curved inner process with terminal triangular knob, medial margin with 2 small processes with terminal setae and lateral spinule row.

First exopodal segment with proximomedial margin forming small and large triangular processes, spinule inserted at base of processes (small knob absent in one paratype specimen). Second segment with serrate medial process on lateral surface, truncate distally, with 2 circular patches of small setules; distal tip appears to be formed usually by 2 elongate plus 1 sub-triangular heavily chitinized elements (latter element absent in two paratypes). Anterior view, legs separated (Fig. 2F), basis with 3–4 large surface setae.

Etymology.—The species is named in honor of Professor Makoto Terazaki, Ocean Research Institute, University of Tokyo.

Remarks.—*Pseudodiaptomus terazakii* is easily assignable to the Lobus species group, *forbesi*—subgroup (Walter 1986a) by the male leg 5 left endopod fused to the basis, forming a large medially curved process, and the female leg 5 first exopodal segment with a triangular process at its distomedial corner. *Pseudodiaptomus terazakii* shares relevant characters with both *P. smithi* (*poppei*—subgroup) and *P. annandalei* (*forbesi*—subgroup): female genital double-somite asymmetrical, with anterolateral paired spines and second exopodal segment of male left fifth leg distally truncate, as in *P. smithi*; and endopod of male right fifth leg distally bifid and left first exopod medially produced with 2 acute processes, as in *P. annandalei*. However, *P. terazakii* is readily distinguishable from *P. smithi* by the following characters: (1) three anterolateral pairs of spines on the female genital double-somite whereas the latter has only one pair; (2) female urosomites 2 and 3 slightly shorter than in *P. smithi*; and (3) male leg 5 right endopod bifid at its apex and the left endopod simple, whereas in *P. smithi* the right the endopod is simple and left endopod bifid. The new species can be differentiated from *P. annandalei* by the presence in the latter of: (1) female genital double-somite with

only one pair of anterolateral spines and no ventral lamellar plates, (2) first exopodal segment of female leg 5 lacking distomedial triangular process, (3) male urosomite 2 with a dorsal spinule patch, and (4) endopodal process on the basis of the male left fifth leg lacking medial knobs, and the first right exopodal segment with a long simple spiniform process.

We noted slight variation of characters in the fifth leg of two paratypic males. The left leg of one lacks the small proximomedial process on the first exopodal segment and an outer process on the second exopodal segment. In the other male, the second exopodal segment of the left leg lacks the small distal chitinized triangular element. Because the remaining characters of the fifth legs of these aberrant paratypes show no additional variations, we suppose that these are intraspecific abnormalities.

Pseudodiaptomus terazakii is a member of the Lobus group. However, if the species-group key presented by Walter (1986a) is used, this species would key down to either the Hyalinus and/or Ramosus groups because of the forked endopod on the male right leg 5. Therefore, we present an emended key to appropriately include this new species.

Distribution.—This species is currently known only from the waters off Panay Island, Philippines.

Pseudodiaptomus bispinosus

Walter, 1984

Figs. 4, 5

Pseudodiaptomus bispinosus Walter, 1984: 384–387, fig. 7.

Material examined.—Culasi Ajuy, Panay Island, Philippines, September 27, 2003, 8 females, 16 males; Iloilo (Fort San Pedro), Panay Island, Philippines, September 27, 2003, 1 male; Iloilo (International Port), Panay Island, Philippines, September 27, 2003, 1 male, by S. Ohtsuka.

