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Two New Marine Tardigrades of Genus *Batillipes* (Heterotardigrada: Batillipedidae) from Korea

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ABSTRACT

Two new marine tardigrade species, *Batillipes longispinosus* n. sp. and *B. orientalis* n. sp. are described on the basis of the specimens collected from the intertidal or shallow sublittoral sands of South Korea. Both the present species are characteristic in the absence of any caudal appendage throughout their life span, and bearing the long clava or cephalic appendages with the long spinous process on the femur of legs Ⅳ. *B. longispinosus* n. sp. most resembles *B. tubernatis* Pollock, but is easily distinguished from it by the flattened caudal region and prominently developed spine of legs IV. *B. orientalis* n. sp. is much related to *B. roscoffensis* Kristensen, in having the wing-formed lateral body projections between legs Ⅲ and legs Ⅳ, the papillae on the head region, and the smooth caudal region, but discernible from it in the general body shape and the relatively longer spine of legs IV.

Key words: Taxonomy, Tardigrada, *Batillipes longispinosus, B. orientalis,* new species, marine, Korea

INTRODUCTION

Since Richters (1909) described the first interstitial tardigrade, *Batillipes mirus* from the Kieler Bay, 21 species have been recognized in the genus until now. Genus *Batillipes*, which is the most dominant and representative one in the marine tardigrade genera of Northern Hemisphere, is characterized by bearing six toes composed of tubular pedestals of unequal lengths and terminal disc-shaped adhesive expansions, as the genus name indicates (*batillium* - spade, *pes* - foot).

Only four species belonging to *Batillipes* have been reported from northern Pacific. For the first time, McGinty (1969) described *B. gilmartini* from California. Thereafter, Pollock (1989) recorded

B. gilmartini, B. mirus, and *B. tridentatus* Pollock, 1989 from intertidal or subtidal sands in the coasts of Washington, Oregon, and California. Lastly, Tchesunov and Mokievsky (1995) described a new species of *B. crassipes from* the supralittoral zone of Furughelm Island, Russia in northern East Sea (Japan Sea).

This report contains the descriptions of two new marine arthrotardigrades, *B. longispinosus* n. sp., *B. orientalis* n. sp., collected from the sands of intertidal or shallow subtidal zone in Korea. This is the first report on the marine tardigrades from Korea.

MATERIALS AND METHODS

Materials were collected from the upper 10 cm of sediments or sands at the intertidal or shallow subtidal zone in the time span of February, 1995 - May, 1997. Samples were dredged into polyethylene vinyl bag by skin scuba divers, and filtered in the field through nylon net after freshwater rinsing for less than a minute for osmotic shock (Kristensen, 1989), or were extracted at the laboratory by the anaesthetization (using $MgCl_2$)-decantation technique (Hulings and Gray, 1971).

Specimens were drawn and measured in lactophenol on Cobb's aluminium hole slide, and also observed and photographed under differential interference microscope. Figures were made with the aid of a drawing tube. The SEM material was fixed with hot (about 80℃) ethanol immediately after extraction, and fixed again for overnight at 4℃ in 2.5% glutaraldehyde, then followed by postfixation with 1% cold osmium tetroxide. After dehydration through a graded series of ethanol (50%, 60%, 70%, 80%, 90%, 100%, 100%) for 30 minutes each, the material was critical point dried, and coated with gold-palladium in a high evaporator, and then examined in a Hitachi S-520 scanning electron microscope operated at 20KV.

DESCRIPTIONS

Class Heterotardigrada Marcus, 1927
Order Arthrotardigrada Marcus, 1927
Family Batillipedidae Ramazzotti, 1962
Genus *Batillipes* Richters, 1909

1. *Batillipes longispinosus* n. sp. (Fig. 1, 3A-E)

Material examined. 6 individuals (female), submerged sand bottom (6 - 7 m deep) of Manripo (36°47′48″N, 126°08′39″E), 12 May 1995, H. S. Rho. All are mounted in lactophenol. Holotype female and three paratypes female will be deposited in the U.S. National Museum of Natural History, Smithsonian Institution. Other paratypes (2 females) are kept in the collection of the authors.

