

**Taxonomic Study of Marine Tardigrades from Korea  
I. Genus *Batillipes* (Heterotardigrada: Batillipedidae)**

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**ABSTRACT**

Eight tardigrade species belonging to the genus *Batillipes* are recorded from the intertidal and shallow sublittoral sands at 29 localities in South Korea. *Batillipes rotundiculus* n. sp. is characteristic in having the round caudal protrusion and the blister-like lateral body protuberance between legs III and IV. Five species (*B. pennaki* Marcus, *B. similis* Schulz, *B. tridentatus* Pollock, *B. crassipes* Tchesunov and Mokievsky, and *B. philippinensis* Chang and Rho), newly known to Korean fauna, are briefly remarked with illustrations. A key to the eight species of the batillipedid tardigrades from Korea is prepared.

Key words: Taxonomy, Tardigrada, Batillipedidae, *Batillipes*, new species, marine, Korea

**INTRODUCTION**

Family Batillipedidae includes a single genus *Batillipes* that is highly specialized for interstitial life, and clearly defined by its unique morphology: six toes composed of tubular pedestals of unequal lengths and terminal disc-shaped adhesive expansions, as the generic name indicates (*batillum*-spade, *pes*-foot).

Genus *Batillipes* was established by Richters (1909), and now has 23 valid species (over 15% of all marine tardigrades currently recognized), to become interpreted as the most diverse and widely distributed marine genus, especially in the Northern Hemisphere. But the Northern Pacific is one

of the areas where the taxonomic study on *Batillipes* has been paid little attention. Only seven species have been recorded from that area including two species from Korea: *B. gilmartini* McGinty from California (McGinty, 1969; Pollock, 1989); *B. mirus* Richters from Oregon, and *B. tridentatus* Pollock from Washington and California (Pollock, 1989); *B. crassipes* Tchesunov and Mokievsky from Furughelm Island (Tchesunov and Mokievsky, 1995); *B. longispinosus* Chang and Rho, and *B. orientalis* Chang and Rho both from Korea (Chang and Rho, 1997a); *B. philippinensis* Chang and Rho from Philippines (Chang and Rho, 1997b).

This paper deals with a provisional summary of the taxonomic study on this fascinating and charactersitic psammo-meiobenthos, which has been accomplished in South Korea during last four years.

## MATERIALS AND METHODS

Materials were collected from the upper 10 cm of sands and shell gravels at the intertidal and shallow sublittoral zone at 29 localities (Fig. 1) in South Korea during the period from February, 1995 to November, 1998. Samples were dredged into polyethylene vinyl bag by scuba divers, and filtered through nylon net in the field after freshwater rinsing for less than a minute. Specimens were drawn and measured in lactophenol or lactic acid on Cobb's hole slide, and examined under differential interference contrast microscope.

