

## A clarification of two congeners, *Pseudodiaptomus lobipes* and *P. binghami* (Calanoida, Pseudodiaptomidae) from India, with description of *P. mixtus* sp.n. from Bangladesh

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### Abstract

Two closely related and often confused species of *Pseudodiaptomus* from the Lobus-species group, *P. lobipes* and *P. binghami* are redescribed from various locations along the east coast of India. These species predominately occur in freshwater though they can survive temporary periods of increased salinity. The distinctive features of the species are found on: female caudal ramal setae, female and male urosome 1-2 spinulation patterns, and fifth legs. A new species *P. mixtus* from Bangladesh is described.

### Introduction

The pseudodiaptomid species of the Bay of Bengal region are numerous and occur from freshwater to hypersaline conditions. There are 16 species of *Pseudodiaptomus* presently known from India: *annandalei* Sewell, *ardjuna* Brehm, *aurivilli* Cleve, *binghami* Sewell, *bowmani* Walter, *clevei* Scott, *compactis* Walter, *heterothrix* Brehm, *hickmani* Sewell, *jonesi* Pillai, *lobipes* Gurney, *malayalus* Wellershaus, *pankajus* Madhupratap & Haridas, *serricaudatus* Scott, *sewelli* Walter, and *tollingeriae* Sewell. Only two of these species have been reported from freshwater habitats *P. binghami* and *lobipes*. Most of these species have been reviewed by Pillai (1980), Reddy & Radhakrishna (1982), and Madhupratap & Haridas (1989, 1992) although a complete review of the genus from the Indian Ocean is needed.

The three species described here occur in fresh to brackish waters along coasts of the Indian Ocean, while the rest of the species from this geographic region are euryhaline, as are the majority of the species of *Pseudodiaptomus*. Occasionally, these low salinity species may be found in highly saline waters, although reproduction and more importantly naupliar development are unlikely.

### General description of species

The abbreviations used throughout the paper are as follows: USNM = United States National Museum; BM = The Natural History Museum, United Kingdom; HM = Hungarian Natural History Museum, Hungary; Pr = prosome; Pdg1-5 = pediger 1-5; Ur 1-5 = urosomites 1-5; A1 = first antenna; P1-5 = swimming legs 1-5; CR = caudal rami; B1-B2 = basipods 1-2; Re = exopod; Ri = endopod.

Measurements were done with a calibrated ocular micrometer in millimetres. Pr and Ur lengths were measured dorsally from anterior margin of head to posterior end of Pdg5 and from anterior margin of Ur1 insertion into Pdg5 to distal tip of CR. Because Pdg5 corners usually overlap Ur, total length may be less than combined lengths of Pr and Ur.

The three species described in this paper belong to the Lobus-species group and the '*forbesi*-subgroup' defined by Walter (1986). Their common morphological characters include: Both sexes with head fused to Pdg1, rostrum with 2 slender filaments. Mouth parts and P1-4 are not drawn here, as they do not differ from those reported by Reddy & Radhakrishna (1982) and Walter (1986). A1 with segments 6-7 partly fused, female with 21 segments, male A1 with 22 and 20 segments, respectively for left and right antennae. Pdg5 with rounded posterior corners and 2

small posterodorsal spines. Female urosome with 4 segments, Ur1-3 with posterior scale row. Egg sacs paired. Male urosome with 5 segments, Ur2-4 with posterior scale row. Caudal rami in females normal or thickened. Female P5, both legs, with 2-segmented basipod and 3-segmented exopod. Posterior view, B2 with large surface seta. Anterior view, B1 with proximal spinule row, B2 with distolateral spinule row, Re1 with distolateral hirsute spine and distal surface spinule row at base of spine, and variable distomedial process. Re2 distolateral corner produced into spine-like process and distomedial corner with large spine. Re3 elongate with medial and lateral fine spinule rows and small proximomedial process. Male P5 with 2-segmented basipod, right leg with 3-segmented exopod, left leg with 2-segmented exopod. Posterior view, B1 right and left legs with proximal spinule row and distolateral corners acute, B2 with large surface seta and left B2 medial margin produced into large process. Anterior view both legs, B1 with distolateral spinules along groove in both legs, B2 with distolateral spinule row. Re2 right leg with 2 small proximomedial knobs, left leg with fine hairs and setae along medial groove and lateral spinous process. Right leg, Re3 claw-like with 2 lateral spinule rows at midlength, medial hirsute hump-like process with nipple, and distal third with medial and lateral spinule and hair rows.