Additional material examined. 10 inds., Chindo I., 25 July 1994 (C. Y. Chang); 1 ind., Hwajinpo, 20 July 1995 (J. M. Lee); 1 ind., Wolpo, 6 October 1995 (H. S. Rho); 1 ind., Cheju I.,

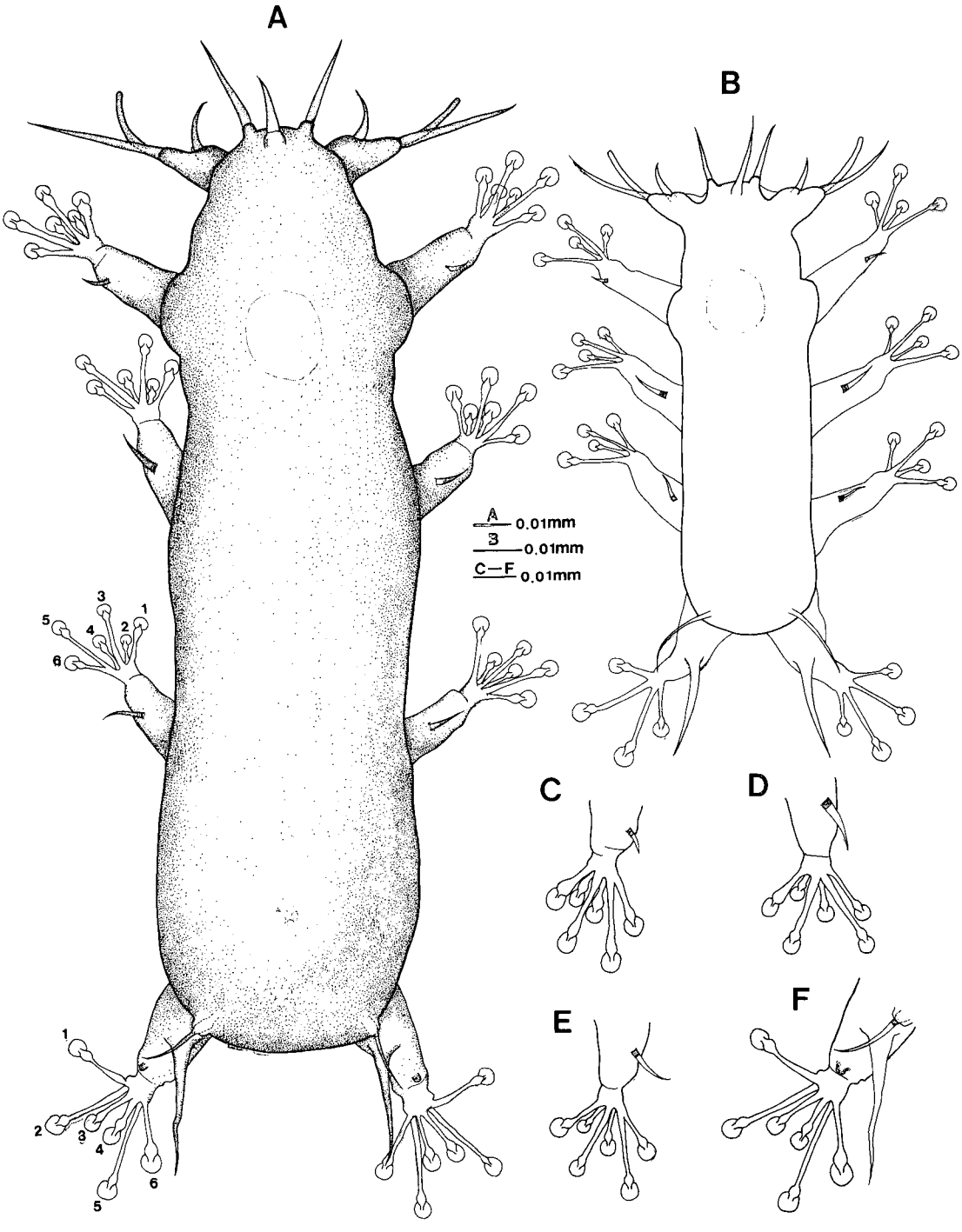

Fig. 1. *Batillipes longispinosus n.* sp.: A, holotype female (dorsal); B, juvenile (dorsal); C-F, toes on legs Ⅰ-Ⅳ, respectively

