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A Taxonomic Study on *Perinereis nuntia* Species Group (Polychaeta: Nereididae) of Korea

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ABSTRACT

A taxonomic study was carried out on the *Perinereis nuntia* species group of Korea by using morphological and molecular data (mitochondrial cytochrome c oxidase subunit I: mtCOI). Two species, *P. mictodonta* (Marenzeller, 1879) and *P. wilsoni* (Glasby and Hsieh, 2006), are recognized and redescribed. In this study, mtCOI gene showed a good resolution as molecular marker for species identification of the *P. nuntia* species group of Korea.

Key words: Polychaeta, Nereididae, *Perinereis nuntia* species group, mtCOI

INTRODUCTION

The *Perinereis nuntia* species group is characterized by an arc of bar-shaped paragnaths on area VI (Wilson and Glasby, 1993). These nereid worms are common in intertidal and shallow marine waters and widely distributed in Indo-West Pacific and East Asian countries. Among those species, *P. nuntia* var. *brevicirris* sensu Fauvel, 1932 and *P. nuntia* var. *vallata* sensu Fauvel, 1932 were reported from the Korean waters by Paik (1972). Later, Paik (1975) considered that there were no significant differences between two varieties, and then he synonymised both varieties with *P. nuntia* (Savigny, 1818). Recently, Glasby and Hsieh (2006) reexamined *P. nuntia* varieties from the Indo-West Pacific including tropical shores, and they treated *P. nuntia* var. *brevicirris* in Paik's previous records as *P. mictodonta*, and *P. nuntia* var. *vallata* as a new species, *P. wilsoni* . In the present paper, we reexamined *P. nuntia* species group of Korea based on the materials collected from 11 localities and reference materials sourced from foreign museums by using morphological and molecular data (mitochondrial cytochrome *c* oxidase subunit I: mtCOI).

MATERIALS AND METHODS

Collection and specimen processing

During the period from October 2005 to September 2006, specimens for present study were collected from 11 localities in South Korea (Fig. 1). Worms were anesthetized with menthol or 7% of $MgCl_2$ for making their proboscides being everted, and if eversion did not occur, then slight pressure was applied to their pharyngeal region. Worms were then fixed in 5% formalin and preserved in 70% ethanol for morphological study. For molecular study, they were preserved in 95% ethanol. Reference materials were sourced from the following museums: Museum and Art Gallery of the Northern Territory, Darwin, Australia (NTM); Museum of Victoria, Melbourne, Australia (VM); Australian Museum, Sydney, Australia (AM).

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Morphological study

P. mictodonta and *P. wilsoni* were divided into two species by Glasby and Hsieh (2006) based on the length ratios of the dorsal cirrus (DC) to dorsal notopodial ligule (DNL). Following their suggestion, we measured the length ratio of DC and DNL at anterior chatiger 10 and one of posterior chaetigers among 75 and 90. In addition, numbers of paragnaths were also counted for 8 areas (area I, II, III, III lateral, IV, V, VI, and VII-VIII). The description in 'diagnosis' section is based on the longest specimen and the numbers in the parenthesis represent the range among specimens.

Molecular taxonomic study

Total genomic DNA was extracted using DNeasy Blood and Tissue Kit (Qiagen) according to manufacturer's instruction. The target DNA segment of the mtCOI was amplified by the polymerase chain reaction (PCR), with primers LCO1490 5′-GGTCAACAAATCATAAAGATATTGG-3′ and HCO2198 5′-TAAACTTCAGGGTGACCAAAAAAT-CA-3′ ormer et al., 1994). PCR amplification was conducted with the following temperature profile: 35 cycles of denaturation (94°C, 1 min.), annealing (48-50°C, 1 min.), and extension (72°C, 2 min.). PCR products were purified with Qiaex II gel extraction kit (Qiagen) and both strands were

sequenced in an automated sequencer ABI 3100 (Perkin Elmer). Sequences were initially aligned using Clustal X multiple alignment program (Tompson et al., 1997). All sequence analyses were conducted using the commercial version of PAUP 4.0b10 (Swofford, 2002). Nucleotide sequence divergences within and between species were calculated using Kimura 2-parameter distances. A neighbor joining method was used to construct a tree.

RESULTS

Morphological taxonomic study

Paragnath counts and length ratios of DC : DNL were listed in Table 1 and 2. Data of paragnath counts for *P. nuntia* and *P. vallata* (Grube, 1858) from Wilson and Glasby, 1993 are also included for the purpose of comparison with *P. nuntia* species group of Korea. Our specimens collected from Seonjedo Is., Jebudo Is., Baealdo beach, Yeongji-ri, Seo-myeon, and Hadong were identified as *P. mictodonta*, and specimens from Yulim beach, Hae-ri, Gunsan-myeon, Hadogul-dong, Joil-ri, and Hadong (Fig. 1) were identified as *P. wilsoni*.

Molecular taxonomic study

A 542 bp fragment of the mtCOI gene was sequenced from selected specimens of Korean *P. nuntia* species group (*P. mictodonta* and *P. wilsoni*), *P. nuntia* and *P. vallata*. The pairwise percentage sequence divergences and total base differences calculated by the Kimura 2-parameter distances are listed in Table 3. No insertions or deletions were detected in any of the sequences. Each of four species showed very low mtCOI sequence divergences among conspecific individuals. By contrast, the sequence divergences exceed 18.88% in all cases of species pair. The divergence values between *P. wilsoni* and *P. mictodonta* range 18.88-19.39%.