*Pseudodiptomus lobipes* Gurney, 1907

(Fig. 1A–J)

*Pseudodiptomus lobipes* Gurney, 1907:27, Pl. 1, Figs 3-5; Tollinger, 1911: 178–179; Sewell, 1924: 786, Pl. 45, Figs 1a-d; Sewell, 1934: 79; Sewell, 1948: 429; Wright, 1928: 588; Brehm, 1934: 93; Brehm, 1950: 14, Figs 2d-e; Pillai, 1970: 78; Pillai, 1972: 164, 171; Reddy & Radhakrishna, 1982: 256; Walter, 1986; Table 1; Madhupratap & Haridas, 1986: 111, Table 2. not *Pseudodiptomus lobipes*, Brehm, 1953: 304–305, Fig. 65. *Schmackeria lobipes*, Marsh, 1933: 45, Pl. 22, Figs 4, 7, 8.

*Material examined*: India, Calcutta, 4♂, 35♀, coll. by E. and urosome lengths and Pr:Ur ratio.

Female (Figs 1A–F): Ur1 with anterolateral patch of fine spinules extending slightly dorsad, followed by 2 rows of larger spinules extending dorsad but incomplete, and 2 posterolateral rows of still larger spinules, first row complete dorsally and curved anteriorly. Ur2

with anterodorsal row of fine (6-9) spinules. CR setae normal and plumose (Fig. 1E). Ur1-4 and CR in proportions of :28:19:23:9:21=100. P5 anterior view (Fig. 1F): B1 with fine proximal hair row, B2 with medial protrusion at midlength and distolateral spinule row extending onto surface. Re1 with distomedial notch forming spinous projection at base; oblong hyaline lobe filling notch.

Male (Figs 1G–J): Ur1 with lateral spinule row at midlength. Ur2 with 3 spinule rows, anterolateral row incomplete ventrally. Ur3 with 2 rows of fine ventral spinules. Ur1-5 and CR in proportions of :10:20:18:22:10:20=100. P5 posterior view (Fig. 1I): Right leg, B2 with large proximomedial rounded protrusion and small distomedial knob with large proximomedial rounded protrusion and small distomedial knob with spinule at base. Re1 distolateral corner produced into large spine-like process with spinules at apex. Re2 with proximomedial knob, 3 surface spinules and small distolateral spine. Re3 elongate, medially curved, large midlength protrusion with nipple and covered with fine spinules and hairs, 2 rows of fine lateral spinules and distal half with 2 medial spinule rows. Left leg: B2 produced medially into large, thick, laterally curved process with slight hump at mid-outer margin, and groove on distal half. Re1 distal end acutely produced. Re2 elongate and sac-like, with several surface spinules and lateral spine-like hirsute process at midlength. P5 anterior view (Fig. 1J): Right leg, B2 with 2 surface spinule rows.

*Remarks*: The original illustrations of *P. lobipes* lack many of the details included here. The characteristics of the female are: Ur2 with anterodorsal spinule row, CR setae narrow, and P5 Re1 with distomedial notch. The male is distinguished by: Ur3 with 2 ventral spinule rows, P5 left B2 medial process curved laterally near rounded apex and protrusion at mid-outer margin, right B1 without medial protrusion, and left Re2 sac-like and elongate.