## TAXONOMIC ACCOUNTS

Order Heterotardigrada Marcus, 1927

Suborder Arthrotardigrada Marcus, 1927

Family Batillipedidae Ramazzotti, 1962

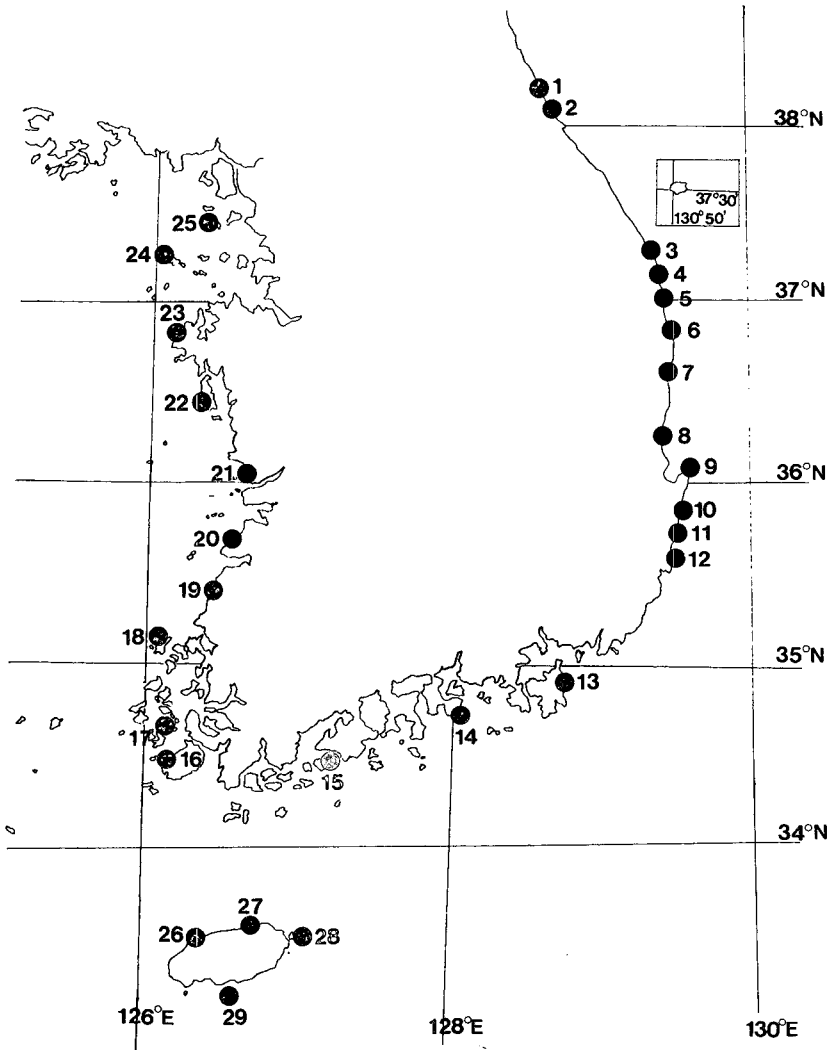
Genus *Batillipes* Richters, 1909

### 1. *Batillipes rotundiculus* Rho and Chang, new species (Fig. 2A)

**Material examined.** 30 females and 20 males from submerged sand bottom (3-6 m deep) of Samjung, Kuryongpo (35° 59' 45"N, 129° 34' 39"E), 29 August 1997 (H. S. Rho and J. W. Choi). 15 specimens were mounted in lactophenol, and 35 specimens were stored in 5% buffered formalin. Holotype female and three paratypes (females) are mounted and deposited in the Natural History Museum of Ewha Womans University under registration number EWNHM 60256 and EWNHM 60257, respectively. Other paratypes are kept in the collection of the authors.

**Additional material examined.** 3 inds., Pongpo, Sokcho, 25 August 1995 (Y. J. Choi); 1 ind. Pongpo, 24 December 1996, H. S. Rho and K. M. Ku; 10 inds., Hungnam-ri, Kojedo I., 30 January 1997, S. H. Kim and H. S. Rho; 3 inds. Uido I., 14 June 1997, S. M. Yoon; 10 inds., Samjung, Kuryongpo, 3 July 1997, H. S. Rho and J. W. Choi; 3 inds., Imjado I., 13 June 1998, H. S. Rho and J. W. Choi; 5 inds., Wonsando I., 6 September 1998, H. S. Rho and H. S. Ahn. All are mounted in lactic acid.

**Diagnosis.** With round caudal protrusion and blister-like lateral body projections between legs III



**Fig. 1.** A map showing the localities. 1, Hwajinpo; 2, Pongpo; 3, Imwon; 4, Hosan; 5, Chukpyon; 6, Pyonghae; 7, Sajin; 8, Wolpo; 9, Taebo; 10, Samjung-2-ri, Kuryongpo; 11, Yangpo; 12, Ponggil; 13, Hungnam-ri; 14, Sangju-ri; 15, Sorokdo I.; 16, Kagye; 17, Uido I.; 18, Imjado I.; 19, Kusipo; 20, Kyokpo; 21, Chunjangdae; 22, Kotchi; 23, Manripo; 24, Sopo-ri, Tokchokdo I.; 25, Yongyudo I.; 26, Hyopcha; 27, Samyang; 28, Udo I.; 29, Supsom, Sogwipo.

and IV; cephalic sensory appendages relatively short; leg IV bearing a very short spiky spine on its femur.