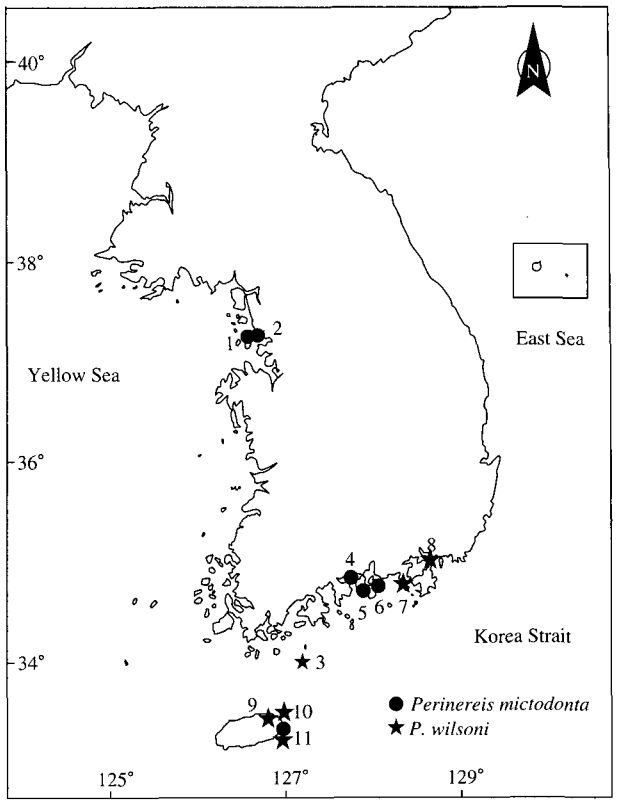

Fig. 1. Map showing sites where specimens of the *Perinereis nuntia* species group were collected. 1. Seonjedo Is., Ongingun, Yeongheung-myeon, Incheon, 37°14′N 126°31′E; 2. Jebudo Is., Hwaseong-si, Gyeonggi-do, 37°10′N 126°37′E; 3. Yulim beach, Geomundo Is., Samsan-myeon, Yeosu-si, Jeollanam-do, 34°54′7″N 127°18′27.2″E; 4. Baealdo beach, Seomjingang Estuary, Jeollanam-do, 34°57′N 127°45′E; 5. Yeongji-ri, Samdong-myeon, Namhae-gun, Gyeongsangnam-do, 34°48′49″N 127°58′4″E; 6. Seomyeon, Namhae-gun, Gyeongsangnam-do, 34°47′N 127°50′E; 7. Hae-ri, Sanyang-eup, Tongyeong-si, Gyeongsangnam-do, 34°49′32.7″N 128°20′26.4″E; 8. Gusan-myeon, Masan-si, Gyeongsangnam-do, 35°6′41.3″N 128°36′4.6″E; 9. Hadogul-dong, Bukjejugun, JeJu-do, 33°31′N 126°53′E; 10. Joil-ri, Wudo-myeon, Bukjeju-gun, JeJu-do, 33°30′N 126°57′E; 11. Hadong, Siheung-ri, Bukjeju-gun, JeJu-do, 33°31′N 126°51′E.

SYSTEMATIC ACCOUNTS

Class Polychaeta Grube, 1850
Order Phyllodocida Dales, 1962
Family Nereididae Johnston, 1865
Subfamily Nereidinae Johnston, 1865
Genus *Perinereis* Kinberg, 1866

[1]***Perinereis mictodonta* (Marenzeller, 1879) (Figs. 2-6)**

Nereis mictodonta Marenzeller, 1879, p. 118, pl. 2, fig. 2; Izuka, 1912, p. 148, pl. 16, figs. 1-6.

Perinereis nuntia var. *brevicirris*: Fauvel, 1936, p. 63; Okuda, 1938, p. 92; 1939, p. 231; 1940, p. 12; Okuda and Yamada, 1954, p. 184, fig. 3e; Khlebovich and Wu, 1962, p. 51, pl. 3, fig. 3; Imajima, 1972, p. 94, fig. 26 l-m; Paik, 1972, p. 131, fig. 2i-j; Wu et al., 1985, p. 208, fig. 120 a, b.

Perinereis brevicirris: Imajima and Hartman, 1964, p. 151; Wu, 1967, p. 71, fig. 11a-d (in part).

Perinereis nuntia: Paik, 1975, p. 242, fig. 1a-d (in part);

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Table 1. Comparison of paragnath counts of the Korean *P. nuntia* species group. Mean, standard deviation and ranges are given. Data for *P. nuntia* and *P. vallata* are taken from Wilson and Glasby (1993), and *P. mictodonta* and *P. wilsoni* are taken from Glasby and Hsieh (2006). c: cones; b: bars; n: number

	I	II	III (total)	III (lateral)	IV (c)	IV (b)	V	VI	VII-VIII
P. mictodonta (present study) (n=49)	1-5 2.5±1.2	13-37 23.9±4.8	20-36 27.8±4.1	Present	23-44 30.6±4.7	Absent or Bar like	1-5 3.0±0.5	2-7 4.5±1.3	26-44 37.2±3.2
P. mictodonta (types) (n=5)	1-5 2.6±1.5	16-25 21.2±3.4	23-31 25.2±3.3	Present	34-39 35.8±1.9	Absent	1-3 2.6±0.9	5-9 7.2±1.6	25-34 31.6±3.8
P. nuntia (n=132)	0-5 1.8±0.8	0-23 6.8±3.0	1-30 11.5±4.2	Present	5-35 16.5±4.6	Absent	0-5 1.9±1.4	4-17 8.2±2.5	10-52 28.0±6.2
P. vallata (n=427)	0-9 1.6±0.7	1-23 11.0±2.5	9-35 18.7±4.4	Present	0-47 28.1±5.7	0-5 2.6±0.6	0-5 2.3±1.0	5-14 12.5±1.5	42-129 69.0±13.6
P. wilsoni (present study) (n=51)	1-7 1.7±1.3	2-24 11.3±4.6	8-34 17.6±5.7	Present	13-45 24.9±6.6	Absent or Bar like	1-4 2.1±0.9	3-9 5.5±1.1	16-37 29.4±4.5
P. wilsoni (n=33)	1-3 1.9±0.6	9-21 15.2±3.0	13-26 19.1±3.3	Present	24-39 29.8±3.6	Absent	1-3 2.0±0.8	4-8 5.3±1.2	22-34 29.3±3.2

Table 2. Comparison of diagnostic characteristics of *P. mictodonta* and *P. wilsoni*

	P. mictodonta (present study)	*P. wilsoni* (present study)
Area II	23.9±4.8	11.3±4.6
Area IV	30.6±4.7	24.9±6.6
Area V, arrangement	Usually 3 in a triangle, or flat trangle	Usually singly or 2 or 3 in a longitudinal line
DC : DNL	1.0±0.1 at chaetiger 10 1.1±0.1 at chaetiger 75-90	1.3±0.2 at chaetiger 10 1.7±0.4 at chaetiger 75-90
	P. mictodonta (taken from Glasby and Hsieh, 2006)	*P. wilsoni* (taken from Glasby and Hsieh, 2006)
Area II	21.2±3.4	15.2±3.0
Area IV	35.8±1.9	29.8±3.6
Area V, arrangement	Usually 3 in a triangle	Singly or 2 or 3 in a longitudinal line
DC : DNL	1.09±0.14 at chaetiger 10 1.29±0.3 at chaetiger 75-90	1.3±0.16 at chaetiger 10 2.12±0.42 at chaetiger 75-90

1989, p. 311, pl. 25-63b-1, 63a, 63c-2, 63b-2, 63c-1, fig. 73a-g (in part).