Confusion about the identity of *P. lobipes* and *P. binghami* was discussed by Reddy & Radhakrishna (1982), although they had not illustrated the former species. Over the years, the narrow CR setae have been used by researchers as a characteristic feature of *P. lobipes* (Sewell, 1924; Reddy & Radhakrishna, 1982). The male has typically been separated by the shape of the left Re2 being elongate and sac-like in *lobipes* while ovate and glove-shaped in *binghami*. Table 2 provides a comparison of morphological features to identify the

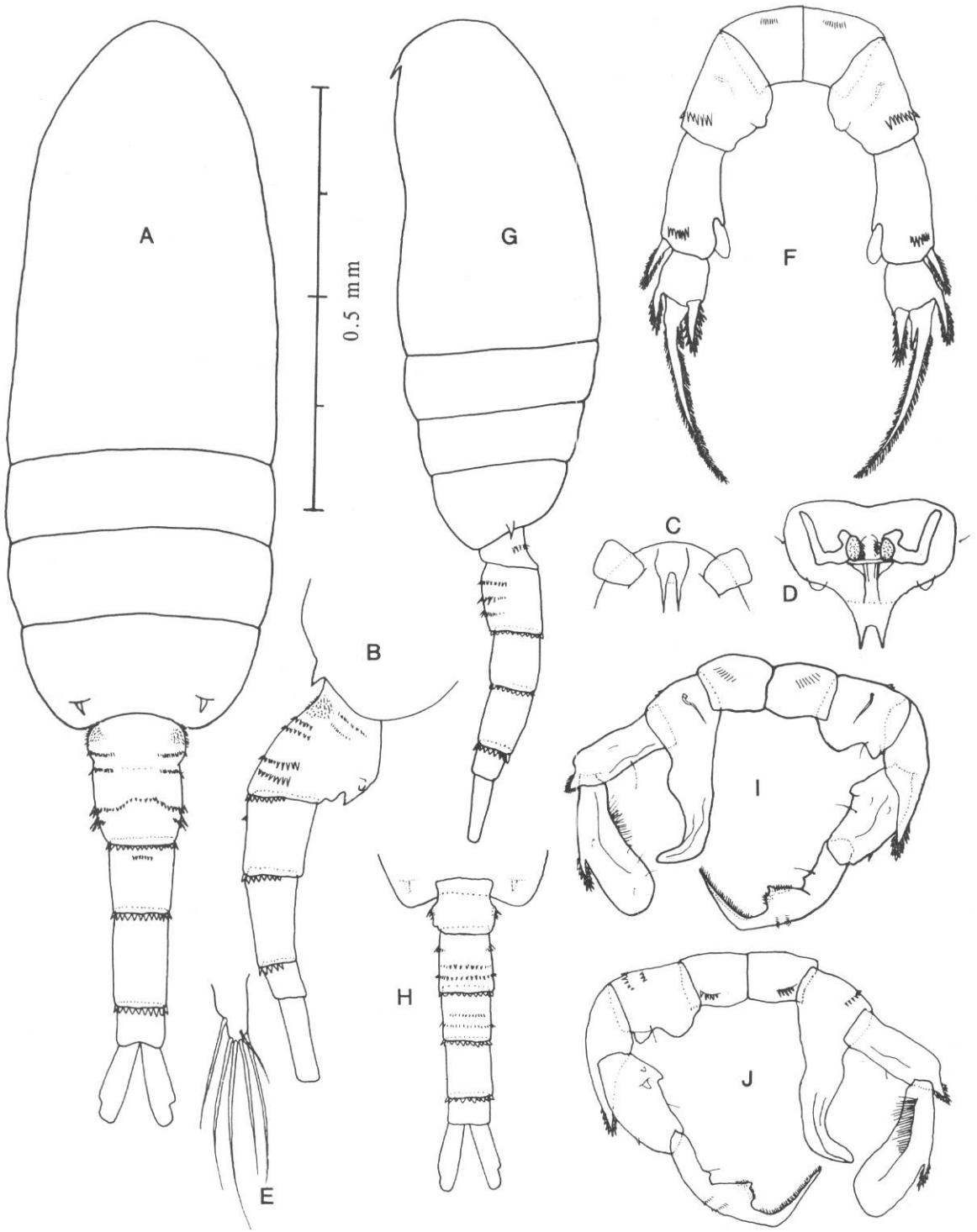


Fig. 1. *Pseudodiptomus lobipes* Gurney A-D, adult female: A, dorsal view; B, Pdg5 and urosome right lateral view; C, head with rostrum ventral view; D, Ur1 genital field ventral view; E, tip of left CR showing narrow normal setae; F, P5 anterior view. G-J, adult male: G, left lateral view; H, urosome ventral view; I, P5 posterior view; J, P5 anterior view.