17 October 1995 (S. J. Song and H. S. Rho); 1 ind., Tokchok I., 27 October 1995 (H. S. Rho); 1 ind., Kyokpo, 22 December 1995 (H. S. Rho); 1 ind., Kochang, 28 April 1996 (C. Y. Chang and H. S. Rho); 16 inds., Cheju I., 14 October 1996 (H. S. Rho and J. W. Choi); 10 inds., Manripo, 16 May 1997 (H. S. Rho, J. W. Choi and H. S. An); 3 inds., Taechon, 17 May 1997 (H. S. Rho, J. W. Choi and H. S. An).

Diagnosis. With rounded caudal region not bearing any caudal appendage; lateral body projections reduced; cephalic appendages long; fourth legs bearing a long spine on its femur.

Holotype. Body length 250㎛, measured from anterior margin to distal margin of caudal region. Cuticle transparent with fairly regular punctations. Head width 65.4 ㎛ between bases of lateral cephalic cirri. Body width 73.1 ㎛ at position of between legs III and legs IV. Head protruding anteriorly with deeper notch between external and internal cephalic cirri, forming distinct pedunculate base with external cephalic cirri. External cephalic cirri (10.6 ㎛) placed laterally, near clavae and lateral cephalic cirri. Unpaired median cephalic cirrus with sharp point 20.1 ㎛, placed well back from anterior margin of head. Internal cephalic cirri (25.4 ㎛) each on conical base, comparatively long, but shorter than lateral cephalic cirri (34.1 ㎛). No papilla between them. Each median cephalic cirrus, internal cephalic cirri and external cephalic cirri having a distinct peduncle on its base under observation of SEM. Clavae slender, undivided, sticklike, round-tipped and cylindrical, inserted ventrally to base of lateral cephalic cirri and directed anterolaterally. Cephalic tubercles absent. Body rounded posteriorly, without caudal appendages. Mouth opening pouting with typical appearance of *Batillipes*, with a delicate cuticular plate as *B. noerrevangi* (see Kristensen, 1978). Small cuticular teeth seen in mouth opening under observation of SEM. Pharyngeal bulb small and circular (length 22.5 ㎛, width 18.8 ㎛, length to width ratio 1.2). Cheek region not so swollen, while 'shoulder' above legs I expanding outeriorly. Posterolateral body spine, cirrus E, located just posterior to above and over base of legs IV, relatively long (18.1 ㎛) and thin, swollen at its base. Caudal region not swollen, only slightly rounded, and not bearing ventrolateral projections between each legs pair.

Spines present on all legs with distinct socket. Proximal part (femur) of legs I-III conical with dorsal leg spines; spines on legs I - III, 8.5 ㎛, 12.2 ㎛, and 12.3 ㎛ long, respectively; spines either gradually increasing in length from legs I to III, or those of II and III about same length and always longer than those of legs I. Spine on legs I placed on distal part of legs, while spines on legs II and III more closer to proximal part of each legs. Spines on legs IV (34.6 ㎛), extending posteriorly to about equal or slightly exceeding innermost disc of legs IV, with thicker basal portion to form a spinal process. Cirrus E of juvenile becomes shortened in adult stage as shown in Fig. 1A-B. Papillae absent on legs I-III, but present on legs IV.