Perinereis mictodonta: Wilson and Glasby, 1993, p. 264; Glasby and Hsieh, 2006, p. 558, fig. 5A-E.

Perinereis sp. 1: Chen et al., 2002, p. 19.

Materials examined. Jebudo Is., Hwaseong-si, Gyeonggi-do, 37° 10′N 126° 37′E, 24 Mar. 2005, (T.S. Park), 6 inds.; Seomyeon, Namhae-gun, Gyeongsangnam-do, 34° 47′N 127° 50′E, 21 Aug. 2005, (T.S. Park), 5 inds.; Seonjedo Is., Onging-gun, Yeongheung-myeon, Incheon, 37° 14′N 126° 31′E, 24 Jan. 2006, (T.S. Park), 24 inds.; Yeongji-ri, Samdong-myeon, Namhae-gun, Gyeongsangnam-do, 34° 48′49″N 127° 58′4″E, 1 Mar. 2006, (T.S. Park), 5 inds.; Baealdo beach, Seomjingang Estuary, Jeollanam-do, 34° 57′N 127° 45′E, 9 May 2006, (T.S. Park), 10 inds.; Hadong, Siheung-ri, Bukjeju-gun, Jeju-do, 33° 31′N 126° 51′E, 15 Oct. 2006, (T.S. Park), 5 inds.

Reference materials examined. Perinereis mictodonta (Marenzeller, 1879): Wazuwei, Tanshui Estuary, Taipei County, Taiwan, 25° 10′N 121° 24′E, 22 Oct. 1999, (H.L. Hsieh), 1 ind. NTM W19301, 1 ind. NTM W19303, 1 ind. NTM W19302; Mitsang, Tanshui Estuary, Taipei County, 25° 8′N 121° 26′E, 22 Oct. 1999, 1 ind. NTM W19308, 1 ind. NTM W19319, 1 ind. NTM W19312, 1 ind. NTM W19318, 1 ind. NTM W19310, 1 ind. NTM W19311, 1 ind. NTM W19317, 1 ind. NTM W19314, 1 ind. NTM W19307, 1 ind. NTM W19309, 1 ind. NTM W19313, 1 ind. NTM W19316; Mitsang, Tanshui Estuary, Taipei County, 18 Nov. 2000, (H.L. Hsieh), 1 ind. NTM W19339, 1 ind. NTM W19298; Tonghsiao, Miaoli County, Taiwan, 24° 29′N 120° 39′E, 4 Nov. 1999, (H.L. Hsieh), 1 ind. NTM W19320, 1 ind. NTM

Table 3. Pairwise percentage sequence divergence (below diagonal) and total base differences (above diagonal) in mtCOI sequences of four *Perinereis* species (Kimura 2-parameter distances). 1. *P. nuntia*; 2. *P. vallata*; 3. *P. mictodonta*; 4. *P. wilsoni*

	PnD1	PnD2	Pval1	Pval2	PnYs5	PsJ3	PsJ6	PnS3	PnYo3	PnJ3	PsYo1	PsJ8	PsJ9	PsJ7	PnS1	PnYo2	PnYs4	PsJ1	PsYo2	PnJh7	PnJh6	PnJh2	PnJh3	PnJh8
1. PnD1	-	0	109	108	114	114	114	114	113	114	114	114	114	114	114	113	113	114	114	109	108	108	108	108
1. PnD2	0.00	-	109	108	114	114	114	114	113	114	114	114	114	114	114	113	113	114	114	109	108	108	108	108
2. Pval1	23.67	23.67	-	2	111	111	111	111	110	111	111	111	111	111	111	110	110	111	111	93	94	94	94	94
2. Pval2	23.40	23.40	0.37	-	111	111	111	111	110	111	111	111	111	111	111	110	110	111	111	93	94	94	94	94
3. PnYs5	25.11	25.11	24.42	24.42	-	0	0	0	1	0	0	0	0	0	0	1	1	0	0	90	89	89	89	89
3. PsJ3	25.11	25.11	24.42	24.42	0.00	-	0	0	1	0	0	0	0	0	0	1	1	0	0	90	89	89	89	89
3. PsJ6	25.11	25.11	24.42	24.42	0.00	0.00	-	0	1	0	0	0	0	0	0	1	1	0	0	90	89	89	89	89
3. PnS3	25.11	25.11	24.42	24.42	0.00	0.00	0.00	-	1	0	0	0	0	0	0	1	1	0	0	90	89	89	89	89
3. PnYo3	24.83	24.83	24.14	24.14	0.18	0.18	0.18	0.18	-	1	1	1	1	1	1	2	2	1	1	91	90	90	90	90
3. PnJ3	25.11	25.11	24.42	24.42	0.00	0.00	0.00	0.00	0.18	-	0	0	0	0	0	1	1	0	0	90	89	89	89	89
3. PsYo1	25.11	25.11	24.42	24.42	0.00	0.00	0.00	0.00	0.18	0.00	-	0	0	0	0	1	1	0	0	90	89	89	89	89
3. PsJ8	25.11	25.11	24.42	24.42	0.00	0.00	0.00	0.00	0.18	0.00	0.00	-	0	0	0	1	1	0	0	90	89	89	89	89
3. PsJ9	25.11	25.11	24.42	24.42	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	-	0	0	1	1	0	0	90	89	89	89	89
3. PsJ7	25.11	25.11	24.42	24.42	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	-	0	1	1	0	0	90	89	89	89	89
3. PnS1	25.11	25.11	24.42	24.42	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	-	1	1	0	0	90	89	89	89	89
3. PnYo2	24.83	24.83	24.14	24.14	0.18	0.18	0.18	0.18	0.37	0.18	0.18	0.18	0.18	0.18	0.18	-	0	1	1	90	89	89	89	89
3. PnYs4	24.83	24.83	24.14	24.14	0.18	0.18	0.18	0.18	0.37	0.18	0.18	0.18	0.18	0.18	0.18	0.00	-	1	1	90	89	89	89	89
3. PsJ1	25.11	25.11	24.42	24.42	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.18	-	0	90	89	89	89	89
3. PsYo2	25.11	25.11	24.42	24.42	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.18	0.00	-	90	89	89	89	89
4. PnJh7	23.65	23.65	19.67	19.67	19.13	19.13	19.13	19.13	19.39	19.13	19.13	19.13	19.13	19.13	19.13	19.13	19.13	19.13	19.13	-	2	1	1	1
4. PnJh6	23.38	23.38	19.92	19.92	18.88	18.88	18.88	18.88	19.13	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	0.37	-	1	1	1
4. PnJh2	23.38	23.38	19.92	19.92	18.88	18.88	18.88	18.88	19.13	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	0.18	0.18	-	0	0
4. PnJh3	23.38	23.38	19.92	19.92	18.88	18.88	18.88	18.88	19.13	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	0.18	0.18	0.00	-	0
4. PnJh8	23.38	23.38	19.92	19.92	18.88	18.88	18.88	18.88	19.13	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	18.88	0.18	0.18	0.00	0.00	-