**Holotype.** Body length 195  $\mu\text{m}$ , measured from anterior margin to caudal extreme region. Body slightly wider posteriorly except between first leg pair, and a little flattened dorsoventrally. Body width 61.3  $\mu\text{m}$ , 31.4U (percentage unit of the ratio to body length) in lateral body projections between legs III and IV. Cuticle transparent with fairly regular punctuations.

Head 52.9  $\mu\text{m}$  wide (27.1U), measured the distance between bases of lateral cephalic cirri.

Frontal margin of head arched gently with deeper notch between external and internal cephalic cirri. All cephalic sensory cirri forming pedunculate base distinctly and not frayed at tips.

Unpaired median cephalic cirrus with sharp point  $15.8\ \mu\text{m}$  long (8.1U), inserted far from rostral edge and directed upwards. Internal cephalic cirri  $20.4\ \mu\text{m}$  (10.5U), comparatively long, but shorter than lateral cephalic cirri ( $28.8\ \mu\text{m}$  long, 14.8U). External cephalic cirri placed laterally near clavae and lateral cephalic cirri in ventral position and preceding mouth. Clavae  $15.4\ \mu\text{m}$  long (7.9U), slightly longer than external cephalic cirri ( $15\ \mu\text{m}$ , 7.7U). Clavae slender, round-tipped, undivided, sticklike, cylindrical, inserted ventrally to base of lateral cephalic cirri and directed anterolaterally. Clavae and lateral cephalic cirri originated together from same enlarged pedestal on each side of head, and paralleled anterolaterally. Without any papilla between internal cephalic cirri and external ones. Cheek region smoothly rounded.

Pharyngeal bulb relatively small and ovoid,  $21.7\ \mu\text{m}$  long (11.1U),  $17.1\ \mu\text{m}$  wide (8.8U), length to width ratio 1.27. Stylet, stylet supports and placoids not confirmed clearly.

Body with distinct neck constriction ( $37.5\ \mu\text{m}$  wide, 19.2U). A pair of prominent lateral protrusion present between head and leg I. Scapular region between first leg pair well developed, and each side bearing a blunt lateral projection at its posterior edge. Similar condition occurred between second leg pair, but lateral projection apparently weaker. With prominent ventrolateral projection between every leg pair,  $2.9\ \mu\text{m}$ ,  $7.5\ \mu\text{m}$ ,  $5\ \mu\text{m}$  long in order, of which first and second ones rather conical, while third one much developed into a blister-like protrusion ( $5\ \mu\text{m}$  long and  $15.8\ \mu\text{m}$  wide). Lateral body spine, cirrus E, thin and relatively short,  $21.7\ \mu\text{m}$  long (11.1U), located dorsolaterally, just posterior to last body protrusion. Caudal projection prominent, forming a semi-circle.

Each leg telescopic, and simply cylindrical. Toes conforming to established pattern in the genus on legs I-III. On leg IV, lateral toe a little shorter than medial one;  $16.6\ \mu\text{m}$ ,  $24.2\ \mu\text{m}$ ,  $17.5\ \mu\text{m}$ ,  $17.1\ \mu\text{m}$ ,  $27.5\ \mu\text{m}$ ,  $17.1\ \mu\text{m}$  long, from lateral to medial. Toe disc very expansive and ovoid. Sensory spines present on all legs,  $8\ \mu\text{m}$ ,  $10\ \mu\text{m}$ ,  $9.2\ \mu\text{m}$ , and  $9.2\ \mu\text{m}$  long, respectively. First spine shortest, and toward posterolaterally. Spines on legs II and III having similar morphology and toward anterolaterally. Spine on leg IV forming a spike-shaped process on femoral portion, pointing posterolaterally.

Female gonopore situated between fourth leg pair, relatively large,  $6.7\ \mu\text{m}$  in diameter, surrounded with 6 rosettes of small cuticular membrane.

**Etymology.** The proposed specific name, *rotundiculus*, is from the Latin *rotundus* (round) and *culus* (buttock). It alludes to the round caudal protrusion.