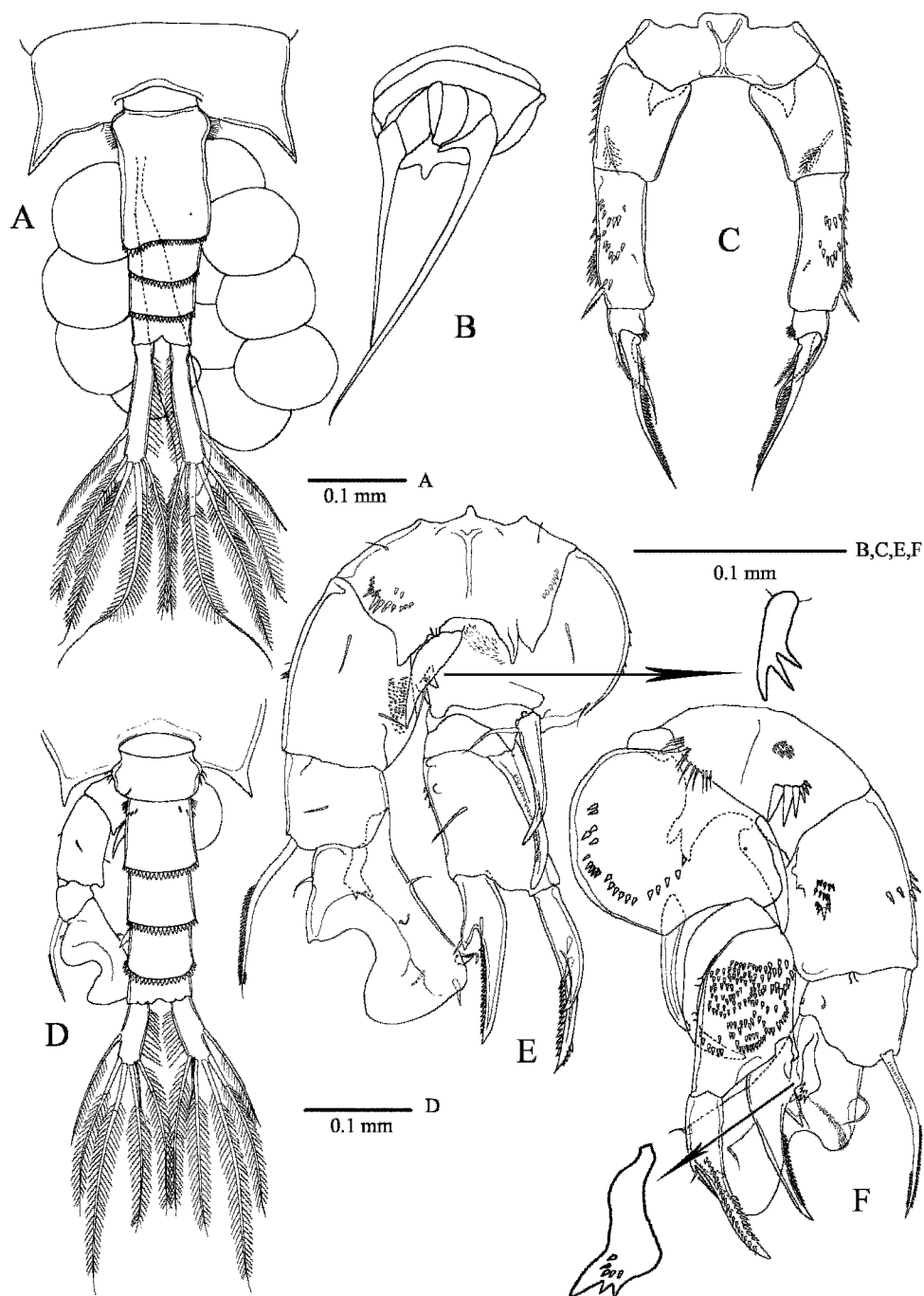


Fig. 4. *Pseudodiaptomus bispinosus*, female (A–C), male (D–F). A, Prosomal end and urosome, with egg sac and dotted line indicating ventrally attached spermatophore, dorsal view; B, Genital area, ventral view; C, Leg 5, anterior view; D, Prosomal end and urosome, dorsal view; E, Leg 5, posterior view (arrowed structure, shows detail of the right tricuspid endopod); F, Leg 5, anterior view (arrowed structure, shows detail of the proximal process on left second exopod).

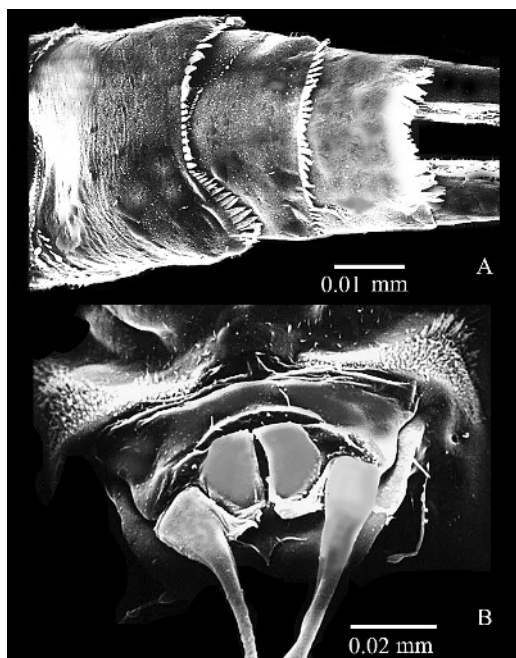


Fig. 5. SEM micrographs of *Pseudodiaptomus bispinosus*, female. A, Urosome, dorsal view of left posterolateral corner of genital double-somite; B, Genital area, ventral view.

Description.—Female: Body length 1.15–1.22 mm (mean $\pm$ *SD* = 1.18 ± 0.03 , *N* = 8). Pedigerous somites 4–5 fused (Fig. 4A) with posterolateral prosomal corners produced into sharply pointed, slightly asymmetrical wings. Genital double-somite (Fig. 4A) expanded anterolaterally on both margins, left posterolateral margin protruberant (Fig. 5A); genital operculum terminating in a pair of long processes (Fig. 5B), left process longer than right (Fig. 4B). Urosomites 1–3 with rows of spinules on posterior margin. Single egg sac with 11–15 eggs in ovigerous females. Caudal rami asymmetrical, right ramus slightly longer than left.

Leg 5 uniramous (Fig. 4C), coxae and intercoxal sclerite fused to form common base with distomedial corner produced, basis with expanded proximomedial corner and lateral spinule row, posterior surface with plumose seta. First exopodal segment with distolateral spine and clusters or rows of surface spinules; second segment small,

medially produced into curved process, with slender outer distal seta and medial patch of minute spinules; third segment distally produced with proximomedial seta, and setulose long medial margin.

Male: Body length 0.85–0.98 mm (mean $\pm$ *SD* = 0.92 ± 0.03 , *N* = 14). Posterolateral prosomal corners (Fig. 4D) produced into sharply pointed process reaching beyond posterior margin of genital somite. Genital somite laterally swollen at midlength, with spinules; second urosomite longest, with rows of spinules on anterolateral and posteroventral surfaces; third urosomite with ventral rows of spinules, urosomites 2–4 with spinule row on posterior margin.

Leg 5 (Fig. 4E, F) only supplementarily described here, after description by Walter (1984). Coxae and intercoxal sclerite almost completely fused to form common base with spinules on posterior and anterior surfaces. Right leg: basis with proximomedial spinule patch, endopod tricusate, and large distolateral curved spine with proximal setae; first exopodal segment produced into large curved distolateral process; second segment, distolateral corner with large spine bifurcate at midlength with 2 small surface spinules. Left leg: first exopodal segment with long narrow medially curved serrate spine; second segment, anterior view, apex of proximomedial process with small prominences.

Remarks.—The specimens from Panay Island vary slightly from the original description by Walter (1984) in a few minor characters: (1) female leg 5 basis and second exopodal segments bearing surface spinules, rather than setules; (2) male leg 5 coxae and intercoxal sclerite of male leg 5 almost completely fused, lacking small pair of distomedial protruberances; and (3) right second exopodal segment of male leg 5 with different spinulation pattern. We believe that these differences fall within intraspecific variability. This species is a member of the

Hyalinus group and the *trihamatus* - subgroup of Walter (1986a).

Distribution.—This is the second record of the species, which appears to be endemic to coastal waters of the Philippines.

Pseudodiaptomus annandalei
Sewell, 1919

Pseudodiaptomus annandalei Sewell, 1919: 5–7, pl. 10, fig. 9.—1924:787, pl. 44, fig. 2a–c. —Brehm 1934:88–92, figs. 3–4.—1953:306–308, figs. 68–71.—Kasturirangan 1963:39, fig. 35a–d.—Weller-shaus 1969:263, figs. 25–26.—Grigg 1972:84–86, figs. 34a–b, 36a–e. —Bayly 1975: table 1.—Pillai 1980:248–250, fig. 1g–j.—Reddy & Radhakrishna 1982:268–270, pl. 6, figs. 1–12.—Goswami 1983:254–257.—Walter 1986a:159–162, fig. 14A–L.—Mulyadi 2002a:9–10, fig. 2.

Pseudodiaptomus nostradamus Brehm, 1933: 137–142, figs. 8–12.—1934:84–92, figs. 5–6.—Kiefer 1938:81–91, figs. 9–17.

Pseudodiaptomus dubius Kiefer, 1936: 231–235, figs. 9–12.—1938:86–91, figs. 18–24.

Schmackeria annandalei (Sewell).—Marsh 1933:42–43, pl. 20 fig. 8, pl. 21 fig. 1.

Schmackeria dubia (Kiefer).—Shen & Song 1979:77–78, fig. 34a–e.—Chen & Zhang 1965:23, pl. 32, figs. 1–6.