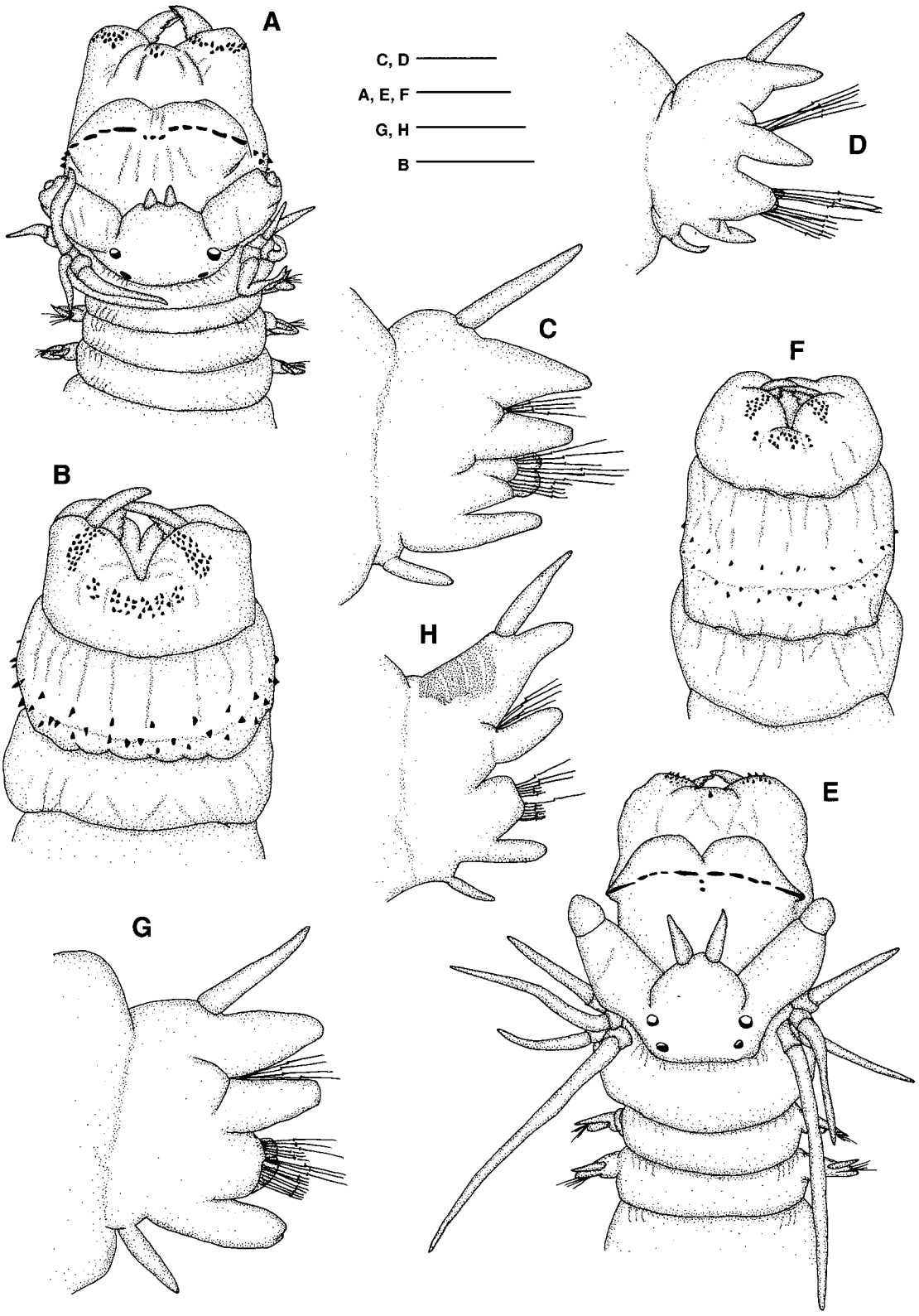

Fig. 2. *Perinereis mictodonta*. A, anterior end, dorsal view; B, anterior end, ventral view; C, anterior parapodium, anterior view; D, posterior parapodium, anterior view. *P. wilsoni*. E, anterior end, dorsal view; F, anterior end, ventral view; G, anterior parapodium, anterior view; H, posterior parapodium, anterior view. Scale bars=0.3 mm (C, D), 2.0 mm (A, B, E, F), 0.6 mm (G, H).

W19321; Chuwei, Tanshui Estuary, Taipei County, Taiwan, 25° 8′N 121° 26′E, 22 Oct. 1999, (H.L. Hsieh), 1 ind. NTM W19297, 1 ind. NTM W19396; Tapeng Lagoon, St. 9, Pingtung County, 22° 26.73′N 120° 29′E, 29 Oct. 2000, (H. L. Hsieh), 1 ind. NTM W19326, 1 ind. NTM W19329, 1 ind. NTM W19328; Kaoping River, between Kaohsiung County and Pingtung County, Taiwan, 22° 28′N 120° 24′E, 23 Jan. 1996, (J.C. Wu and P.H. Lin), 10 inds. NTM W19330; Minamata River, Minamata, Kumamoto, Japan, 22 Apr. 2000, (I. Hayashi). 10 inds. NTM W19420, identified as *Perinereis nuntia brevicirris*.