Legs I through Ⅳ possessing toes of varying lengths. On legs Ⅰ, Ⅱ and Ⅲ, toes 1, 3, 5, 6 compeletely dorsal, and toes 2, 4 ventral. But on legs Ⅳ, toes 1, 3, 4, 6 completely dorsal and toes 2, 5 ventral. Toe with round terminal discs, conform to established pattern on legs I - III (lengths from anterior to posterior: 13.8 ㎛, 10.7 ㎛, 18.1 ㎛, 10.4 ㎛, 22.3 ㎛, and 14.6 ㎛). In all cases, toe '5' clearly longest in legs I-III. Innermost two toes on legs IV slightly unequal; lateral toe just longer than medial toe (lengths, lateral to medial: 17.7 ㎛, 24.2 ㎛, 14.6 ㎛, 13.8 ㎛, 26.5 ㎛, and 17.7 ㎛) toes '3' and '4' nearly equal and shortest. Discs appeared somewhat circular or oval

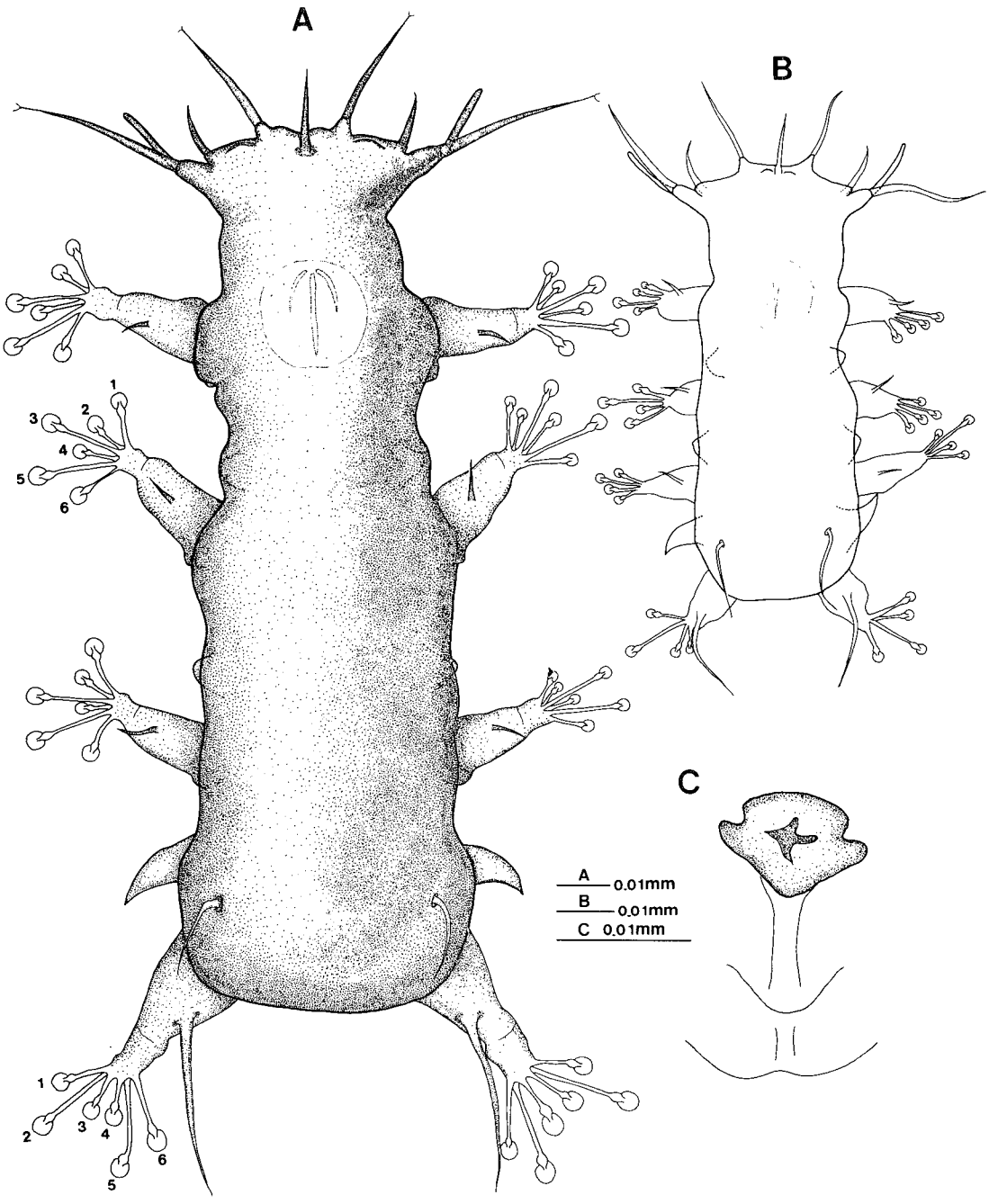

Fig. 2. *Batillipes orientalis n.* sp.: A, holotype female (dorsal); B, juvenile (dorsal); C, genital region of female.