Material examined.—Leganes, 4 females, 4 males; Iloilo, Fort San Pedro and International Port, 2 females, 1 male, Panay Island, Philippines, September 27, 2003 by S. Ohtsuka. Body length, female 1.13–1.46 mm (mean $\pm$ SD = 1.33 $\pm$ 0.15, N = 4), male 1.05–1.11 mm (mean $\pm$ SD = 1.08 $\pm$ 0.03, N = 4). These specimens do not differ from those described by Walter (1986a, 1987).

Distribution.—This species is broadly distributed in the Indo-West Pacific, from the coasts of India, Philippines, Indonesia, Australia, and China. From the

Philippines it was recorded from Calatagan, Batangas Province, Luzon Island (Walter 1986a), and Panay Island (Golez et al. 2004). Recently, it was found off Taiwan (R. Huys, pers. comm. to S. Ohtsuka, 2004).

Pseudodiaptomus clevei A. Scott, 1909

Pseudodiaptomus clevei A. Scott, 1909: 116–117, pl. 37, figs. 1–8.—Früchtl 1924: 48–49, figs. 29–30.—Sewell 1932:235.—Marsh 1933:31, pl. 6, figs. 1–2.—Mori 1942:553.—Pillai 1980:246, 256, fig. 1o–s.—Walter 1986a:139–140, fig. 4A–H.—Ohtsuka et al. 2000:133–137, 144, fig. 4b, c.—Mulyadi 2002a:11–12, fig. 4.

Material examined.—One female, Iloilo (International Port), Panay Island, Philippines, September 27, 2003 by S. Ohtsuka. Body length.—Female 1.77 mm. This specimen does not differ from those described by Walter (1986a, 1987).

Distribution.—This species has a restricted distribution in the tropical regions of the Indo-West Pacific: Indonesia, the Andaman Sea, Thailand, and the Philippines. From the Philippines it was previously recorded from Padre Burgos, Quezon Province (Walter, 1986a).

Pseudodiaptomus trihamatus
Wright, 1937

Pseudodiaptomus trihamatus Wright, 1937: 155–157, pl. 1, fig. 1. [male only].—Walter 1984:380–383, figs. 5a–i. —Oka, Saisho, & Hirota 1991:86, fig. 4a–d.

Mazellina galleti Rose, 1957:235–240, figs. 1–3, [female only = *P. trihamatus*]

Pseudodiaptomus penicillus Li & Huang, 1984:386–390, figs. 12–18.

Remarks.—This species was not found during this study, but has been reported from the Philippines (Walter 1984). We did not examine the specimens of Li & Huang. Nonetheless, we propose the synonymy of *P. penicillus* with *P. trihamatus*, as the former is identical in

appearance and description to the latter and the authors made no reference to the existence of *P. trihamatus*.

Key to the 14 Species of *Pseudodiaptomus* known from the Philippines

Fourteen pseudodiaptomid species, including the new species *P. terazakii*, have been recorded from the Philippines (Walter 1986a, 1987; Walter et al. 2002; present study). Walter (1984, 1986a, 1987) recognized seven species groups in *Pseudodiaptomus*, with the following species groups represented by the Philippine species: Nudus group (*P. clevei*); Improcerus group (*P. ornatus*, *P. trispinosus*); Lobus group (*P. annandalei*, *P. brehmi*, *P. smithi*, *P. terazakii*); Hyalinus group (*P. aurivilli*, *P. bispinosus*, *P. trihamatus*); Ramosus group (*P. philippinensis*, *P. caritus*, *P. diadelus*, *P. galleti*). The following keys are for each sex and include only those species of *Pseudodiaptomus* currently known from the Philippines. Only the female of *P. trispinosus* is known, because the male of this species was re-assigned as the male of *P. ornatus* (Walter et al. 2002). Abbreviations are used in this key for convenience.

Female

1. Pediger 5 posterior corners expanded distolaterally 2
Pediger 5 posterior corners rounded, not expanded distolaterally 11
2. P5 Ba produced into 2 acute prominences at distomedial corner ... *P. clevei*
P5 Ba without acute prominences at distomedial corner 3
3. P5 Re3 about twice as long as medial margin of Re2 4
P5 Re3 equal or subequal to medial margin of Re2 6
4. Ur1 without specialized ornamentation dorsally; P5 Ba with proximomedial corner rounded ... *P. aurivilli*
Ur 1 with dorsal process or projection; P5 Ba with proximomedial corner pointed 5
5. Ur1 left posterodorsal margin with 2 pointed processes *P. trihamatus*
Ur1 left posterodorsal margin without pointed processes ... *P. bispinosus*

6. P5 right Ba with bluntly produced distomedial process 7
P5 right Ba without distomedial process 8
7. P5 Ba with distomedial process reaching midlength of Re1 *P. ornatus*
P5 Ba with distomedial process reaching at most one-fourth length of Re1 *P. trispinosus*
8. Pediger 5 asymmetrical, with left posterior corner larger and more laterally directed *P. caritus*
Pediger 5 symmetrical 9
9. P5 Ba with 2–3 distolateral spinules *P. philippinensis*
P5 Ba without distolateral spinules 10
10. Ur1 with spinules on left and right margins *P. diadelus*
Ur1 with spinules on right margin only *P. galleti*
11. Ur1 without lateral spines *P. brehmi*
Ur1 with 1 or 3 pairs of lateral spines anteriorly 12
12. Ur1 with 3 pairs of lateral spines anteriorly *P. terazakii*
Ur1 with 1 pair of lateral spines anteriorly 13
13. Ur and CR asymmetrical; P5 Re 1 with triangular process near distomedial corner *P. smithi*
Ur and CR symmetrical; P5 Re1 without distomedial process.
..... *P. annandalei*

Male

1. P5 without right or left Ri ... *P. clevei*
P5 with right and/or left Ri 2
2. Pediger 5 rounded 3
Pediger 5 distally pointed 7
3. P5 with left Ri large, elongate, medially curved and fused to Ba 4
P5 with left Ri simple, separated from Ba *P. ornatus*
4. P5 with left Ri simple 5
P5 with left Ri bifid *P. smithi*
5. P5 with left Re1 produced medially, with 2 pointed processes 6
P5 with left Re1 lacking medial pointed processes *P. brehmi*
6. P5 right Re1 distolateral process slender and simple *P. annandalei*

- P5 right Re1 distolateral process thickened and hirsute *P. terazakii*
7. P5 without left Ri 8
P5 with left Ri 10
8. P5 with left Re2 hyaline margin convexly curved *P. aurivilli*
P5 with left Re2 hyaline margin incised 9
9. P5 right Ri with 3 processes, distal process longest; distomedial corner of left Ba produced into large acute process *P. trihamatus*
P5 right Ri with 3 processes, all equal in length; distomedial corner of left Ba produced into small rounded process *P. bispinosus*
10. P5 with outer spine on right Re1 bifid at tip *P. philippinensis*
P5 with outer spine on right Re1 simple at tip 11
11. P5 with left Ri small, reaching at most distal end of Re1 *P. galleti*
P5 with left Ri large, reaching well beyond distal end of Re1 12
12. P5 with right Ri widely bifurcated distally *P. diadelus*
P5 with right Ri narrowly bifurcated proximally *P. caritus*