Perinereis nuntia (Savigny, 1818): Enderby I., Western Australia, no date information, (P. Hutchings), 3 inds. AM W201967-8, mangroves, intertidal; Queensland, Yorkeys Knob, Australia, 19-20 Nov. 1984, (R. Hanley), 3 inds. NTM W2364, W2365, intertidal, under rock; Redcliff, SEQ1d, Australia, 21 Sep. 2005, (P. Palmer), 2 inds. NTM; St. Johns I., Southern shore, Singapore, 8 Dec. 2003, 2 inds. NTM; South Paris I., Jacarta, Java, Indonesia, 14 Feb. 2003, no collector data, 3 inds. NTM.

Perinereis vallata (Grube, 1858): Macquarie I., Australia, no further data, 1 ind. VM F54004; Werri Bee, Australia, 14 Dec. 2005, no collector data, 5 inds. VM; Southern Australia, 21 Feb. 2006, no collector data, 3 inds. VM.

Diagnosis. Longest specimens 108.5 mm long, 99 chaetigers and 5.7 mm wide at chaetiger 10 (including parapodia); 3.9 mm wide at chaetiger 10 (excluding parapodia).

Anterior dorsum brown. Prostomium slightly wider than long; antennae 1/3 prostomium length, and separated at their bases; longest tentacular cirri extending back to chaetiger 9 (3-9). Jaws brown, dentate cutting edge with 8 (7-8) teeth (Fig. 2A). Paragnaths dark brown, cones on oral ring much larger than those on maxillary ring. Area I with 3 (1-5) conical paragnaths; area II with 24 left, 26 right (13-37) conical paragnaths in elongated patches; area III with 15 (14-26) conical paragnaths in a rectangular patch and lateral groups of 3 left, 4 right (1-8) paragnaths on either side; area IV with 27 left, 25 right (23-44) conical paragnaths in crescentic patches, smooth bar-like paragnaths present near jaws about half of all Korean specimens; area V with 3 (1-5) conical paragnaths in a transverse row (or triangle); area VI with 3 left, 5 right (2-7) bars of uneven length, end ones longer; area VII-VIII with 34 (26-44) conical paragnaths in 2 rows (Fig. 2A, B).

Dorsal notopodial ligule on anterior chaetigers slightly larger than dorsal neuropodial ligule. Dorsal cirrus 0.81 (0.74-1.23) times as long as dorsal notopodial ligule anteriorly (chaetiger 10) (Fig. 2C); posteriorly dorsal cirrus 1.00 (0.81-1.34) times as long as dorsal notopodial ligule (chaetiger 75-90) (Fig. 2D). Neuropodial postsetal lobe low rounded, not projecting beyond end of acicular ligule. Ventral neuropodial ligule similar in length to acicular neuropodial ligule length in all chaetigers. Neuropodial dorsal fascicle heterogomph falcigers with serated blades (Fig. 4A). Neuropodial dorsal fascicle heterogomph spinigers present throughout.

Variation. Some specimens from Jebudo Is., Seonjedo Is., and Yupo-ri have only 2 elongated bars on area VI (Fig. 5).

Remarks. Korean *P. nuntia* var. *brevicirris* was synonymised with *P. nuntia* by Paik (1975). However, Glasby and Hsieh (2006) referred this taxon as a *P. mictodonta* on the basis of Paik's literature. According to the present taxonomic study, Korean materials agree well with Glasby and Hsieh's (2006) redescription of *P. mictodonta* (Tables 1, 2). *P. mictodonta* is most similar to *P. wilsoni*, but can be distinguished from this species by the dorsal cirrus, which is relatively longer in *P. wilsoni*. Glasby and Hsieh (2006) did not mention about bars on area IV, however, half of all Korean specimens and some Taiwanese specimens have elongated paragnath (bar-like) on area IV (Fig. 6).

Habitats. Intertidal, in muddy sand to gravely sand substrate, especially under rocks, also associated with oyster bed.

[1]**Perinereis wilsoni* Glasby and Hsieh, 2006 (Figs. 2-4)

Perinereis wilsoni Glasby and Hsieh, 2006, p. 570, fig. 10A-F.

Perinereis nuntia var. *vallata*: Khlebovich and Wu, 1962, p. 51, pl. 3; Paik, 1972, p. 131, fig. 2a-h; Imajima, 1972, p. 92; Wu et al., 1985, p. 210, fig. 121a-k. [not *Nereis vallata* (Grube, 1858)].

Perinereis brevicirris: Wu, 1967, p. 71, fig. 11a-d.

Perinereis nuntia: Paik, 1975, p. 242, fig. 1a-d (in part); 1989, p. 311, pl. 25-63b-1, 63a, 63c-2, 63b-2, 63c-1, fig. 73a-g (in part).

Perinereis sp. 2: Chen et al., 2002, p. 19.

Material examined. Hadogul-dong, Bukjeju-gun, Jeju-do, 33° 31′N 126° 53′E, 26 Oct. 2005, (T.S. Park), 31 inds.; Gusan-myeon, Masan-si, Gyeongsangnam-do, 35° 6′41.3″N 128° 36′4.6″E, 28 Jun. 2006, (T.S. Park), 3 inds.; Hae-ri, Sanyang-eup, Tongyeong-si, Gyeongsangnam-do, 34° 49′32.7″N 128° 20′26.4″E, 30 Jun. 2006, (T.S. Park), 7 inds.; Yulim beach, Geomun Is., Samsan-myeon, Yeosu-si, Jeollanam-do, 34° 54′7″N 127° 18′27.2″E, 20 Sep. 2006, (T.S. Park) 10 inds.; Joil-ri, Wudo-myeon, Bukjeju-gun, Jeju-do, 33° 30′N 126° 57′E, 14 Oct. 2006, (T.S. Park), 23 inds.; Ha-dong, Siheung-ri, Bukjeju-gun, Jeju-do, 33° 31′N

[1]*긴수염눈썹참갯지렁이 (신칭)