**Remarks.** The classification of genus *Batillipes* is mainly based on the character combination of lateral body projections, caudal projection, clavae or cephalic appendages, sensory spine on leg IV and conformation of toe discs (see Chang and Rho, 1997a). *Batillipes rotundiculus* n. sp. is apparently characteristic, and easily separated from all its congeners in having the unique morphology both of the lateral body projection between legs III and IV, and the caudal protuberance. Until now, the lateral body projections of all recorded batillipedid species are categorized into four types: (1) completely flattened, (2) totally swollen, (3) a pair of wing-shaped projection, (4) two pairs of wing-shaped projections, while the present new species has unique blister-like appearance in both females and males. Concerning the caudal appendage, the

*Batillipes* species are grouped into two, that is, the one possessing the smooth (flattened) caudal region and the other bearing conical projection, at times bifid or tripartite one. *B. rotundiculus* n. sp. shows another new style of the round protuberance, or rather of the semi-circular formation. Adding to the decisive characters above, other considerable character states of this new species can be enumerated as follows: (1) cephalic sensory organs are comparatively short, (2) lateral body projections between head and leg pairs are well developed, (3) digits are relatively more expansive, (4) sensory spine on leg IV is spike-shaped, and (5) having the deeper notch between external and internal cephalic cirri.

*B. rotundiculus* n. sp. was collected from the intertidal and shallow sublittoral sand bottom, and supposedly distributed over around Korean coasts, that is, East Sea (Sea of Japan), South Sea, West Sea (Yellow Sea).

## 2. *Batillipes pennaki* Marcus, 1946 (Fig. 2B)

*Batillipes pennaki* Marcus, 1946, p. 2, fig. 1; Schulz, 1955, p. 78, fig. 21-8; Pollock, 1970a, p. 39, fig. 1A, table 1; Pollock, 1970b, p. 309, fig. 1A; Pollock, 1975, p. 318, fig. 6; McKirdy, 1975, p. 187, figs. 1, 3-5, 12A, 17, table 1; Grimaldi de Zio and D'Addabbo Gallo, 1975, p. 243, figs. 1-12, table 1; Pollock, 1976, p. 8; Pollock, 1979, p. 148; Grimaldi de Zio *et al.*, 1979,

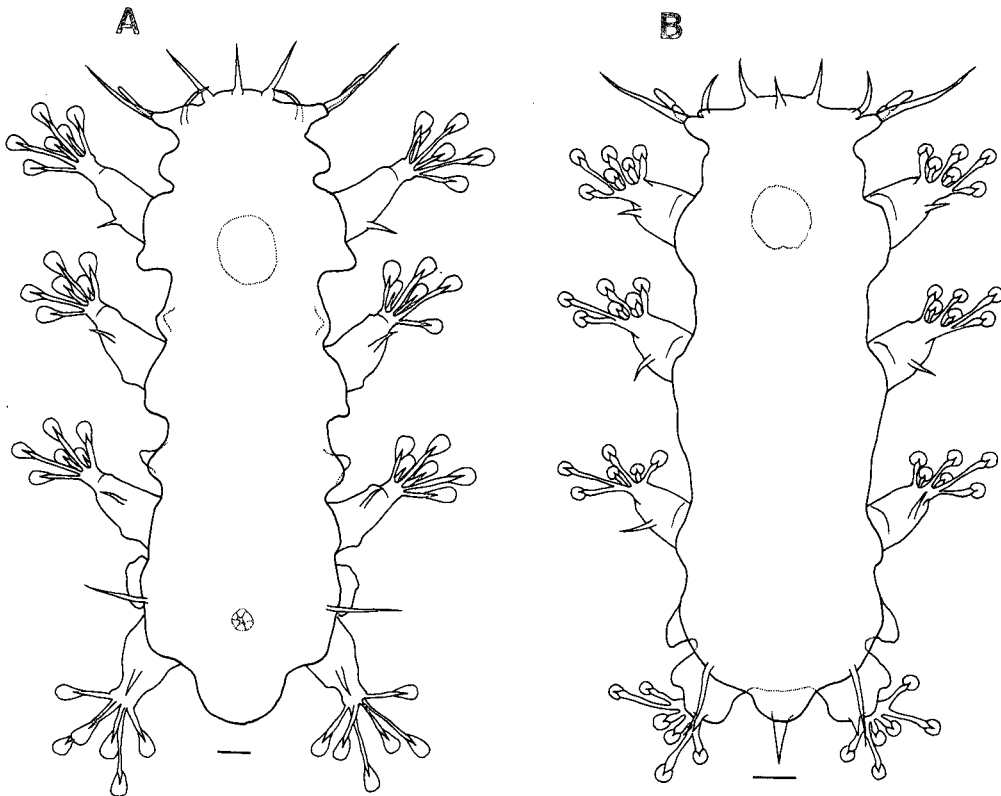


Fig. 2. A, *Batillipes rotundiculus* n. sp., habitus, holotype female (dorsal); B, *Batillipes pennaki* Marcus, habitus (dorsal). Scale bar = 10  $\mu$ m.