Species-group Variation in Morphology and Revised Group Key

We have examined more than 75% of the known species of *Pseudodiaptomus*. It is obvious that extensive variation in body shape and/or the fusion of somites and segments in certain appendages (i.e., antennules and leg 5) occurs within the genus (Table 2). Among the 77 currently recognized species, the mouthparts and swimming legs are almost identical in shape, segmentation, spination, and/or spinulation patterns. The female genital double-somite is of particular interest (Soh et al. 2001, Walter et al. 2002), especially regarding the ventral genital flaps and egg sac number. Antennule segmentation has 3 basic patterns within this genus, with segments 6–7 partly fused and counted separately. In the first pattern, the antennules are 21-segmented in the female and in the left male antennule, with segments 4–5 fused; the right male antennule consists of 20 segments, with 2 of the

segments distal from the geniculation (*Hyalinus* species group). In the second pattern, the antennules are 22-segmented in the female and left male antennule, with segments 4–5 separate; the right male antennule consists of 20 segments, with 2 segments distal after the geniculation (*Lobus* species group). In the third antennule pattern, the antennules have 22 segments in the female and left male antennule, with segments 4–5 separate; a modified barbed setae is present on the antepenultimate segment (except in the *Americanus* and *Nudus* species groups), whereas the right male antennule is typically 21-segmented, with 3 segments distal after the geniculation (*Americanus*, *Burckhardt*, *Improcerus*, *Nudus*, and *Ramosus* species groups). The *Nudus* group is unique in consisting of only two species, *P. clevei* (from the Pacific) and *P. gracilis* (from Brazil), and possess a right male antennule 20-segmented pattern (rather than 21 segments); both species have segments 2–3 fused. Previous reports of antennule segmentation were incorrectly stated for some species groups by Walter (1986a, 1987, 1989) and Walter et al. (2002), but are correct in the above described patterns for the species groups.

The leg 5 in females is typically symmetrical and of limited value to separate species. Exceptions are noted for two species groups: the *Improcerus* group, in which the basis may have a distinct distomedial rounded processes; and the *Nudus* group, in which *P. clevei* has a unique pair of sharp spine-like medial protrusions on the basis.

The male leg 5 typically provides the most reliable morphological character(s) used for species determination and species group placement. The presence and/or absence of the left and/or right endopods easily indicates to which group a species belongs. The *Lobus* group is characterized by the fusion of the large left endopod to the basis, which is typically curved and can be simple or branched, whereas the right endopod is small, of variable shape, and may appear partly fused to the basis in some species. Rather than discuss each of the species-group characteristics of the male leg 5, because each group is unique in terms of the presence and/or absence of an endopod

Table 2.—Salinity preference, geographical distribution and morphological characters for the species groups of *Pseudodiaptomus*. Additional abbreviations and symbols used in this table: A = Africa; EM = estuarine-marine; FEM = freshwater-marine; M = marine; NW = New World;! = species introduced into a new geographic region; S = separate; F = fused; * = possesses dorsal spines; ± = some species with or without dorsal spines; P = pointed; R = rounded; L = lacks dorsal spines; + = partly fused in *P. aurivilli*; % = paired egg sac in *P. paulini*; △ male right/male left & female antennule segmentation; ▲ = antepenultimate segment with modified barbed seta; VS = variably shaped; SB = simple or branched; SYM = symmetrical; ASYM = asymmetrical; @ = Ba in *P. clevei* with paired pointed process; ● = Ba with distomedial processes; ◆ = Ba proximomedially swollen; ■ = Re1 with produced medial process.

Character	Nudus	Species group					Lobus
		Burckhardt	Improcerus	Ramosus	Americanus	Hyalinus	
Salinity	EM	M	M	M	EM	M	FEM
Geographical Distribution	NW,IP	IP	IP,A	IP	NW	IP,NW,!	IP, NW,!
Cephalon/Pdgl	S	S	S	S	S	F	F
Pdgl4-5	*F,P (<i>P. clevei</i>) L,S,R (<i>P. gracilis</i>)	*F,P	±,F,P or R	±,F,P or R	L,S,P or R	±,F,P,+	±,F,R
Egg Sac	single	single	single,%	single	paired	single	paired
Antennule△	21/22 (<i>clevei</i>) 20/22 (<i>gracilis</i>)	21/22▲	21/22▲	21/22▲	21/22	20/21	20/22
Male P5 left Ri	lacking	rudimentary	VS	simple	VS	lacking	F, large,SB
Male P5 right Ri	lacking	rudimentary	rudimentary	branched	lacking	SB	△S, small,VS
Female P5	SYM,@	SYM	ASYM,●	SYM	SYM	SYM,◆	SYM,■
Female Ur segment no.	4	4	4	4	2-4	4	4

on the right and/or left leg 5, we refer the reader to Table 2.

This key to the species groups and subgroups of *Pseudodiaptomus* is revised from the original presented by Walter (1986a). The key is based primarily on the male fifth leg, because female characters are not consistent among and within species groups. >=(greater than or equal to); <=(less than or equal to).

1. Male Ba with right Ri absent 2
Male Ba with right Ri present 3
2. Male left Ri absent Nudus
Male left Ri small and digitiform
. Americanus
(a) Male left Re2 rounded.
. *acutus*—subgroup
(b) Male left Re2 spatulate.
. *pelagicus*—subgroup
3. Male right Ri rudimentary or small
and simple, left Ri fused or separate 4
Male right Ri large and/or branched,
left Ri never fused 6
4. Male left Ri rudimentary
. Burckhardt
Male left Ri large and variably
shaped 5
5. Male left Ri simple, large, and variably
spatulate; Female P5 Ba usually with
small, bluntly triangular process at
distomedial corners; cephalon & Pdg1
separate Improcerus
Male left Ri large process fused to
Ba; Female P5 Re 1 with small
triangular process and hyaline cover-
ing at distomedial corners; cephalon
& Pdg1 fused Lobus
(a) Male left Ri apex hook-like and
simple. *forbesi*—subgroup
(b) Male left Ri apex hook-like and
bifid. *poppei*—subgroup
6. Male left Ri absent; Female P5 Re3
>= Re2 Hyalinus
(a) Male left Re2 convexly curved,
hyaline. *aurivilli*—subgroup
(b) Male left Re2 incised, hyaline
. *trihamatus*—subgroup
Male left Ri present, variable in size;
Female P5 Re3 <= length of
Re2 Ramosus
(a) Male right Rel, distolateral spine
bifid. *hickmani*—subgroup

