

***Pterostichus macrogenys* Bates (Coleoptera: Carabidae) and Its Allied Species of Northern Japan: Descriptions of Seven Additional Species and Possible Evidence Supporting Species Status**

Kôji Sasakawa

Laboratory of Plant Evolution and Biodiversity, Department of General Systems Studies, Graduate School of Arts and Sciences, The University of Tokyo, 3-8-1 Komaba, Meguro-ku, Tokyo 153-8902, Japan

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Kôji Sasakawa (2009) *Pterostichus macrogenys* Bates (Coleoptera: Carabidae) and its allied species of northern Japan: descriptions of seven additional species and possible evidence supporting species status. *Zoological Studies* 48(2): 262-269. *Pterostichus macrogenys* Bates (Coleoptera: Carabidae) and its allied species of northern Japan are revised based mainly on the structures of the male endophallus (inner sac everted from the aedeagus). Seven species are newly described: *P. shirakamisan* sp. nov., *P. takadateyamanus* sp. nov., *P. chokaisanus* sp. nov., *P. gassanus* sp. nov., *P. eboshiyamanus* sp. nov., *P. yahikosanus* sp. nov., and *P. iwakiensis* sp. nov. Collection data and body-size differences among these species suggest the sympatric occurrence of large and small species in some localities. The implications of these results for the species-level taxonomy of this group are discussed. <http://zoolstud.sinica.edu.tw/Journals/48.2/262.pdf>

Key words: Ground beetle, Male endophallus, New species, *Nialoe*, Species status.

Pterostichus macrogenys Bates and its allied species are one of the most differentiated groups in the subgenus *Nialoe* Tanaka (sensu Sasakawa 2005b). This group is characterized by a large head with long mandibles (Kasahara 1988, Sasakawa 2005a b), is endemic to the island of Honshu in the Japanese Archipelago, and includes approximately 20 species (Sasakawa 2005a, Sugimura 2005 2006 2007). When Sasakawa (2005a) revised the group, he recognized 14 species from Chubu and Tohoku Districts. However, there were many localities from which no specimens were examined in his study (cf. Fig. 1), and this led him tentatively to treat these allopatric "species" as distinct species and not as subspecies of a single species.

Herein I describe 7 additional species in this group from Chubu and Tohoku Districts. Despite a marked similarity in external morphology (Figs.

2-10), these species are readily distinguishable by the structures of the male endophallus (inner sac everted from the aedeagus; Figs. 11-18); this structure has not been sufficiently examined in previous studies (but see Nemoto 1988, Sasakawa 2005a). In addition, some of these species seem to occur sympatrically with other species. This finding is notable because sympatry provides direct evidence for reproductive isolation among species and thereby justifies their separate species status. The goal of this study was to describe the 7 new species and discuss their distribution patterns with regard to the species-level taxonomy of this group.

MATERIALS AND METHODS

Specimens examined were borrowed from the National Science Museum, Tokyo, Japan (NSMT)

*To whom correspondence and reprint requests should be addressed. Tel/Fax: 81-3-54546638. E-mail: cksasa@mail.ecc.u-tokyo.ac.jp

and the National Institute for Agro-Environmental Science, Tsukuba, Japan (NIAES). Information about some of the related species compared was

obtained from Sasakawa (2005a), which describes key characters, such as the male endophallus, of all known species of this group in Chubu and