p. 39, fig. 6; Renaud-Mornant, 1982, p. 167, figs. 5, 8E, 10A; Grimaldi de Zio *et al.*, 1982, p. 225; Pæriolani *et al.*, 1984, p. 310, table 1; D'Addabbo Gallo *et al.*, 1987, p. 106; Morgan and O'Reilly, 1988, p. 452.

**Material examined.** 20 females and 5 males, Sangju-ri, 1 April 1995, B. H. Min; 2 inds., Chukpyon, 12 May 1995, H. S. Rho; 8 inds., Manripo, 12 May 1995, H. S. Rho; 5 inds., Sopori, Tokjokdo I., 27 October 1997, H. S. Rho; 1 ind., Kyokpo, 22 December 1995, H. S. Rho; 1 ind., Chunjangdae, 23 December 1995, H. S. Rho; 2 inds., Youngyudo I., 22 March 1996, H. S. Rho; 30 inds., Sangju-ri, 2 May 1997, H. S. Ahn and Y. H. Song; 12 inds., Manripo, 16 May 1997, H. S. Rho, J. W. Choi and H. S. Ahn; 3 inds., Imjado I., 12 June 1998, H. S. Rho and J. W. Choi.

**Remarks.** The most remarkable peculiarity of *B. pennaki* is the broadened femur of leg IV as shown in *B. gilmartini* McGinty and *B. crassipes* Tchesunov and Mokievsky. However, *B. pennaki* is differentiated from the two species above by the wing-shaped lateral body projection and the pointed caudal projection, and from the latter by the constricted clavae.

No remarkable difference was found between Marcus' (1946) original description and Korean specimens except that the lateral body projections of ours were a little smaller than Marcus'.

The Korean specimens were collected from the intertidal sand beach.

**Distribution.** Africa (Algeria), Bermuda, Brazil (Rio de Janeiro), France (Bassin d'Arcachon), Guadeloupe I., India (Waltair), Italy (Amendolara, Torre dell'Orso, Torre Canne, Bari, Brindisi, Pugliesi), Spain (Valencia), USA (Florida, Massachusetts, California), and Korea.

### 3. *Batillipes similis* Schulz, 1955 (Fig. 3A)

*Batillipes similis* Schulz, 1955, p. 78, figs. 10, 21, 22; Pollock, 1976, p. 8; Pollock, 1979, p. 148; Bertolani *et al.*, 1984, p. 310, table 1; Pollock, 1989, p. 176.

**Material examined.** 8 females, Chukpyon, 1 August 1995, H. S. Rho; 2 inds., Wolpo, 7 August 1995, H. S. Rho and J. H. Lee; 6 inds., Ponggil, 29 March 1997, H. S. Rho and J. W. Choi; 5 inds., Manripo, 17 May 1997, H. S. Rho and J. W. Choi; 2 inds., Udo I., 26 June 1997, J. W. Choi and H. S. Ahn; 6 inds., Samjung-2-ri, Kuryonpo, 3 July 1997, H. S. Rho and J. W. Choi; 2 inds., Yangpo, 2 November 1997, J. W. Choi and H. S. Ahn; 3 inds., Sajin, Taejin, 26 November 1998, H. S. Rho and S. G. Paik.

**Remarks.** *B. similis* is readily separated from its congeners by the following combination of characteristics: (1) a prominent wing-shaped lateral body projection between legs III and IV, (2) the triangular caudal projection, (3) the absence of sensory papilla between internal cephalic cirri. Our specimens fit well with the original description of Schulz (1955) except that the spine on leg IV is relatively shorter. Spines on legs I-III, which Korean specimens are furnished with, were not pointed out in the original description. This is the first record in the Pacific Ocean.