- (b) Male right Rel, distolateral spine
not bifid. *serricaudatus*—subgroup

Schmackeria: a junior synonym of
Pseudodiaptomus

The genus *Pseudodiaptomus* was established by Herrick (1884) when he described *P. pelagicus* from the Gulf of Mexico. The establishment of this genus got off to a difficult start, because Herrick did not provide any illustration of the species and it was published in little known publication, The Reports of the Geological and Natural History Survey of Minnesota. An illustration of the species was finally published by Herrick (1887) in another, not widely available publication, the Memoirs of the Denison Scientific Association, University of Denison, where Herrick taught. Herrick's illustrations and description were incomplete. Three years later, Poppe & Richard (1890) described the new genus and species *Schmackeria forbesi* from Shanghai, China. In that paper they made no reference to Herrick's genus *Pseudodiaptomus*. Within the next 10 years, seven additional species were described and assigned to different genera: *Weismanella acuta* Dahl, 1894, *W. gracilis* Dahl, 1894, and *W. richardi* Dahl, 1894, from South America; *S. hessei* Mrázek, 1895 from the Congo; *Heterocalanus serricaudatus* T. Scott, 1894 from the Gulf of Guinea; *S. stuhlmanni* Poppe & Mrázek, 1895 from Mozambique; and *S. salina* Giesbrecht, 1896 from the Red Sea. Poppe & Mrázek (1895) synonymized *Weismannella* with *Schmackeria*, recognizing Dahl's species as belonging to *Schmackeria* even though they were from different oceans. None of these authors made reference to *Pseudodiaptomus*, and we speculate here that they were unaware of Herrick's articles.

Since 1900, an additional 80 species have been described as *Pseudodiaptomus* or *Schmackeria*, and a number of these have already been synonymized. Currently, we recognize 77 species, including *P.*

terazakii, in the genus *Pseudodiaptomus*. Boxshall & Halsey (2004), Razouls (1995), Walter (1984, 1986a,b, 1987, 1989), and Walter et al. (2002) concluded that the genera *Mazellina*, *Schmackeria*, and *Weismanella*, and the species *Heterocalanus serricaudatus* are junior synonyms of *Pseudodiaptomus*. The species reported as *Schmackeria* are the 17 members of the Lobus species group. These species typically occur in estuarine and freshwater habitats, though several species are found in fully marine habitats. Most species of this group are known from the waters around China, Japan, and Korea, and some are found throughout the Indo-West-Pacific. Within the last two decades, species of the Lobus species group have been reported as introduced into the eastern Pacific, along the coasts of Oregon and California, mainly via ship ballast water, by Orsi & Walter (1991), Cordell et al. (1992), and Cordell & Morrison (1996).

Some authors have considered *Schmackeria* and *Pseudodiaptomus* as separate genera (Marsh 1933; Shen & Song 1979; Dussart & Defaye 1983, 2001, 2002; Borutzky et al. 1991). The publication by Borutzky et al. (1991) is a revision of an old manuscript by Borutzky that was not published until 15 years after his death, by the co-authors Stepanova and Kos. They separated the genera based on only three characters particular to *Schmackeria*: (1) last thoracic somite with roundish outer corners, (2) male fifth leg, left basis with long distal outgrowth(s) on inner margin, outgrowth(s) not separated from the segment, endopodite absent. (We believe this means fused, based on the Russian transliteration), and (3) female leg 5 first exopodal segment with pointed outer distal corner (Borutzky et al. probably meant the distomedial corner). Dussart & Defaye (2002), supporting the use of *Schmackeria* by Borutzky et al. (1991), included the following eight species as members of the

genus *Schmackeria*—*bulbosa*, *forbesi*, *inflata*, *inopina*, *inopina gordiodes*, *inopina saccupoda*, *poplesia*, and *spatulata*. Surprisingly, they did not include the other nine species of the Lobus species group—*annandalei*, *binghami*, *brehmi*, *lobipes*, *malayalus*, *mixtus*, *poppei*, *smithi*, and *tollingeriae*—in their account of *Schmackeria*.

From the data presented in Table 2, it is clear that maintaining the genus *Schmackeria* is not valid, based on the following considerations: (1) the rounded fifth pedigerous somite is present in the Americanus, Lobus, and Nudus groups, and several species in the Ramosus group; therefore, this character of *Pseudodiaptomus* is shared with *Schmackeria*, and is not exclusive to the latter genus as suggested by Borutzky et al. (1991). (2) the female fifth leg with a distomedial processes on the exopodal segment 1 is indeed a character unique to the Lobus group (i.e., *Schmackeria*). However, the presence of processes is not unique among females in *Pseudodiaptomus*; members of the Hyalinus, Improcerus and Nudus groups all have different processes and/or protrusions on their basis segment. (3) although the fusion of the endopod with the basis of the male left fifth leg is unique among the Lobus species group, it is only a variation of endopodal shape, size, and presence within the genus *Pseudodiaptomus*. Therefore, we conclude that the genus *Schmackeria* is a junior synonym of *Pseudodiaptomus*, because *Pseudodiaptomus* was described in 1884 and has priority over *Schmackeria* according to the ICZN rules.

Acknowledgments

We express our sincere thanks to Dr. Kazuya Nagasawa, Mr. Nobuto Nakadachi, and Ms. Reiko Yoshizaki for their cooperation in the field. SO and LC are indebted to Professors Makoto Terazaki and Shuhei Nishida for their encourage-

ment throughout the study. This was partially supported by a grant-in-aid from the Japan Society for the Promotion of Sciences (JSPS) awarded to SO (No. 14560151), and also by a grant from the JSPS Multilateral International Cooperation Program. We thank Drs. Viatcheslav Ivanenko and Elena Markhaseva for translating the section on Pseudodiaptomidae in Borutzky et al. (1991).