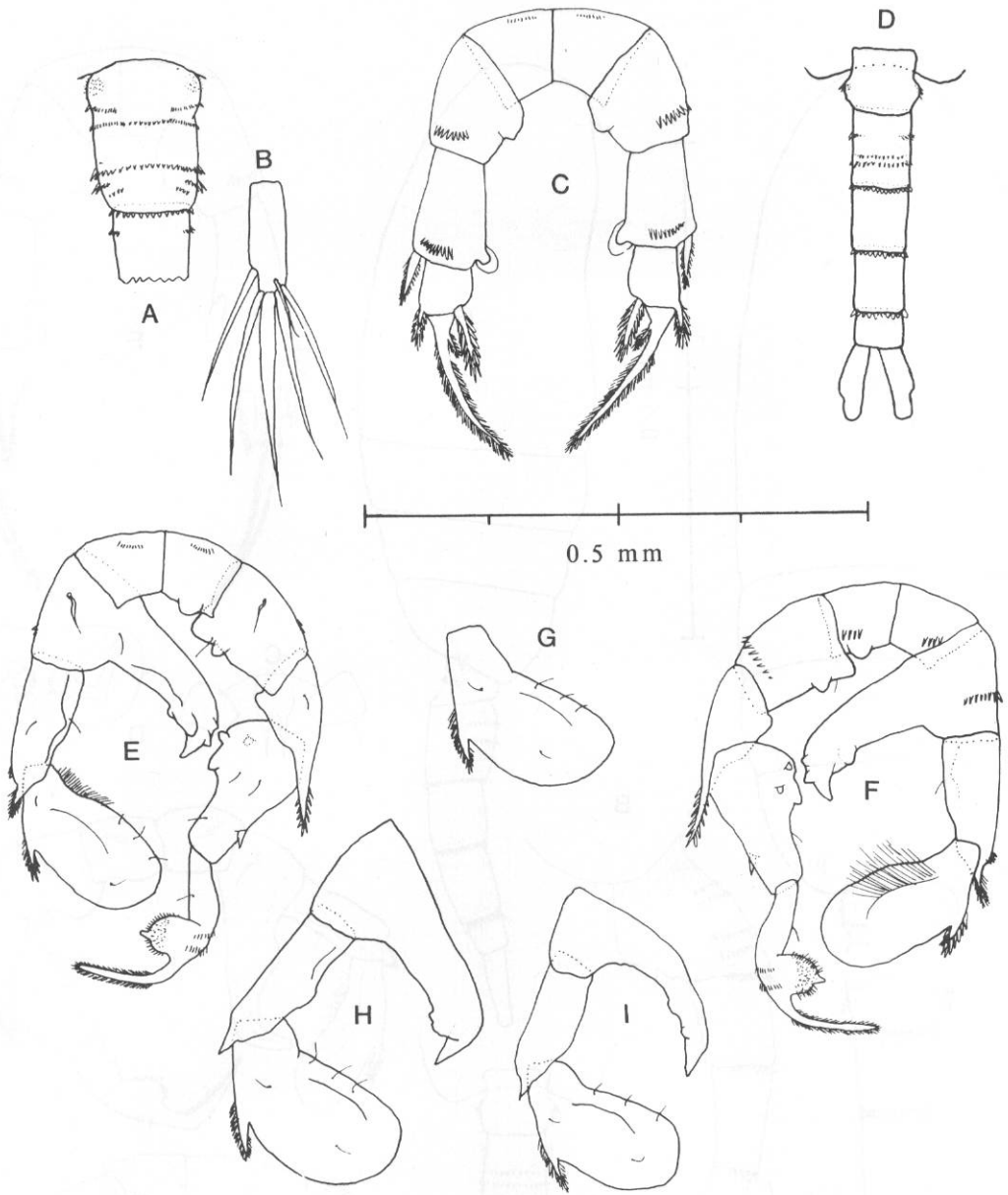


Fig. 2. *Pseudodiptomus binghami* Sewell A-C, adult female: A, Ur1-2 dorsal view; B, tip of left CR showing thickened setae; C, P5 anterior view. D-I, adult male: D, urosome ventral view; E, P5 posterior view; F, P5 anterior view; G, P5 of left Re2 posterior view; H-I, left B2-Re2 variation.

species. This species has so far been reported only from Calcutta, the type locality. Reddy and Radhakrishna (1982:260), reported that they examined "1 female and 1 male (unspecified types) of *P. lobipes*, loaned from the British Museum" however, from my observations these specimens were not *lobipes* but rather *binghami*.

*Pseudodiptomus binghami* Sewell, 1912

(Figs 2A-I)

*Pseudodiptomus binghami* Sewell, 1912:337, Pl. 17, Figs 8-11; Sewell, 1919:7-9; Sewell, 1924:786-787, Pl. 45, Fig. 2; Sewell, 1932:240-241; Sewell, 1934:78; Sewell, 1948:323,429; Sewell, 1956:169-170; Früchtl, 1924:48; Wright, 1928:588; Brehm,