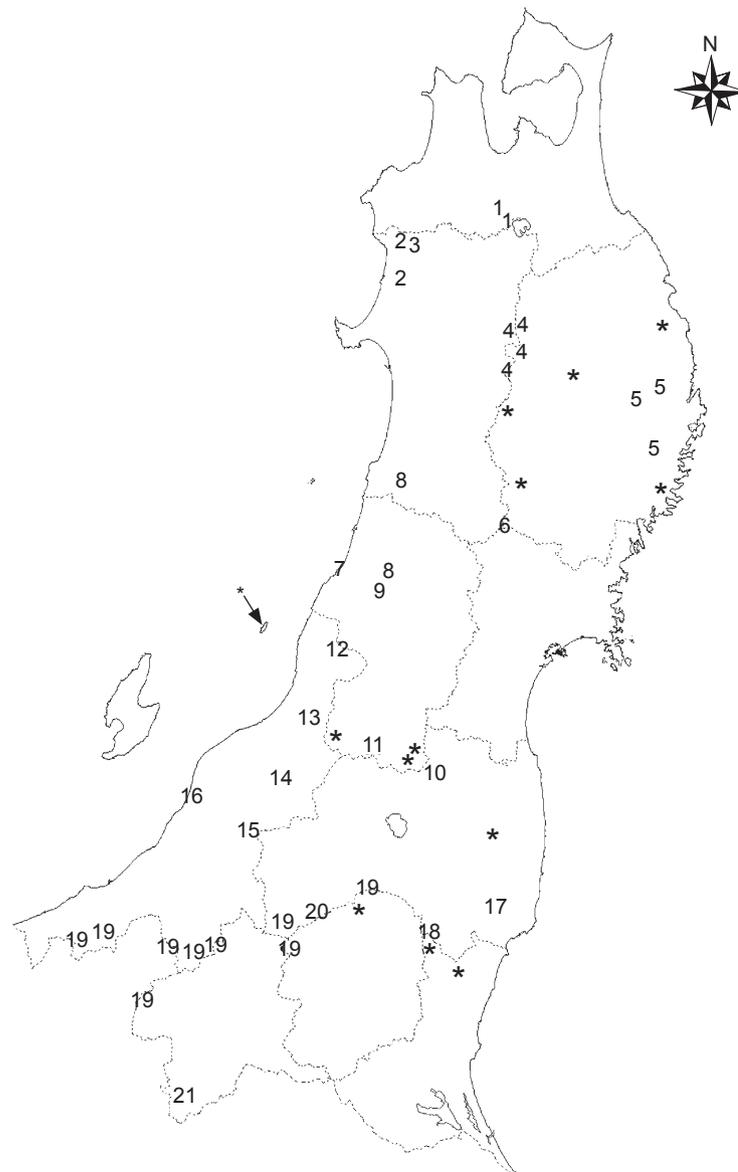


Fig. 1. Distribution of *Pterostichus macrogenys* Bates and its allied species in Chubu and Tohoku Districts, compiled from Takahashi (1986), Kubota (1988), Kasahara and Nishiyama (1990), Shimizu (2001), Sasakawa (2005a), and the following additional materials (*P. macrogenys*: 1 ♀, Mt. Naeba, Sakae City, Nagano Pref., 23.vi.2005, W. Toki leg., in author's coll.; *P. tanakai*: 1 ♂, labeled '800 m Komagatake Akita Pref, 19801005 M.Fujioka-leg.', in NSMT; 1 ♂, labeled 'Tamagawa spa Akita Pref. 6-VIII-1981 S. Kasahara leg.', in NSMT; *P. kitakamisanus*: 1 ♂, labeled 'Kwannon-iwa-no-ana Cave at Kutsukake 8-VII-1954', in NSMT; *Pterostichus* spp. (indeterminable specimens): 1 ♀, labeled 'Oni-ana Ōtakine-machi Fukushima Pref. 21-VI-1991 S. Sone leg'; 1 ♀, labeled '/No. 5961♀//Momonokidai-no-ana Cave at Nen-nen, Akka-mura (IWATE)//6-VII-1954 Leg. S. Uéno'; 1 ♀, labeled 'Yamanashizawa Yonezawa-shi Yamagata Pref. 6. VI. 1986 S. Kasahara leg.'; 1 ♀, labeled 'Namegawa Yonezawa C. Yamagata Pref. 5. IX. 1982 B. Yamaya leg.'). 1, *Pterostichus orionis* Jedlička; 2, *P. shirakamisanus* Sasakawa; 3, *P. shirakamisan* sp. nov.; 4, *P. tanakai* Ishida; 5, *P. kitakamisanus* Sasakawa; 6, *P. kurikomisanus* Sasakawa; 7, *P. takadateyamanus* sp. nov.; 8, *P. chokaisanus* sp. nov.; 9, *P. gassanus* sp. nov.; 10, *P. adatarasanus* Sasakawa; 11, *P. eboshiyamanus* sp. nov.; 12, *P. asahinus* Habu and Baba; 13, *P. falcispinus* Sasakawa; 14, *P. ohsawacavus* Sasakawa; 15, *P. sumondakensis* Sasakawa; 16, *P. yahikosanus* sp. nov.; 17, *P. iwakiensis* sp. nov.; 18, *P. yamizosanus* Sasakawa; 19, *P. macrogenys* Bates; 20, *P. isolatus* Sasakawa; 21, *P. koheii* Nakane. Asterisks indicate collection sites of indispensable specimens (all female) or records from the literature.