rather than rectangular with blunt edges, similar to those of *B. bullacaudatus* McGinty and Higgins (see McKirdy, 1975).

Gonopores surrounded by six identical plates, relatively large, 5.4 ㎛ in diameter. Distance between female gonopore and anus about 20.8 ㎛.

Remarks. Discussed in the remarks of the next species.

2. *Batillipes orientalis* n. sp. (Fig. 2, 3F)

Material examined. 15 individuals (female), submerged sand bottom (6-7m deep) of Manripo, (36°47′48″N, 126°08′39″E), 12 May 1995, H. S. Rho. All are mounted in lactophenol. Holotype female and three paratypes female will be deposited in the U.S. National Museum of Natural History, Smithsonian Institution. Other paratypes (11 female) are kept in the collection of the authors.

Additional material examined. 2 inds., Hyopche, Cheju I., 14 October 1996 (H. S. Rho and J. W. Choi); 3 inds., Bongil, 29 March 1997 (H. S. Rho and J. W. Choi); 22 inds., Manripo, 16 May 1997 (H. S. Rho, J. W. Choi and H. S. An).

Diagnosis. With flattened caudal region not bearing any caudal appendage; one pair of prominent lateral body projections between legs III and IV; cephalic appendages long.

Holotype. Body length 162.5 ㎛, measured from anterior margin to distal margin of caudal region. Body wider posteriorly and little flattened dorsoventrally. A pair of conspicuous lateral auricles present between posterior end of head and legs I. Head width 48.8 ㎛ between bases of lateral cephalic cirri. Body width 54.4 ㎛ between body projections at legs III-IV. Head margin arched gently with deeper notch lateral to external cephalic cirri forming distinct pedunculate base. External cephalic cirri placed laterally near clavae and lateral cephalic cirri in ventral position and preceding mouth. Unpaired median cephalic cirrus 10.7 ㎛, inserted far from rostral edge and directed upwards. Internal cephalic cirri 25 ㎛, comparatively long, but shorter than lateral cephalic cirri, 30 ㎛. Internal and lateral cephalic cirri frayed at tips, generally into two. Clavae (13.4 ㎛) about 1.5 times longer than external cephalic cirri (9.4 ㎛). Clavae slender, round-tipped, and directed antero-laterally. Clavae and lateral cephalic cirri inserted together to some enlarged pedestal on either side of head. Forehead protruding with 2 papillae on antero-median margin between interal cephalic cirri, and 2 prominent papillae placed between internal cephalic cirri and external cephalic cirri. Cheek region smoothly rounded. Pharyngeal bulb large and circular (length 19.4 ㎛, width 19.4 ㎛, length to width ratio 1).

Body with distinct 'neck' constriction (29.7 ㎛ wide). With prominent ventrolateral projection each between every legs pair, (4.1 ㎛, 5.6 ㎛, 12.5 ㎛ in order). First and second lateral body projections of same shape, but third lateral body projections different from formers. Third lateral body projections ventrolaterally directed and wing-formed. Lateral cirrus E long (15.4 ㎛) and thin, located dorsally just posterior to last lateral body projections between legs III-IV, more prominent in juvenile. Spines present on all legs: spines on legs I - IV 5.9 ㎛, 7.5 ㎛, 8.8 ㎛, and 35 ㎛, respectively. First spines shortest, and placed distally. Spines on legs Ⅱ and III having similar morphology. Spine on legs Ⅳ strong and long, forming a spinal process on femural portion. Caudal projections lacking.