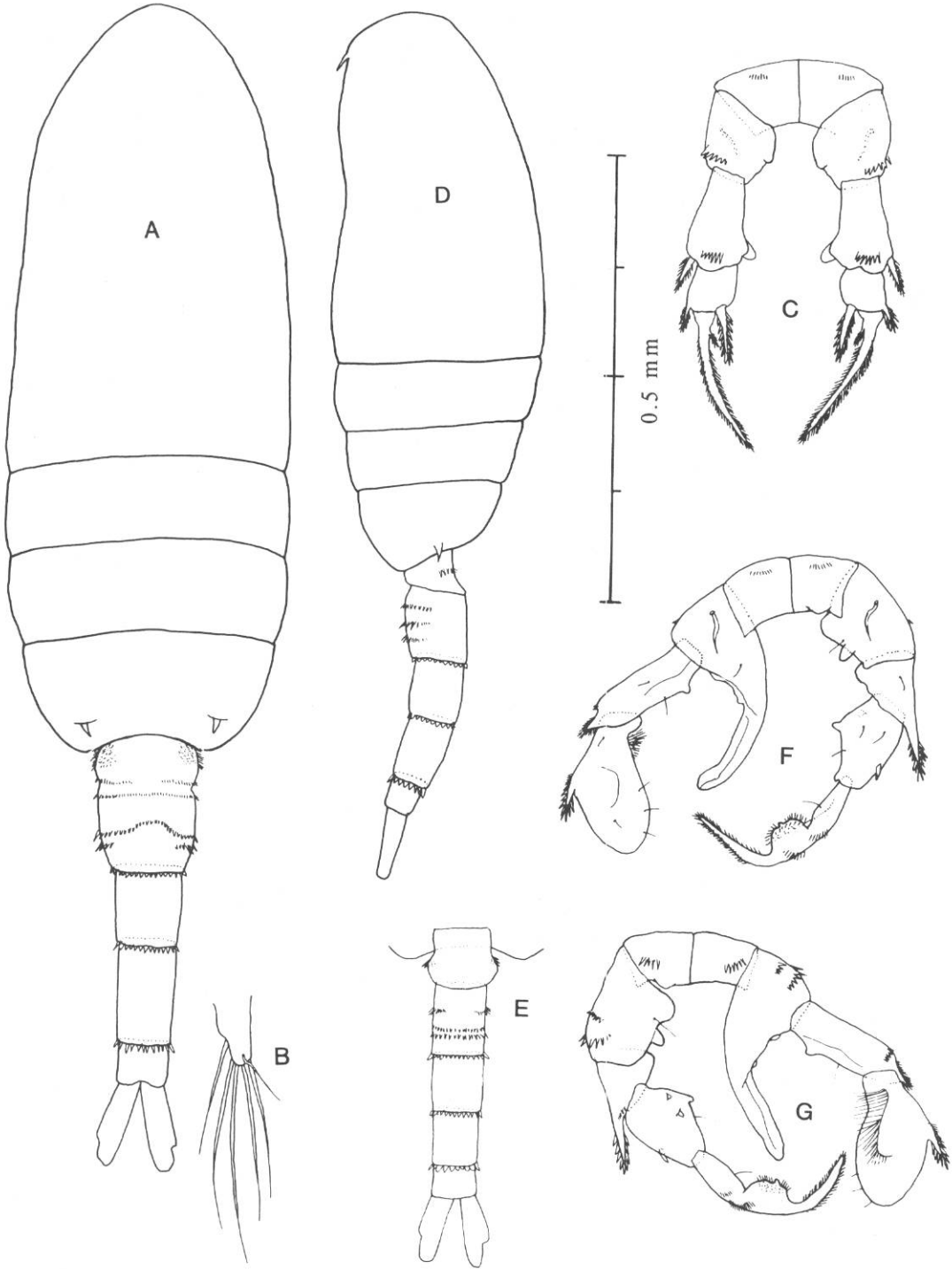


Fig. 3. *Pseudodiptomus mixtus* n.sp. A-C, adult female: A, dorsal view; B, tip of left CR showing normal setae; C, P5 anterior view. D-G, adult male: D, left lateral view; E, urosome ventral view; F, P5 posterior view; G, P5 anterior view.

Table 1. A comparison of the three species of *Pseudodiptomus* from India and Bangladesh. Sex, number of specimens measured, total body length range, mean total body length, mean prosome length, mean urosome length and prosome/urosome ratio of lengths. The three lines for *P. binghami* are measurements of BM 1925, USNM 216571, USNM 264767, respectively.

Sex	No.	Length (mm)	$\bar{x}$	Pr $\bar{x}$	Ur $\bar{x}$	Pr:Ur
<i>P. lobipes</i>						
Female	20	1.29–1.33	1.31	0.89	0.51	1:1.7
Male	2	0.95–0.98	0.97	0.66	0.40	1:1.6
<i>P. binghami</i>						
Female	4	0.97–1.03	1.01	0.67	0.39	1:1.7
	10	1.22–1.28	1.25	0.87	0.50	1:1.7
	10	1.19–1.25	1.23	0.82	0.49	1:1.7
Male	1	0.82	0.82	0.55	0.35	1:1.6
	10	0.90–0.95	0.94	0.66	0.38	1:1.7
	10	0.87–0.92	0.90	0.63	0.36	1:1.7
<i>P. mixtus</i>						
Female	30	1.14–1.23	1.19	0.74	0.47	1:1.6
Male	30	0.90–0.96	0.94	0.64	0.40	1:1.6

Table 2. A comparison of morphological features of the three species of *Pseudodiptomus* from India and Bangladesh.