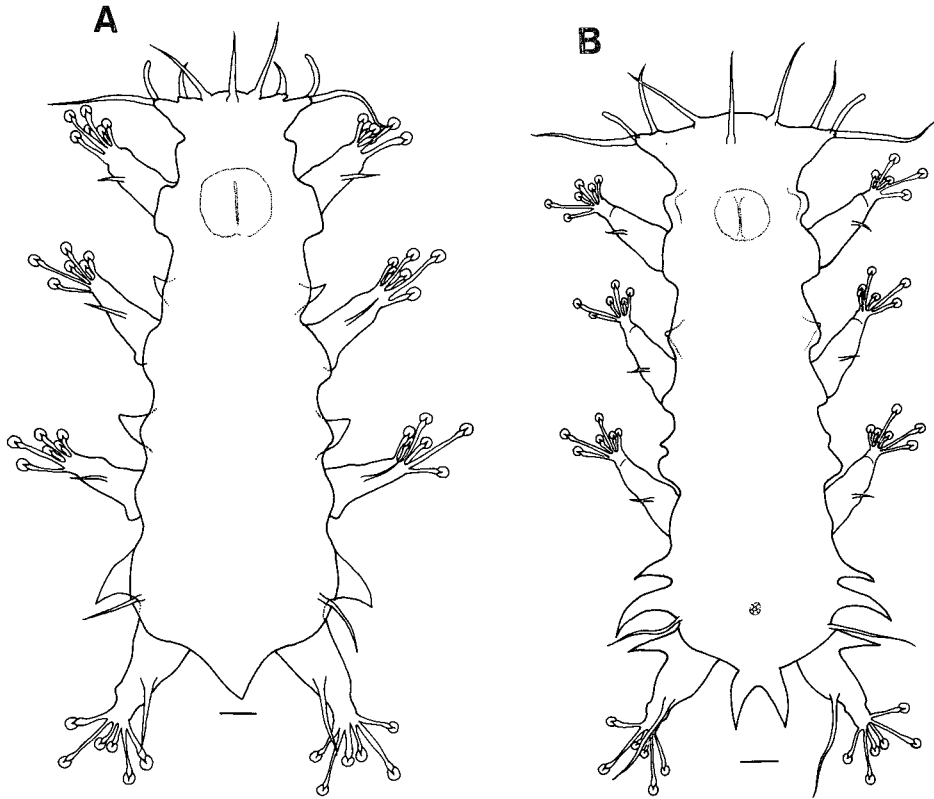
**Distribution.** Mediterranean, British Isles and Korea.

### 4. *Batillipes tridentatus* Pollock, 1989 (Fig. 3B)

*Batillipes tridentatus* Pollock, 1989, p. 172, fig. 2, 3, table II.

**Material examined.** 3 females, Hosan, Youngduk, 12 May 1995, H. S. Rho.

**Remarks.** *B. tridentatus* was described from the Clallam Bay, Washington, and Californian coast



**Fig. 3.** A, *Batillipes similis* Schulz, habitus (dorsal); B, *Batillipes tridentatus* Pollock, habitus (dorsal). Scale bar = 10  $\mu$ m.

by Pollock (1989), and this is the second record. *B. tridentatus* is characteristic in having the following features: (1) two pairs of prominent lateral body projections between legs III and IV, (2) a prominent spiky spine on the shank of leg IV, (3) a two-pointed caudal projection. Our Korean specimens are in a good agreement with Pollock's original description, even in minute details.

Korean specimens were collected from the intertidal zone of East Sea (Sea of Japan) by rinsing coarse sand.

**Distribution.** USA (Washington and California) and Korea.

##### 5. *Batillipes crassipes* Tchesunov and Mokievsky, 1995 (Fig. 4A)

*Batillipes crassipes* Tchesunov and Mokievsky, 1995, p. 154, figs. 1-3, table 1, 2.

**Material examined.** 2 females, Chukpyon, 12 May 1995, H. S. Rho; 67 inds., Pyonghae, 20 November 1995, J. J. Kim; 1 ind., Imwon, 10 January 1996, H. S. Rho and S. P. Jung; 1 ind., Pongpo, 16 March 1997, H. S. Rho and K. M. Ku; 4 inds., Pyonghae, 28 September 1997, C. Y. Chang and H. S. Rho.