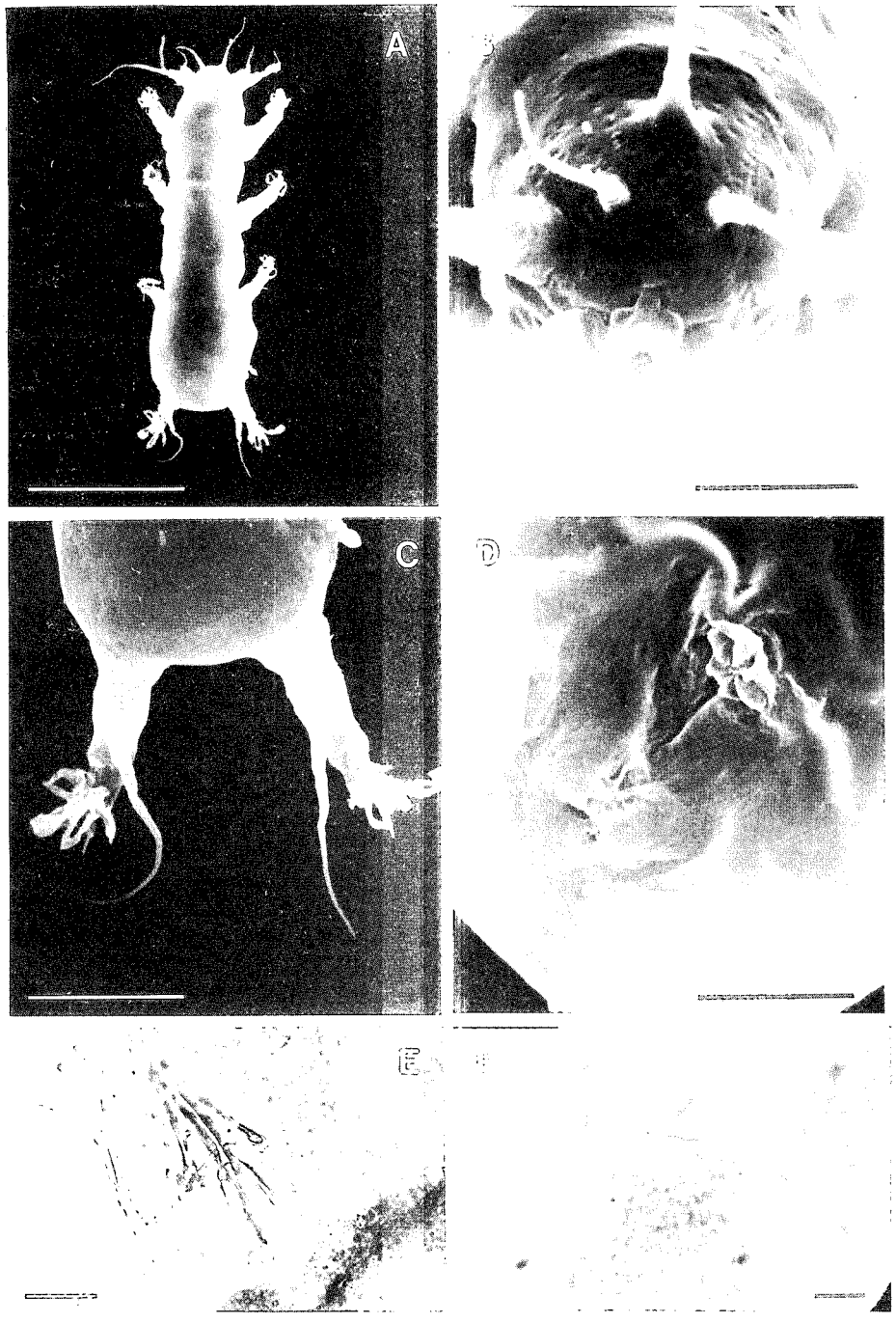

Fig. 3. *Batillipes longispinosus* n. sp., A-E: A, habitus (scale: 50 ㎛); B, head region (scale: 10 ㎛); C, spine of legs Ⅳ (scale: 17.6 ㎛); D, genital region of female (scale: 7.5 ㎛); E, pharyngeal apparatus (ventral) (scale: 10 ㎛). *Batillipes orientalis* n. sp.: F, head region (scale: 10 ㎛).