	<i>lobipes</i>	<i>binghami</i>	<i>mixtus</i> n.sp.
Morphological Character			
Female			
Ur1 2nd anterolateral spinule row	incomplete	complete	complete
1st posterolateral spinule row	curved anteriad	straight	curved anteriad
posterodorsal spinules	none	4–5	none
Ur2 spinules	anterodorsal	anterolateral	none
CR setae	thin	thick	thin
P5 Re1 distomedial surface	notch	large knob	small knob
Male			
Ur3 ventral spinule rows	two	none	none
P5 right B1 medial hump	none	large	small
left B2 process bent near	apex	apex	midlength
left Re2	sac-like	glove-like	glove-like
	elongate	ovate	ovate

1934:93; Brehm, 1951:97; Brehm, 1953:304–305, Fig. 65; Shen & Tai, 1964:229,230,242, Table 3; Pillai, 1970:78; Pillai, 1972:164,171; Pillai, 1980:246,251, Fig. 1; Mohan, 1977:332–334; Reddy & Radhakrishna, 1982:256–261, Pl. 1, Figs 1–11, Pl. 2, Figs 12–19; Goswami, 1983:254–257; Walter, 1986: Table 1; Madhupratap & Haridas, 1986:111, Table 2; Sarkar *et al.*:

1986:178. *Schmackeria binghami* Marsh, 1933:43–44, Pl. 21, Figs 2–3.

*Material examined*: India, Orissa, Chilka Lake, 1 ♂, 4 ♀, coll. 1925, BM1925.1.30.9–13; Andhra Pradesh, Nagarjuna University Reservoir, 10 ♂, 19 ♀, coll. by C. Rama Devi, 08 SEP 1983, USNM 216571; Andhra

Pradesh, Lake Kolleru, Kolletikota, 3 ♂, 5 ♀, coll. by Y. Ranga Reddy, – JUL 1974, USNM 264767. Table 1 shows total body, prosome and urosome lengths and Pr:Ur ratio.

Female (Figs 2A–C): Ur1 with fine anterolateral spinule patches extending slightly dorsad, followed by 2 anterolateral rows of large spinules, second row complete dorsally, 2 posterolateral rows of slightly larger spinules, first row complete dorsally second row incomplete, and 4–5 posterodorsal spinules on each side near posterior margin. Ur2 with 3–6 anterolateral spinules. CR setae enlarged and flattened (Fig. 2B), particularly setae 2 and 3. Ur1-4 and CR in proportions of: 32:16:20:9:23=100 [BM 1925], 29:15:23:10:23=100 [USNM 216571], 30:17:22:9:22=100 [USNM 264767]. P5 anterior view (Fig. 2C): same as in *P. lobipes* except for Re1 distomedial rectangular knob replacing notch and hyaline lobe, oval to circular in shape covering knob.

Male (Figs 2D–I): Ur1-2 same as in *P. lobipes*, Ur3 without ventral spinule rows. Ur1-5 and CR in proportions of: 11:20:18:20:11:20=100 [BM 1925], 12:21:17:17:10:23=100 [USNM 216571], 12:20:18:18:10:22=100 [USNM 264767]. P5 posterior view (Figs 2E, G–I): Right leg, B1 with large medial protrusion. B2 with rounded proximomedial corner and small knob with spinule at base. Re2 medial knobs as in *P. lobipes*, though distolateral spine slightly larger. Left leg; B2 process somewhat pointed, apical part reflexed and with 2–4 knobs, varying with view. Re2 glove-shaped, shorter, more ovate than elongate, distal end varying in shape from rounded to slightly triangular depending on view (Fig. 2E–I).