**Remarks.** *Batillipes crassipes* was described from the supralittoral zone of Furughelm Island (Peter the Great Bay) by Tchesunov and Mokievsky (1995), who pointed out the features

characterizing this species as follows: (1) femur on leg IV broadened, (2) clavae undivided, (3) cirrus E located at the level of leg IV, (4) last lateral projection rather smooth (or absent). Our Korean specimens agree well with the original description except the last one above. They usually bear the well-developed lateral body protuberances between legs III and IV both in females and males against the type specimens lacking it in females and relatively small in males.

Korean specimens were collected from the intertidal and subtidal sand bottom of the East Sea.

**Distribution.** Russia (north of East Sea) and Korea.

### 6. *Batillipes longispinosus* Chang and Rho, 1997

*Batillipes longispinosus* Chang and Rho, 1997a, p. 93, figs. 1, 3A-E.

**Material examined.** 4 inds., Sangju-ri, 1 July 1998, H. S. Rho, S. W. Choi, J. W. Choi, and Y. H. Song; 6 inds., Sorokdo I., 3 July 1998, H. S. Rho and J. W. Choi.

**Remarks.** As Chang and Rho (1997a) already mentioned, this species seems to be most close to *B. tubernatis* as far as the general body appearance and the absence of lateral body projections are concerned. However, the former exhibits the significant morphological discrepancies of the flattened caudal region and the prominently longer spine on leg IV. No remarkable difference was detected between the type material and the present specimens from Sangju-ri and Sorokdo I.

The present species was reported from the intertidal and subtidal sand bottom, and frequently occurred all around the coasts of South Korea.

**Distribution.** Korea.

### 7. *Batillipes orientalis* Chang and Rho, 1997

*Batillipes orientalis* Chang and Rho, 1997a, p. 93, figs. 2, 3F.

**Material examined.** 6 inds., Samjung-2-ri, Kuryongpo, 10 May 1998, H. S. Rho and J. W. Choi; 5 inds., Imjado I., 13 June 1998, H. S. Rho and J. W. Choi.

**Remarks.** *B. orientalis* is evidently most related to *B. roscoffensis* Kristensen among the congeners bearing the wing-formed lateral body projections between legs III and IV by the presence of the sensory papillae between internal cephalic cirri and the convex caudal region, but discernible from it in the body shape (wider posteriorly in *B. orientalis*, while broadest in the middle in *B. roscoffensis*) and much longer spine on leg IV.

As *B. longispinosus*, this species is one of the most frequent tardigrades, occurring in the intertidal and subtidal sand bottom all around Korean coast.

**Distribution.** Korea.

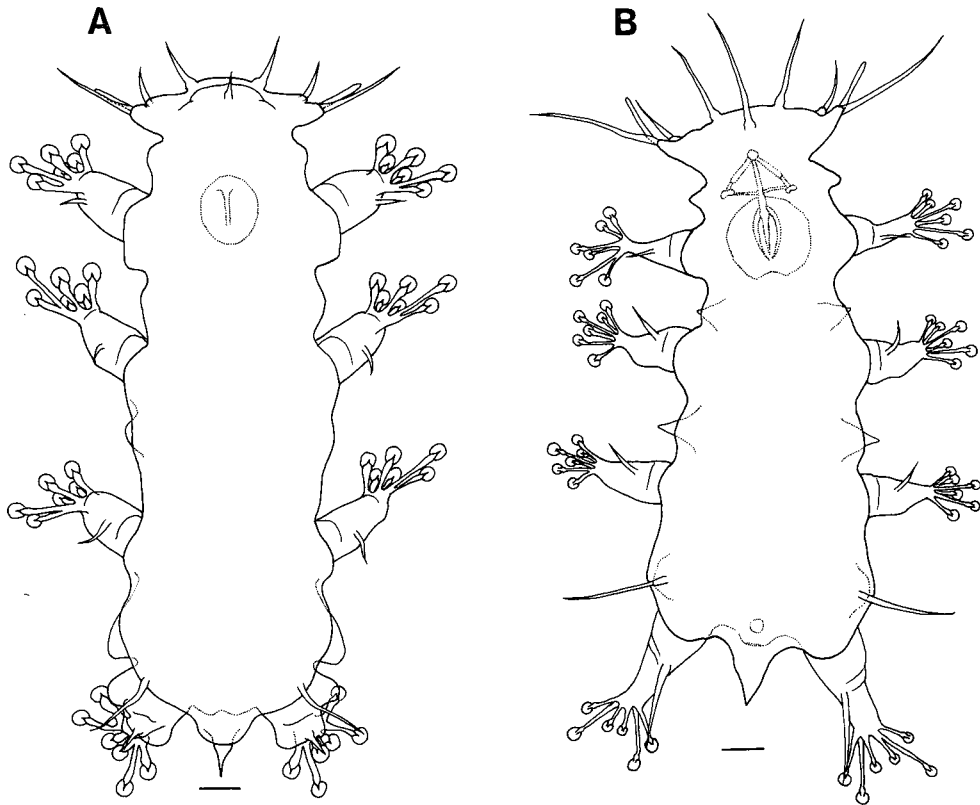
### 8. *Batillipes philippinensis* Chang and Rho, 1997 (Fig. 4B)