Toes conforming to established pattern on legs I-III. Innermost two toes on legs IV slightly unequal, lateral toe just longer than medial toe (lengths, lateral to medial: 14.3 ㎛, 19.7 ㎛, 12.5 ㎛, 11.3 ㎛, 20.9 ㎛, 10.6 ㎛). Toe disc large and circular, similar to those of *B. bullacaudatus* McGinty and Higgins (see McKirdy, 1975). Gonopores different from those described for most other *Batillipes*.

Remarks. Genus *Batillipes* comprises 21 species, the classification of which usually depends on the characters such as lateral body projections, variation in caudal appendages, shape of clavae or cephalic appendages, toe discs and femur of legs Ⅳ (Mckirdy, 1975; Kristensen, 1978; Pollock, 1971, 1979; Tchesunov & Mokievsky, 1995). The present two new species are very similiar each other in the absence of any caudal appendage throughout their life span, and the shape of clavae or cephalic appendages, toe discs and femur of legs Ⅳ except the lateral body projections and the general shape of head.

B. longispinosus n. sp., in general body shape (wider posteriorly) and absence of lateral body projections, resembles *B. acaudatus* Pollock and *B. tubernatis* Pollock, but *B. longispinosus* is different from *B. acaudatus* in having the more developed head appendages and a long spine of legs IV. *B. longispinosus* shares rather more features with *B. tubernatis*, but the former is easily distinguished from the latter by the flattened caudal region, and prominently longer spine of legs IV.

B. orientalis n. sp., in having the wing -formed lateral body projections between legs Ⅲ and legs Ⅳ, shows some resemblance with *B. roscoffensis* Kristensen, *B. annulatus* De Zio, *B. littoralis* Renaud- Debyser, *B. marcelli* Morone De Lucia, D' Addabbo Gallo and Grimaldi de Zio, B. phreaticus Renaud-Debyser, and *B. similis* Schulz, of which *B. orientalis* n. sp. is most similar to *B. roscoffensis* in having the papillae on the head region, and the slightly rounded caudal region, but discernible from it in the body shape (body is wider posteriorly in *B. orientalis*, while widest in the middle in *B. roscoffensis*) and much longer spine of legs IV. *B. orientalis* is different from *B. annulatus* by having smooth clavae and rounded caudal region, against *B. annulatus* having four annular constriction clavae, and horn-shaped caudal appendages. *B. orientalis* is easily distinguished from *B. littoralis*, *B. marcelli* and *B. phreaticus* by the absence of caudal appendages in both adult and juvenile stages, while *B. littoralis* has a tripartite shaped caudal process, and *B. marcelli* has a long straight spine, which bears at its base a variable number of small spines from 2 to 4. Moreover, *B. orientalis* differs from *B. similis* by the presence of papillae on the head region.

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*Batillipes*속 (異緩步綱, Batillipedidae과)의 해양 완보류 2신종

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요 약

조간대와 수심 20 m 미만의 조하대 모래틈에서 채집한 해양 완보류 2신종 - *Batillipes longispinosus* n. sp., *B. orientalis* n. sp. - 을 기재한다. 이들 2신종은 미성숙 개체와 성체 모두에서 몸통 뒷부분에 돌기가 없으며 머리에 난 여러 돌기들이 길다는 점, 제4다리위에 긴돌기를 가진다는 점에서 특징적이다. *B. longispinosus* n. sp.는 *Batillipes* 속에 기록된 21종 중에서 *B. tubernatis* Pollock과 가장 유사하나 4번째 다리에 긴 돌기를 가지는 점에서 다르다. 또한 *B. orientalis* n. sp.는 몸 측면 돌기를 가진다는 점에서 *B. roscoffensis* Kristensen와 닮았으나 머리의 모양과 4번째 다리에 긴 돌기를 가지는 점에서 뚜렷하게 구별된다.