Tohoku Districts (*P. shirakamisanus* Sasakawa, *P. kurikomisanus* Sasakawa, *P. adatarasanus* Sasakawa, *P. ohsawacavus* Sasakawa, *P. yamizosanus* Sasakawa, and *P. falcispinus* Sasakawa; cf. Fig. 1).

The terminology of the male genitalia follows Sasakawa (2005a, b). Body lengths were measured from the mandible apices to the elytral end, but measurements from the anterior margin of the labrum to the elytral end and from the clypeal apex to the elytral end are also provided. This is because the anterior end in the Carabidae has been arbitrarily set by each author (cf. Sasakawa et al. 2008). All measurements are reported in millimeters. Morphological characters are abbreviated as follows: BLm, body length from mandible apices to elytral end; BLl, body length from anterior margin of labrum to elytral end; BLc, body length from clypeal apex to elytral end; HL, head length from clypeal apex to neck base; HW, head width at widest part; PL, pronotum length along median line; PW, pronotum width at widest part; PAW, pronotal anterior margin width; PPW, pronotal posterior margin width; EL, elytral length from shoulder tip to apices; EW, elytral width at widest part.

Descriptions

All species treated here belong to the subgenus *Nialoe* (for a definition, see Sasakawa 2005b) and share the following character states.

External structures: Dorsal surface dark brown to black and shiny. Apterous. Head large-sized (Figs. 2-10), widest at tempora; frontal impressions shallow with posterior ends at mid-eye level; frons smooth; 2 pairs of supraorbital setae, anterior pair at mid eye-level and posterior pair at basal level 1/2 of tempora; eyes small and less convex with hind posterior margin in front of hind supraorbital setae; tempora markedly swollen, longer than eyes, with smooth surface.

Pronotum cordate, notably flat, widest at apical 1/4-1/3; anterior margin emarginate, wider than posterior margin; anterior angles produced; lateral margins arcuate on apical 2/3, slightly sinuate on basal 1/3; 2 marginal setae on each side, anterior setae near widest pronotal point and posterior setae near hind angles; posterior margin emarginated at median area; hind angles almost square, not denticulate; laterobasal impressions single, shallow.

Elytra almost parallel-sided, less convex; shoulder distinct, but not denticulate; scutellar stria

present; 1 setigerous puncture at anterior end of stria 1; 2 setigerous punctures on interval 3, anterior one almost on basal 1/2 and posterior one on apical 1/6-1/5, both adjoining stria 2. Ventral side almost smooth; male sternum 7 more or less concave.

Male genitalia: Aedeagus stout and without conspicuous tubercle; endophallus short, stout, strongly bent ventrally (Figs. 11-18); left dorsolateral surface near ostium more or less sclerotized (i.e., left pigmented band); 3 lobes present on surface of endophallus, one on right ventral surface (i.e., right preapical lobe), one on left dorsolateral surface (i.e., left preapical lobe), and one on left ventrolateral surface (i.e., left apical lobe); gonopore with 1 sclerotized part (i.e., gonoporal piece); left paramere square; right paramere short, straight, rounded apically (Fig. 19), except for *P. takadayamanus* sp. nov. (Fig. 20).

Pterostichus (Nialoe) shirakamisan sp. nov. (Figs. 3, 11, 19)

Pterostichus macrogenys Bates: Tanaka 1985: 114; Kasahara 1988: 55.

This species is distinguished from other related species by the large, bifurcated left apical lobe of the endophallus. It is likely sympatric with *P. shirakamisanus* (Figs. 1, 2), but is readily distinguished by its larger body size (cf. *P. shirakamisanus* ♂, BLl 11.7) and the structure of the endophallus (Sasakawa 2005a, Fig. 2; cf. *P. yahikosanus* sp. nov.).