Literature Cited

- Bayly, I. A. E. 1966. A new species and new records of *Pseudodiaptomus* (Copepoda: Calanoida) from the Brisbane River Estuary, Queensland.—Proceedings of the Royal Society of Queensland 78(5):49–57.
- . 1975. Australian estuaries. Pp. 41–66 in H. A. Nix and M. A. Elliot, eds., Managing aquatic ecosystems.—Proceedings of the Ecological Society of Australia 8:1–178.
- Borutzky, E. V., L. A. Stepanova, & M. S. Kos. 1991. A handbook of Calanoida from the freshwaters of the USSR.—Oprelideliti Faune SSSR 156:1–503. (In Russian, with summary in English.)
- Boxshall, G. A., & S. H. Halsey. 2004. An introduction to copepod diversity.—Ray Society, London 166:1–966. (2 volume set)
- Brehm, V. 1933. Mitteilungen von der Wallacea Expedition Woltereck. 7. Neue und wenig bekannte Entomostraken.—Zoologischer Anzeiger 104(5/6):130–142.
- . 1934. Mitteilungen von der Wallacea Expedition Woltereck. 10. Über die systematische Stellung des von der Wallacea-Expedition entdeckten *Pseudodiaptomus nostradamus* Brehm und über die Systematik der Pseudodiaptomiden überhaupt.—Zoologischer Anzeiger 106(3/4):84–93.
- . 1951. *Pseudodiaptomus pauliani* (Crustacea: Copepoda). Der erste Vertreter der Pseudodiaptomiden in der madagassischen Fauna.—Mémoires de l'Institut Scientifique de Madagascar, Série A 6(2):419–425.
- . 1952. Ein *Pseudodiaptomus* aus Südostasien.—Anzeiger der Österreichischen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Klasse 89(10):122–124.
- . 1953. Indische Diaptomiden, Pseudodiaptomiden und Cladoceren.—Österreichische Zoologische Zeitschrift, Vienna 4:241–345.
- . 1954. *Pseudodiaptomus batillipes* spec. nov., ein zweiter *Pseudodiaptomus* aus Madagascar.—Sitzungsberichten der Österreichischen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Klasse, Abteilung I 163:604–607.
- Burckhardt, G. 1913. Wissenschaftliche Ergebnisse einer Reise um die Erde von M. Pernod und C. Schröter. III. Zooplankton aus ost- und süd-asiatischen Binnengewässern.—Zoologische Jahrbücher, Abteilung für Systematik, Ökologie und Geographie der Tiere 34(4):341–472.
- Chen, Q. C., & S. Z. Zhang. 1965. The planktonic copepods of the Yellow Sea and the East China Sea, 1. Calanoida.—Hai Yang K'o Hsueh Chi K'an—Studia Marina Sinica 7(1):20–131.
- Cleve, P. T. 1901. Plankton from the Indian Ocean and the Malay Archipelago.—Kongliga Svenska Vetenskaps Akademiens Handlingar, Stockholm 35(5):1–58.
- Cordell, J. R., C. A. Morgan, & C. A. Simenstad. 1992. Occurrence of the Asian calanoid copepod *Pseudodiaptomus inopinus* in the zooplankton of the Columbia River estuary.—Journal of Crustacean Biology 12(2):260–269.
- , & M. Morrison. 1996. The invasive Asian copepod *Pseudodiaptomus inopinus* in Oregon, Washington, and British Columbia estuaries.—Estuaries 16(3):629–638.
- Dahl, F. 1894. Die Copepodenfauna des unteren Amazonas.—Berichte der Naturforschenden Gesellschaft zu Freiburg i.B 8:10–23.
- Dussart, B. H., & D. Defaye. 1983. Répertoire mondial des Crustacés Copépodes des eaux intérieures. I. Calanoïdes.—Centre National de la Recherche Scientifique, Paris, 244 pp.
- . 2001. Copepoda: Introduction to the Copepoda. (2nd edition revised and enlarged).—Guides to the Identification of the Microinvertebrates of the Continental Waters of the World. SPB Academic Publishers, The Hague, 16:344 pp.
- . 2002. World directory of Crustacea Copepoda of inland waters. I - Calaniformes.—Backhuys Publishers, Leiden, 276 pp.
- Früchtl, F. 1923. Cladocera und Copepoda der Aru-Inseln. (Vorläufige Mitteilung: Artenliste und kurze Diagnosen der neuen Formen).—Abhandlungen der Senckenbergischen Naturforschenden Gesellschaft 37(4):449–457.
- . 1924. Die Cladoceren- und Copepoden-Fauna des Aru-Archipels. Mit Beiträgen zur Kenntnis der strukturellen Anomalien indo-

- pazifischer Plankton-Copepoden.—Arbeiten aus dem Zoologischen Institut der Universität Innsbruck 2(2):1–114.
- Giesbrecht, W. 1896. Über pelagische Copepoden des Rothen Meeres, gesammelt vom Marinestabsarzt Dr. Augustin Krämer.—Zoologische Jahrbücher, Abteilung für Systematik, Geographie und Biologie der Tiere 9:315–328.
- Golez, M. S., T. Takahashi, T. Ishimaru, & A. Ohno. 2004. Post-embryonic development and reproduction of *Pseudodiaptomus annandalei* (Copepoda: Calanoida).—Plankton Biology and Ecology 51:15–25.
- González, J. G., & T. E. Bowman. 1965. Planktonic copepods from Bahía Fosforescente, Puerto Rico, and adjacent waters.—Proceedings of the United States National Museum 117(3513):241–304.
- Goswami, S. C. 1983. Coexistence and succession of copepod species in the Mandovi and Zuari estuaries, Goa, Mahasagar.—Bulletin of the National Institute of Oceanography 16(2): 251–258.
- Grice, G. D. 1964. Two new species of calanoid copepods from the Galapagos Islands with remarks on the identity of three other species.—Crustaceana 6(4):255–264.
- Grigg, H. 1972. The taxonomy and distribution of *Pseudodiaptomus* (Copepoda: Calanoida) in the Townsville region. M.S. thesis, James Cook University, Australia 192 pp.
- Gurney, R. 1907. Further notes on Indian freshwater Entomostraca.—Records of the Indian Museum, Calcutta 1:21–33.
- Herrick, C. L. 1884. Final report on the Crustacea of Minnesota, included in the orders Cladocera and Copepoda, together with a synopsis of the described species in North America, and keys to the known species of the more important genera.—Reports of the Geological and Natural History Survey of Minnesota 12:1–192.
- . 1887. List of the fresh-water and marine Crustacea of Alabama, with descriptions of the new species and synoptical keys for identification. Contribution to the Fauna of the Gulf of Mexico and the South. Memoirs of the Denison Scientific Association, University of Denison, Granville, Ohio, 1(1):1–56.
- Hirakawa, K. 1983. A new species of *Pseudodiaptomus* (Copepoda: Calanoida) from the coast of Niigata, the Japan Sea.—Bulletin of the Plankton Society of Japan 30(1):65–69.
- Huys, R., & G. A. Boxshall. 1991. Copepod Evolution.—The Ray Society, London, 468 pp.
- Johnson, M. W. 1939. *Pseudodiaptomus* (*Pseudodiaptallous*) *euryhalinus* a new subgenus and species of Copepoda, with preliminary notes on its ecology.—Transactions of the American Microscopical Society 58(3):349–355.
- . 1964. On a new species of *Pseudodiaptomus* from the west coast of Mexico, Costa Rica, and Ecuador (Copepoda).—Crustaceana 7(1): 33–41.
- Kasturirangan, L. R. 1963. A key for the identification of the more common planktonic Copepoda of Indian coastal waters. Indian National Commission on Oceanic Research, Council for Scientific and Industrial Research, New Delhi, India, 2:1–87.
- Kiefer, F. 1936. Indische Ruderfüßkrebse (Crustacea: Copepoda) 11.—Zoologischer Anzeiger 113(9/10):231–233.
- . 1938. Bemerkungen zur Pseudodiaptomide-nausbeute der Wallacea-Expedition.—Internationale Revue der Gesamten Hydrobiologie und Hydrographie 38(1/2):75–98.
- Li, S. J., & J. Q. Huang. 1984. On two new species of planktonic Copepoda from the estuary of Jiulong River, Fujian, China.—Journal of the Xiamen University of Natural Sciences 23(3):381–390.
- Madhupratap, M., & P. Haridas. 1992. New species of *Pseudodiaptomus* (Copepoda: Calanoida) from the salt pans of the Gulf of Kutch, India and a comment on its speciation.—Journal of Plankton Research 14:555–562.
- Marsh, C. D. 1913. Report on fresh-water Copepoda from Panama, with descriptions of new species.—Smithsonian Miscellaneous Collections 61(3):1–30.
- . 1933. Synopsis of the calanoid crustaceans exclusive of the Diaptomidae, found in fresh and brackish waters, chiefly of North America.—Proceedings of the United States National Museum 82(2959):1–58.
- Mori, T. 1942. Systematic studies of the plankton organisms occurring in Iwayama Bay, Palao. IV. Copepoda from the bay and adjacent waters.—Palao Tropical Biological Station Studies 2(3):549–580.
- Mrázek, A. 1895. Über eine neue *Schmackeria* (*Schmackeria hessei* n.sp.) aus der Kongo-Mündung.—Vorläufige Mittheilung.—Sitzungsberichte der Königl. Böhmisches Gesellschaft der Wissenschaften 1894(24): 1–3.
- Mulyadi. 1997. Taxonomy and distribution of the family Candaciidae in Indonesian coastal waters.—Treubia, A Journal on Zoology of the Indo-Australian Archipelago, Bogor 31(2):63–112.
- . 1998. New records and taxonomic reexamination of the genus *Centropages* (Copepoda: Calanoida), with notes on their geo-