*Batillipes philippinensis* Chang and Rho, 1997b, p. 419, fig. 2.

**Material examined.** 3 males, Supsom islet, Cheju I., 8 November 1997, J. M. Choi, H. S. Rho, and J. W. Choi.

**Remarks.** The most diagnostic features of *B. philippinensis* can be enumerated as follows: (1) body expanding posteriorly, (2) clavae smooth, (3) lateral body projections present between all leg pairs, (4) caudal projection conical, (5) head appendages well developed (see Chang and Rho, 1997b).





**Fig. 4.** A, *Batillipes crassipes* Tchesunov and Mokievsky, habitus (dorsal); B, *Batillipes philippinensis* Chang and Rho, habitus (dorsal). Scale bar = 10  $\mu$ m.

As indicated in the specific name, *B. philippinensis* was originally described from the coralline sand of Palawan Island, the Philippines, and this is the second record of the species. Korean specimens, also collected from the subtidal (18 m deep) coralline sand at Supsom islet off Cheju Island, agree well with the original description.

**Distribution.** Philippines (Palawan I.) and Korea (Cheju I.).

A key to the species of genus *Batillipes* from Korea

- 1. Caudal projection absent ..... 2
- Caudal projection present ..... 3
- 2. Lateral projection absent ..... *Batillipes longispinosus*
- Lateral projections present ..... *B. orientalis*
- 3. Clavae with a constriction ..... *B. pennaki*
- Clavae without any constriction ..... 4
- 4. Two pairs of prominent lateral projections present between legs III and IV ..... *B. tridentatus*
- A pair of lateral projection present between legs III and IV ..... 5
- 5. Lateral projection between legs III and IV wing-shaped ..... 6

- Lateral projection between legs III and IV not wing-shaped ..... 7
6. Femur of leg IV broadened ..... *B. crassipes*  
 Femur of leg IV not broadened ..... *B. similis*
7. Blister-shaped lateral projection present between legs III and IV ..... *B. rotundiculus* n. sp.  
 Small protrusion present between legs III and IV ..... *B. philippinensis*

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한국산 해양 완보류의 분류학적 연구  
I. *Batillipes* 속 (이완보 강: Batillipedidae 과)

노 현 수 · 민 봉 회 · 장 천 영  
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요 약

1995년 2월부터 1998년 11월까지 한국 해안의 조간대와 조하대의 모래틈이나 부식질틈에서 채집된 *Batillipes* 속 해양완보류를 조사한 결과, 29개 지점에서 출현한 8종을 동정·분류하였다. 이 가운데 1종 (*B. rotundiculus* n. sp.)은 신종, 5종 (*B. pennaki* Marcus, *B. similis* Schulz, *B. tridentatus* Pollock, *B. crassipes* Tchesunov and Mokievsky, *B. philippinensis* Chang and Rho)은 한국 미기록종이었다. 신종을 기재하였고, 5종의 한국 미기록종에 대하여는 삽화와 함께 간략히 고찰하였으며, 한국산 *Batillipes* 속에 대한 종검색표를 작성하였다.