External structures: Body large (♂/♀ BLm 17.5/17.6; BLl 15.7/15.7; BLc 15.0/15.2), stout, dark brown. HL/HW 0.82-0.83; antennal segment 2 with 2 setae. Pronotum cordate with smooth surface; PL/PW 0.58-0.62; PAW/PW 0.88-0.89; PPW/PW 0.71. EL/EW 1.50-1.53. Male sternum 7 fairly concave. Female 1st fore tarsomere without adhesive hairs on ventral side.

Male genitalia: Left pigmented band weakly sclerotized; right preapical lobe widely swollen; left preapical lobe large; left apical lobe markedly large and bifurcated.

Female genitalia: Vagina without conspicuous pigmentations; spermatheca and median oviduct each with a sclerotized apophysis on basal part; spermatheca cylindrical, almost straight; apical part of spermatheca differentiated at part connected to spermathecal gland.

Type materials: Holotype, ♂, labeled 'Riv. Kasuke-gawa (500 m) Fujisato-machi Akita Pref. 4. VIII. 1985. F. Satô Leg.' in NSMT. Paratype, 1 ♀, same data as for holotype, in NSMT.

Type locality: River Kasuke, Mts. Shirakami, on the border between Aomori and Akita Prefs.

***Pterostichus (Nialoe) takadateyamanus* sp. nov.**

(Figs. 4, 12, 20)

Pterostichus macrogenys Bates: Tanaka 1985: 114; Kasahara 1988: 55.

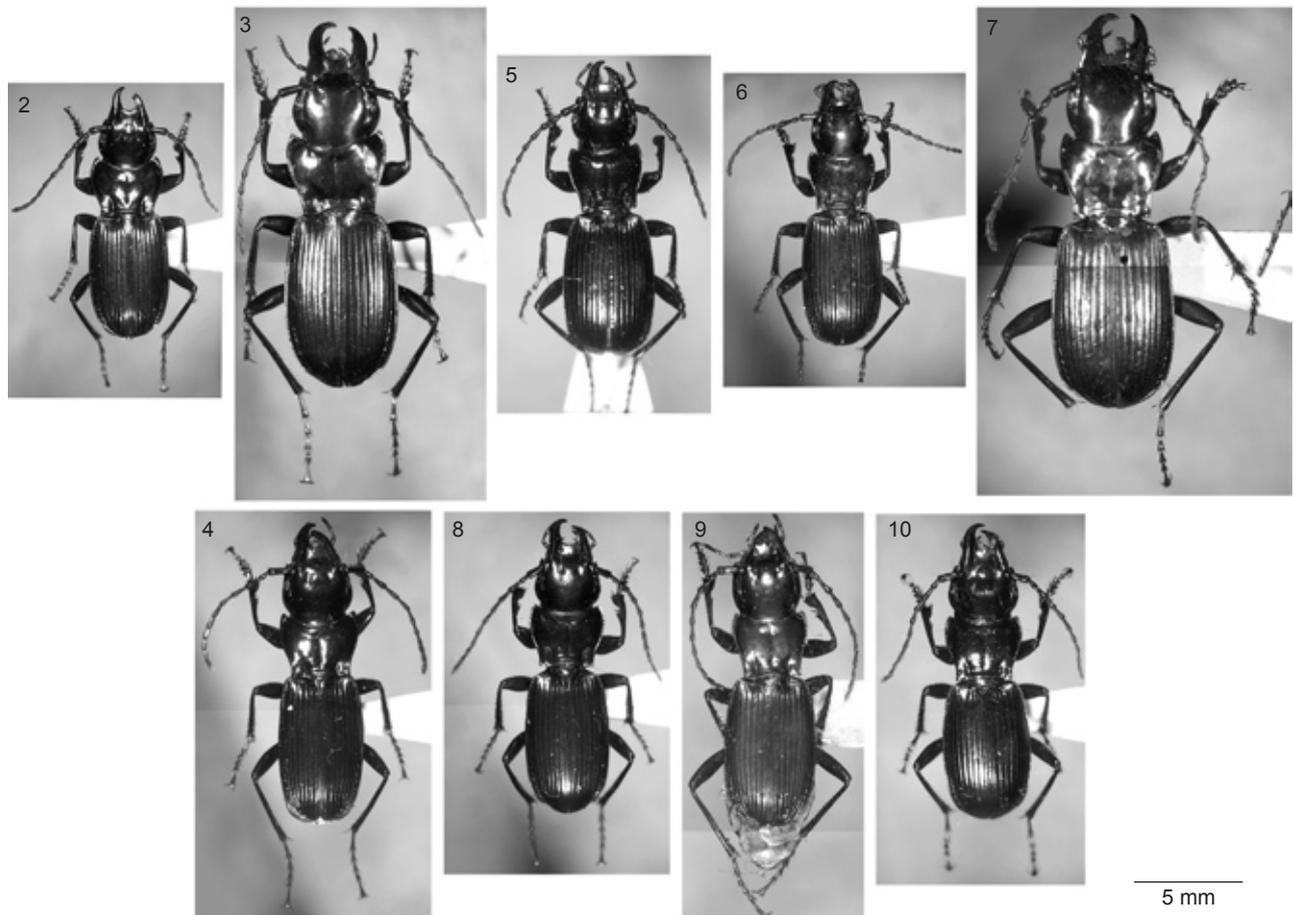
This species is similar to *P. falcispinus*, but is distinguished by the shape of the right paramere (Fig. 20; see also Habu 1977: plate-fig. 4d).