- graphic distribution in Indonesian waters.—The Raffles Bulletin of Zoology 46(1): 53–70.
- . 2002a. The calanoid copepods of the genus *Pseudodiaptomus* Herrick in Indonesian coastal waters.—Berkala Penelitian Hayati, Journal of Biological Researches 32(2):7–18.
- . 2002b. The calanoid copepods Family Pontellidae from Indonesian waters, with notes on its species-groups.—Treubia, A Journal on Zoology of the Indo-Australian Archipelago, Bogor 32(2):1–167. (for 2001).
- , & H. Ueda. 1996. A new species of *Calanopia* (Copepoda, Calanoida) from Sunda Strait, Indonesia, with remarks on species-groups in the genus.—Crustaceana 69(7):907–915.
- Nicholls, A. G. 1944. Littoral Copepoda from South Australia. II. Calanoida, Cyclopoida, Notodelphyoida, Monstrilloida and Caligoida.—Records of the South Australian Museum, Adelaide 8(1):1–62.
- Nishida, S. 1985. Pelagic copepods in Kabira Bay, Ishigaki Island, southwestern Japan, with the description of a new species of the genus *Pseudodiaptomus*.—Publications of the Seto Marine Biological Laboratory 30(1/3): 125–144.
- , & I. F. M. Rumengan. 2005. A new species of *Pseudodiaptomus* (Copepoda: Calanoida: Pseudodiaptomidae) from the coastal waters of Sulawesi, Indonesia.—Plankton Biology and Ecology 52(1):27–32.
- Ohtsuka, S., A. Fosshagen, & S. Putchakarn. 1999. Three new species of the demersal calanoid copepod *Pseudocyclops* from Phuket, Thailand.—Plankton Biology and Ecology 46(2): 132–147.
- , D. McKinnon, K. Pinkaew, S. Putchakarn, & K. Chalermwat. 2003. New record of *Centropages brevifurcus* (Crustacea: Copepoda: Calanoida) from the Gulf of Thailand and its full redescription.—Species Diversity 8:67–78.
- , S. Putchakarn, K. Pinakaew, & S. Chullasorn. 2000. Taxonomy and feeding ecology of demersal calanoid copepods collected from Thailand. Pp. 133–147 in M. N. Saadon, S. A. Abdullah, S. M. Sheriff and N. A. Ariffin, eds., The 10th JSPS/VCC, Joint Seminar on Marine and Fishery Sciences, Sustainable Utilization of Marine Resources, Kolej Universiti Terengganu, Terengganu, Malaysia, 496 pp.
- , H. Y. Soh, & H. Ueda. 1998. *Platycopia compacta* n.sp., the second species of Platycopioidea (Crustacea: Copepoda) in the Indo-Pacific region, with remarks on development, feeding, swimming, and zoogeography.—Zoological Science, Tokyo 15(3):415–424.
- Oka, S. I., T. Saisho, & R. Hirota. 1991. *Pseudodiaptomus* (Crustacea, Copepoda) in the brackish waters of mangrove regions in the Nansei Islands, southwestern Japan.—Bulletin of the Biogeographical Society of Japan 46(8):83–88.
- Orsi, J. J., & T. C. Walter. 1991. *Pseudodiaptomus forbesi* and *P. marinus* (Copepoda Calanoida), the latest copepod immigrants to California's Sacramento-San Joaquin Estuary. Pp. 553–562 in S. I. Uye, S. Nishida and J. S. Ho, eds., Bulletin of the plankton society of Japan, Proceedings of the Fourth International Conference on Copepoda.—Special volume 1991, 645 pp.
- Pillai, P. P. 1970. *Pseudodiaptomus jonesi*, a new calanoid from Indian waters.—Current Science 39(4):78–80.
- . 1980. A review of the calanoid copepod family Pseudodiaptomidae with remarks on the taxonomy and distribution of the species from the Indian Ocean.—Journal of the Marine Biological Association of India 18:242–265.
- Poppe, S. A., & A. Mrázek. 1895. Entomostroken des Naturhistorischen Museums in Hamburg. 1. Die von Herrn Dr. F. Stuhlmann auf Zanzibar und dem gegenüberliegenden Festlande gesammelten Süswasser-Copepoden.—Jahrbuch der Hamburgischen Wissenschaftlichen Anstalten 12:3–20.
- , & J. Richard. 1890. Description du *Schmackeria forbesi* n. gen. et sp., Calanide nouveau recueilli par M. Schmacker dans les eaux douces des environs de Shanghai.—Mémoires de la Société Zoologique de France 3:396–403.
- Razouls, C. 1995. Diversité et répartition géographique chez les copépodes pélagiques. 1. Calanoida.—Annales de l'Institut Océanographique, Paris 71(2):81–401.
- Reddy, Y. R., & Y. Radhakrishna. 1982. Redescription and/or remarks on four species of *Pseudodiaptomus* Herrick (Copepoda: Calanoida) from South India.—Hydrobiologia 87:255–271.
- Rose, M. 1957. Description de Copépodes nouveaux du plankton marin de Nha-Trang (Viet-Nam).—Bulletin du Museum National d'Histoire Naturelle, Paris (2) 29:235–245.
- Roy, T. 1977. Description of a new calanoid copepod, *Pseudodiaptomus nankauriensis* sp. nov. from Nicobar Islands, India. Pp. 100–104 in Proceedings of the Symposium