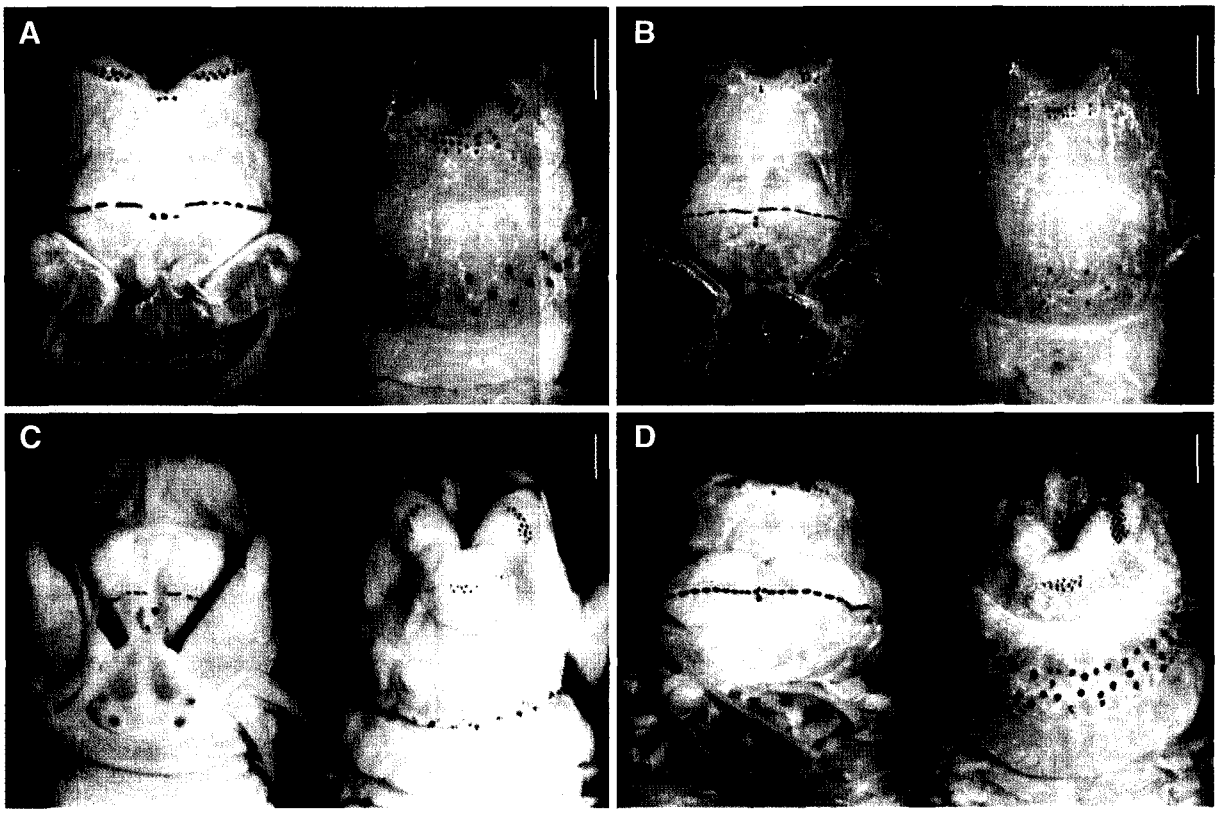

Fig. 3. Four species of *P. nuntia* species group. A, *P. mictodonta*; B, *P. wilsoni*; C, *P. nuntia*; D, *P. vallata*. Scale bars=1.0 mm (A-D).

126° 51′E, 15 Oct. 2006, (T.S. Park), 25 inds.

Reference materials examined. Perinereis wilsoni Glasby and Hsieh, 2006: Lungtung, Taipei County, Taiwan, 25° 6′N 121° 54′E, 8 Oct. 1998, (H.L. Hsieh), 1 ind. NTM W19279, 1 ind. NTM W19281, 1 ind. NTM W19284, 1 ind. NTM W19283, 1 ind. NTM W19278, 1 ind. NTM W19280; Tiehhsien, Penghu County, Taiwan, 23° 32′8.11″N 119° 35′18.95″E, 19 Mar. 2003, (M.J. Kuo), 1 ind. NTM W19276, 3 inds. NTM W19277; Liukuaitso, Tanshui Town, Taipei County, Taiwan, 25° 14′N 121° 26′E, 26 Mar. 2003, (H.L. Hsieh), 1 ind. NTM W19286, 1 ind. NTM W19285.

Perinereis nuntia (Savigny, 1818): Western Australia, Enderby I., Australia, (P. Hutchings), 3 inds. AM W201967 -8, mangroves, intertidal; Queensland, Yorkeys Knob, Australia, 19-20 Nov. 1984, (R. Hanley), 3 inds. (NTM W2364, W2365), intertidal, under rock; Redcliff, SEQ1d, Australia, 21 Sep. 2005, (P. Palmer), 2 inds. (NTM); St. Johns I., Southern shore, Singapore, 8 Dec. 2003, no collector data, 2 inds. (NTM); South Paris I., Jacarta, Java, Indonesia, 14 Feb. 2003, no collector data, 3 inds. NTM.

Perinereis vallata (Grube, 1858): Macquarie I., Australia, no further data, 1 ind. VM F54004; Werri Bee, Australia, 14 Dec. 2005, no further data, 5 inds. VM; Southern Australia, 21 Feb. 2006, no collector data, 3 inds. VM.

Diagnosis. Longest specimens 151.5 mm long, 102 chaetigers and 6.3 mm wide at chaetiger 10 (including parapodia), 3.9 mm wide at chaetiger 10 (excluding parapodia).

Anterior dorsum brown or olive. Prostomium slight longer than wide; antennae 1/3 prostomium length, and separated at their bases; longest tentacular cirri extending back to chaetiger 9 (6-12). Jaws brown, dentate cutting edge with 8 (7-8) teeth (Fig. 2E). Paragnaths brown, cones on oral ring slightly larger than those on maxillary ring. Area I with 2 (1-7) conical paragnaths; area II with 19 left, 19 right (6-28) conical paragnaths in elongated patches; area III with 25 (6-28) conical paragnaths in a rectangular patch and lateral groups of 3 left, 3 right (1-7) paragnaths on either side; area IV with 33 left, 32 right (13-44) conical paragnaths in crescentic patches, smooth bar-like paragnaths present near jaws about half of all Korean specimens; area V with 2 (1-4) conical paragnaths in a longitudinal row (or narrow triangle); area VI with 7 left, 6 right (3-9) bars of uneven length, end ones longer; area VII-VIII with 31 (16-37) conical paragnaths in 2 rows (Fig. 2E, F).