*Remarks:* The original description of *P. binghami* was based on females collected from a Rangoon estuary, Burma (Sewell, 1912). Subsequently, Sewell (1919) discovered males from Chilka Lake, India. Unfortunately no drawings of the male were available until Sewell published them (1924). This species was reviewed by Reddy & Radhakrishna (1982); here some additional points are added for this species. Female Ur1 with short posterodorsal fine spinules on each side near posterior margin and P5 Re1 with anterior spinule row. In the male, Ur2 with three ventral spinule rows, which the above authors indicated as ‘a few spinules on either side half-way’, and P5 B1 with spinules and left B2 with protrusions near apex. Table 2 provides a comparison of morphological features to identify the

species. The specimens from Chilka Lake collected in 1925 are much smaller than the other two localities.

As previously indicated, this species closely resembles *P. lobipes*, although females of *binghami* are easily distinguished by the thickened CR setae and P5 Re1 distomedial knob. The *binghami* males are unique in that they lack ventral spinule rows on Ur3, P5 left B2 apex pointed with knobs, left Re2 glove-like and ovate in shape, and right B1 with large medial protrusion. This species is reported from freshwater lakes and rivers from Calcutta south to the State of Andhra Pradesh and as far inland as Mirzapore in the State of Uttar Pradesh, (Brehm, 1950).

*Pseudodiptomus mixtus* n.sp.

(Figs 3A–F)

*Material examined:* Bangladesh, Kaptai Lake, Rangamati, coll. by C.C. Lindsey, 27 APR 1976, 5-21 ms, Holotype, 1 ♂, USNM 264766; Paratypes, 50 ♀, 50 ♂, USNM 264881. Table 1 shows total body, prosome and urosome lengths and Pr:Ur ratio.

Female (Figs 3A–C): Pr, Ur and CR same as *P. lobipes* except that Ur1 anterodorsal second spinule row complete and Ur2 lacking anterodorsal row of fine spinules. CR setae normal and plumose. Ur1-4 and CR in proportions of: 29:19:21:10:21=100. P5 anterior view (Fig. 3C) same as in *P. binghami* except for Re1 distomedial knob being reduced to slight protrusion, and hyaline lobe, oval to circular, covering protrusion.

Male (Figs 3D–G): Pr and Ur same as *P. binghami*. U1-5 and CR in the proportions of: 11:20:19:20:10:20=100. P5 posterior view (Fig. 3F): Right leg, B1 with slight medial protrusion, B2 with rounded proximomedial corner and medial protrusion at midlength. Re1–Re3 same as in *P. lobipes*. Left leg; B2 produced medially into large, thick, laterally curved process (approximately 90° near midlength) with several small protrusions proximal to midlength near Re1 insertion, and apex smooth and rounded. Re1 with small proximomedial protrusions. Re2 glove-shaped, slightly shorter than in *binghami*, more ovate than elongate, distal end somewhat triangular in shape though slightly varying in shape. P5 anterior view (Fig. 3G) Right leg, B2 with 2 distolateral spinule rows and Re1 with distal spinules at base of Re2.

*Etymology:* The specific name *mixtus* is Latin for mixed or blended, referring to the mixing of morphological characters possessed by *binghami* and *lobipes*.

*Remarks:* At first it was thought these specimens represented a variant of *P.lobipes*; however, certain morphological features could also be attributed to those of *P. binghami*. Because type material of the two species is not available, the above-mentioned specimens are compared. Based on the following morphological characteristics *P. mixtus* is established. In females of *P. mixtus*, CR setae are narrow as in *P. lobipes*, though Ur2 lacks the dorsal spinule row. The P5 is similar to *binghami*, but Re1 distomedial knob is reduced whereas in *lobipes* it is replaced by a notch. In males, the P5 left Re2 is glove-like and ovate as in *binghami*, while the left B2 resembles that of *lobipes*, though medial process is bent at midlength rather than near the apex as in *lobipes* and *binghami*. Finally, the right B1 possesses a small medial protrusion, which is larger in *binghami* but is absent in *lobipes*. Table 2 provides a comparison of morphological features to identify the species.

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