- on Warm Water Zooplankton, UNESCO/NIO, Goa.—Special Publications of the National Institute of Oceanography, Goa, India, 722 pp.
- Sars, G. O. 1902. An Account of the Crustacea of Norway, Copepoda Calanoida, Parts VII & VIII.—Bergen Museum, Christiania 4: 73–96.
- . 1903. An Account of the Crustacea of Norway, with short descriptions and figures of all the species. Copepoda, Calanoida, with supplement.—Bergen Museum, Christiania 4(1–14):1–171.
- Sato, C. 1913. Free-swimming Copepoda (I).—Hokkaido Fisheries Research Laboratory, Investigation Reports 1(1):1–82.
- Scott, A. 1909. The Copepoda of the Siboga Expedition. Part I. Free-living, littoral and semi-parasitic copepods.—Siboga Expeditie, Monographie 29a:323 pp.
- Scott, T. 1894. Report on Entomostraca from the Gulf of Guinea, collected by John Rattray, B.Sc.—Transactions of the Linnean Society of London, Zoology, Series 2(6):1–161.
- Sewell, R. B. S. 1912. Notes on the surface living Copepoda of the Bay of Bengal I and II.—Records of the Indian Museum, Calcutta 7:313–382.
- . 1919. A preliminary note on some new species of Copepoda.—Records of the Indian Museum, Calcutta 16:1–18.
- . 1924. Crustacea Copepoda: Fauna of Chilka Lake.—Memoirs of the Indian Museum, Calcutta 5:771–851.
- . 1932. The Copepoda of Indian Seas. Calanoida.—Memoirs of the Indian Museum, Calcutta 10:223–407.
- Shen, C. J. 1955. On some marine crustaceans from the coastal water of Fenghsien, Kiangsu Province.—Acta Zoologica Sinica 7:75–100.
- , & F. S. Lee. 1963. The estuarine Copepoda of Chiekong and Zaikong Rivers, Kwangtung Province, China.—Acta Zoologica Sinica 15(4):571–596.
- , D. X. Song. 1979. Fauna Sinica, Crustacea. Freshwater Copepoda. Pp. 53–163 in C. J. Shen, ed., and Fauna Editorial Committee, Academia Sinica, Science Press, Beijing, 450 pp.
- , & A. Y. Tai. 1962. The Copepoda of the Wu-Li Lake, Wu-Sih, Kiangsu Province. I. Calanoida.—Acta Zoologica Sinica 14(1):99–118.
- . 1964. Description of eight new species of freshwater Copepoda (Calanoida) from the delta of the Pearl River, south China.—Acta Zoologica Sinica 16(2):225–246.
- Soh, H. Y., H. L. Suh, O. K. 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(1/3):203–215.
- Stingelin, T. 1900. Beitrag zur Kenntniss der Süswasserfauna von Celebes. Entomostraca.—Revue Suisse de Zoologie 8(2):193–207.
- Walter, T. C. 1984. New species of *Pseudodiaptomus* from the Indo-Pacific, with clarification of *P. aurivilli* and *P. mertoni* (Crustacea: Copepoda: Calanoida).—Proceedings of the Biological Society of Washington 97:369–391.
- . 1986a. New and poorly known Indo-Pacific species of *Pseudodiaptomus* (Copepoda: Calanoida), with a key to the species group.—Journal of Plankton Research 8:129–168.
- . 1986b. The zoogeography of the genus *Pseudodiaptomus* (Calanoida: Pseudodiaptomidae). Pp. 502–508 in G. Schriever, H. K. Schminke and C. T. Shih, eds., Proceedings of the Second International Conference on Copepoda, Ottawa, Canada, 13–17 August, 1984.—Syllogeus 58:662 pp.
- . 1987. Review of the taxonomy and distribution of the demersal copepod genus *Pseudodiaptomus* (Calanoida: Pseudodiaptomidae) from southern Indo-West Pacific waters.—Australian Journal of Marine and Freshwater Research 38:363–396.
- . 1989. Review of the New World species of *Pseudodiaptomus* (Copepoda: Calanoida), with a key to the species.—Bulletin of Marine Science 45:590–628.
- . 1994. A clarification of two congeners, *Pseudodiaptomus lobipes* and *P. binghami* (Calanoida, Pseudodiaptomidae) from India, with description of *P. mixtus* sp.n. from Bangladesh. Pp. 123–130 in F. D. Ferrari and B. P. Bradley, eds., Ecology and morphology of copepods. Developments in Hydrobiology 102.—Hydrobiologia 292/293:530 pp.
- . 1998. A redescription of *Pseudodiaptomus salinus* (Giesbrecht, 1896) and a new species from the Arabian Sea (Copepoda, Calanoida, Pseudodiaptomidae).—Journal of Marine Systems 15:451–456.
- , S. Ohtsuka, S. Puthakarn, K. Pinkaew, & S. Chullasorn. 2002. Redescription of two species of *Pseudodiaptomus* from Asia and Australia (Crustacea: Copepoda: Calanoida: Pseudodiaptomidae) with discussion of the female genital structure and zoogeography of Indo-West Pacific species.—Proceedings of the Biological Society of Washington 115(3): 650–669.

- Wellershaus, S. 1969. On the taxonomy of planktonic Copepoda in the Cochin Backwater (a South Indian estuary).—*Veröffentlichungen des Instituts für Meeresforschung in Bremerhaven* 11(2):245–286.
- Wright, S. 1928. A contribution to the knowledge of the genus *Pseudodiaptomus*.—*Transactions of the Wisconsin Academy of Sciences, Arts, and Letters* 23:587–600.
- . 1936. A revision of the South American species of *Pseudodiaptomus*.—*Anais da Academia Brasileira de Ciências* 8(1):1–24.
- . 1937. Two new species of *Pseudodiaptomus*.—*Anais da Academia Brasileira de Ciências* 9:155–162.

Associate Editor: Janet W. Reid