Dorsal notopodial ligule on anterior chaetigers equal to dorsal neuropodial ligule. Dorsal cirrus 1.38 (1-1.98) times

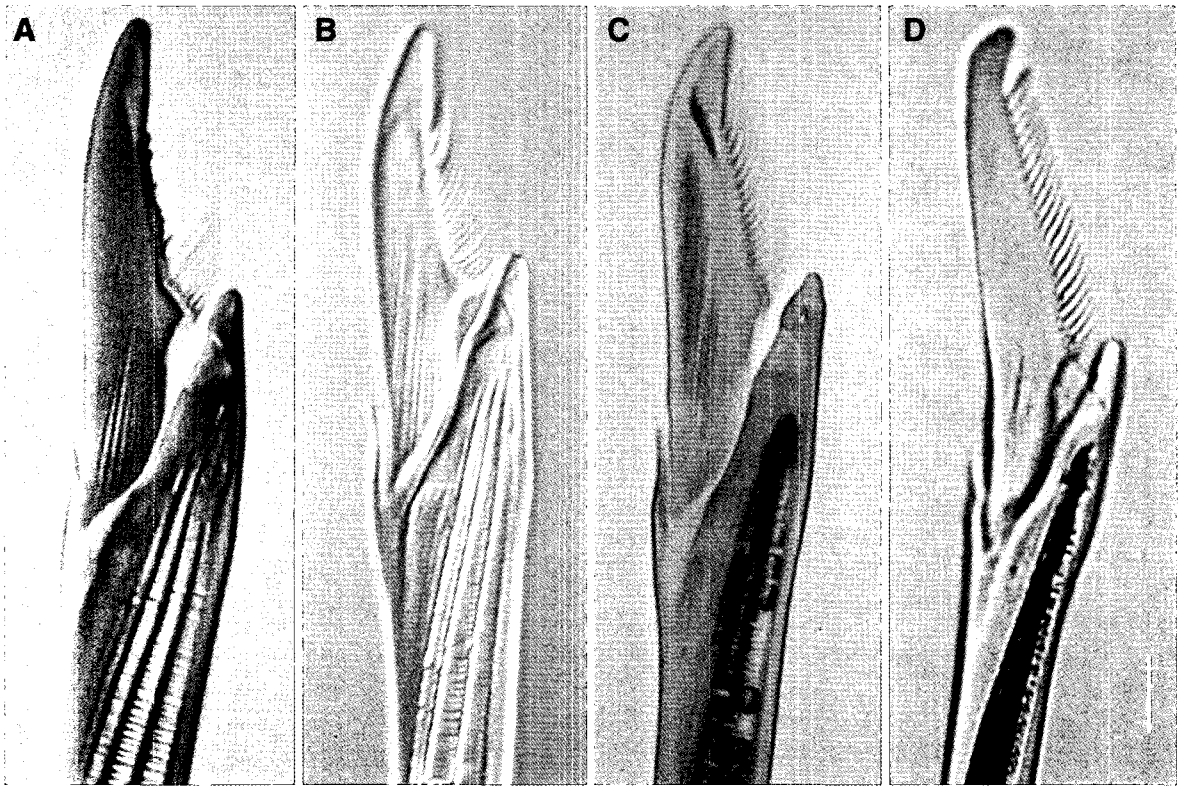

Fig. 4. Heterogomph falciger: A, *P. mictodonta*; B, *P. wilsoni*; C, *P. nuntia*; D, *P. vallata*. Scale bar=0.01 mm (A-D).

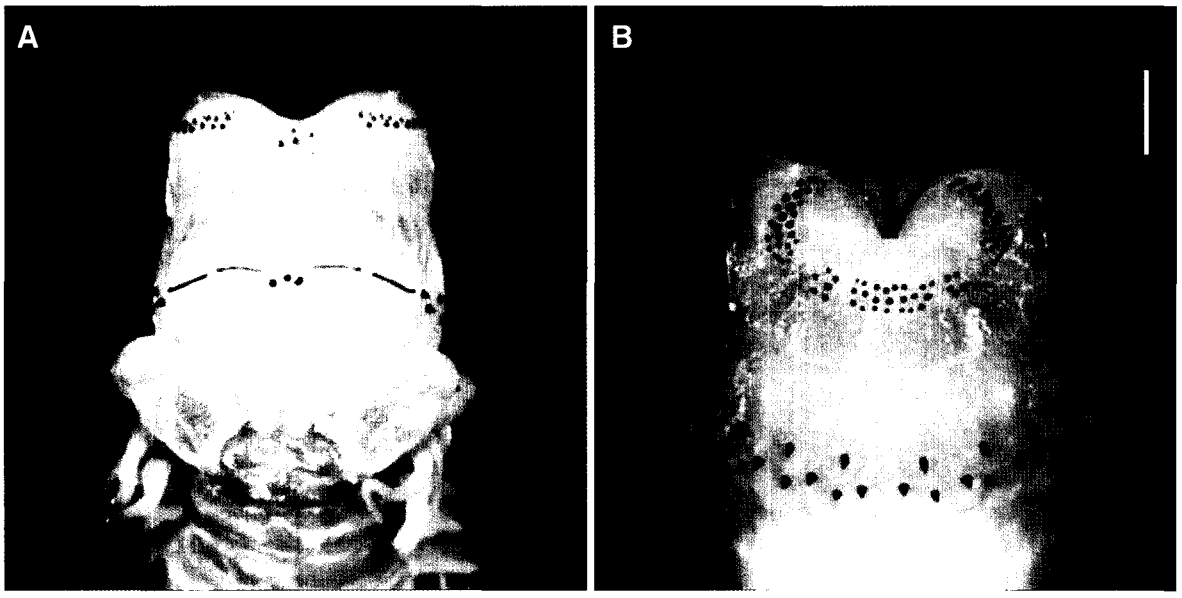

Fig. 5. Variation of *P. mictodonta*. A, dorsal view, showing only 2 elongated paragnaths on each area VI; B, ventral view. Collected from Seonjedo Island. Scale bar=1.0 mm (A, B).

as long as dorsal notopodial ligule anteriorly (chaetiger 10) (Fig. 2G); posteriorly dorsal cirrus 1.85 (1.05-2.8) times as long as dorsal notopodial ligule (chaetiger 75-90) (Fig. 2H). Neuropodial postsetal lobe low, rounded, not projecting

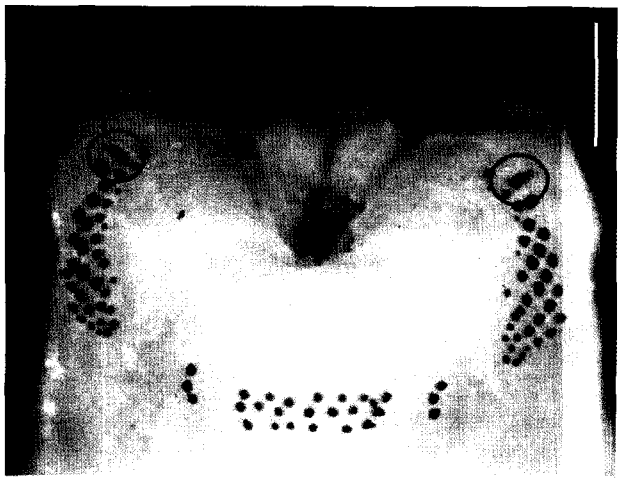

Fig. 6. Bar like paragnath on area IV (*P. mictodonta*, ventral view). Scale bar=1.0 mm.

beyond end of acicular ligule. Ventral neuropodial ligule as long as acicular neuropodial ligule in all chaetigers. Neuropodial dorsal fascicle heterogomph falcigers with serated blades (Fig. 4B). Neuropodial dorsal fascicle heterogomph spinigers present throughout.

Variation. Jejudo Is. specimens usually have fewer paragnaths on area II. Variation in paragnath count on area II: 6-16 (average 9.91, standard deviation ±2.12).

Remarks. Korean *P. nuntia* var. *vallata* was reported by Paik (1972) and in the later study, Paik (1975) synonymised this species with *P. nuntia*. Recently, Glasby and Hsieh (2006) referred *P. nuntia* var. *vallata* by Paik (1972) as *P. wilsoni* n. sp. based on the Paik's literature. According to the present taxonomic study, Korean materials agree well with original description of *P. wilsoni* (Table 1, 2). Glasby and Hsieh (2006) did not mention about bars on area IV, however, half of all Korean materials and some Taiwanese specimens have elongated paragnath (bar-like) on area IV.

Habitats. Intertidal reef flat or rocky shore, under boulders.

DISCUSSION

Recently, a molecular taxonomic study of marine polychaete worms belonging to the genus *Perinereis* have been conducted by Chen et al. (2002) using ribosomal internal transcribed spacers (ITS). This study indicated the existence of two unnamed sympatric species. Later, Glasby and Hsieh (2006) reported those two species as *P. mictodonta* and *P. wilsoni*. Although ITS sequence is useful to discriminate closely related *Perinereis* species, the mtCOI sequence has several advantage as a molecular marker: (1) the clear sequence data can be obtained from direct sequence; (2) the alignment of mtCOI sequences is straightforward, as indels are uncommon; (3) the mtCOI sequences possess a high level of diversity among species and the universal primers for this gene are very robust (Former et al., 1994; Hebert et al., 2003a).

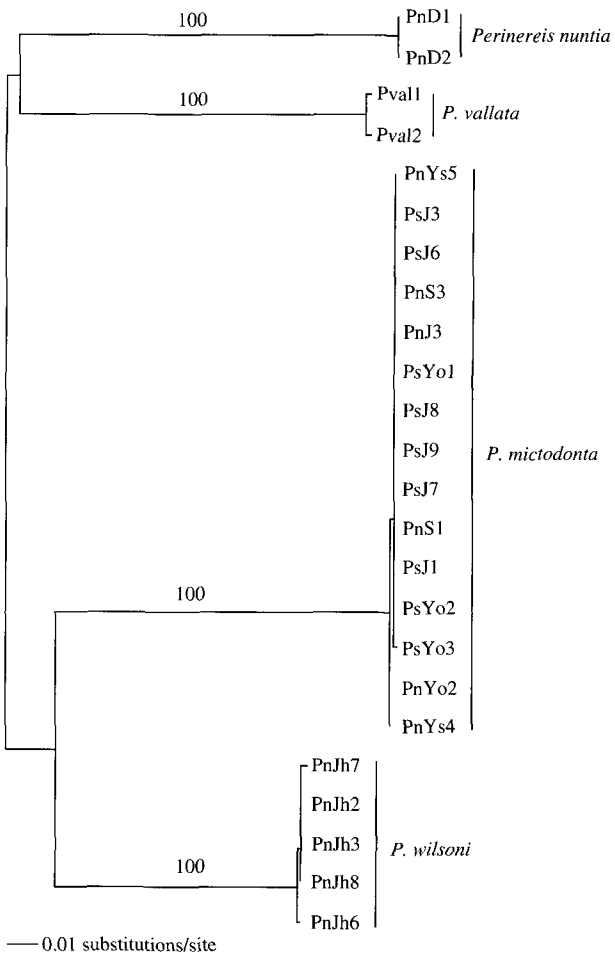

Fig. 7. Neighbor-joining tree (Kimura 2-parameter model) of four species of *P. nuntia* species group based on 542 base pairs of mtCO1 gene.

In the present molecular taxonomic study, we tested the mtCOI gene as a molecular marker for the species discrimination of *P. nuntia* species group of Korea. The percentage sequence divergence among individuals of *P. mictodonta* (n=15) and *P. wilsoni* (n=5) ranges 0 to 0.37%, respectively. In the case of *P. nuntia* (n=2) and *P. vallata* (n=2) the divergence is 0% and 0.37%, respectively. Mean of the divergence between species pair among four species ranges 18.95 to 25.05% (18.95% for *P. wilsoni* vs. *P. mictodonta*; 23.44% for *P. wilsoni* vs. *P. nuntia*; 19.87% for *P. wilsoni* vs. *P. vallata*; 25.05% for *P. mictodonta* vs. *P. nuntia*;

24.37% for *P. mictodonta* vs. *P. vallata*; 23.54% for *P. nuntia* vs. *P. vallata*). According to Hebert (2003b), mean of the mtCOI percentage sequence divergence between species pairs in Annelida is 15.7%. Therefore, it is considered that the sequence divergences between species pair obtained in this study are big enough to discriminate between *P. mictodonta* and *P. wilsoni* (Fig. 7).

Some Korean specimens of *P. mictodonta* have only two elongated bars on area VI (Fig. 5) (see description part). According to Hutchings (1991), they should be treated as distinct species belonging to a group known as *Perinereis* group 2A. In the present study, the mtCOI sequences of these individuals showed more than 99% identity with those of *P. mictodonta*. The mtCOI gene clearly solved the different taxonomic view caused by ambiguous morphological characters and the present study showed that it is to be a good molecular marker for species identification of the *P. nuntia* species group of Korea.

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