External structures: Body small (♂ BLM 14.3;

BLI 13.1; BLc 12.6), slender, dark brown. HL/HW 0.99; antennal segment 2 with 2 setae. Pronotum cordate with smooth surface, except for laterobasal impressions; laterobasal impressions moderately punctuate; HL/HW 0.99; PL/PW 0.62; PAW/PW 0.90; PPW/PW 0.75. EL/EW 1.64. Male sternum 7 fairly concave.

Male genitalia: Left pigmented band rudimentary and slightly sclerotized; right preapical lobe markedly large, elongated, with widely rounded apex; left preapical lobe large; left apical lobe markedly small, with weakly sclerotized surface. Right paramere bent at about 90° at apical 1/3; apical part wide from dorsal view, with protruding right corner.

Type material: Holotype, ♂, labeled 'Mt. Takadate Yamagata 29. IV. 1981 S. Sakamoto', in NSMT.



Figs. 2-10. Dorsal view of *Pterostichus* spp. 2. *Pterostichus shirakamisanus* Sasakawa (holotype male); 3. *P. shirakamisanus* sp. nov. (holotype male); 4. *P. takadateyamanus* sp. nov. (holotype male); 5. *P. chokaisanus* sp. nov. (holotype male); 6. ditto (paratype male from Nakamura near Mt. Gassan); 7. *P. gassanus* sp. nov. (holotype male); 8. *P. eboshiyamanus* sp. nov. (holotype male); 9. *P. yahikosanus* sp. nov. (holotype male); 10. *P. iwakiensis* sp. nov. (holotype male).

Type locality: Mt. Takadate, Tsuruoka City, Yamagata Pref.

***Pterostichus (Nialoe) chokaisanus* sp. nov.**
(Figs. 5, 6, 13, 14)

Pterostichus macrogenys Bates: Tanaka 1985: 114; Kasahara 1988: 55.

This species is similar to *P. adatarasanus* and *P. eboshiyamanus* sp. nov., but can be distinguished by its smaller body size (cf. *P. adatarasanus* ♂, BLI 12.9) and less-sclerotized left pigmented band of the endophallus. It is probably sympatric with *P. gassanus* sp. nov., but is readily distinguished by its smaller body (Figs. 5-7).

External structures: Body small (♂ BLM 12.7-13.9; BLI 11.8-12.9; BLc 11.5-12.4), slender, and black. HL/HW 0.89-0.92; antennal segment 2 with 2 setae. Pronotum less cordate, with smooth surface except for laterobasal impressions; laterobasal impressions moderately punctate in holotype, weakly in paratype; PL/PW 0.71-0.72; PAW/PW 0.82-0.85; PPW/PW 0.72-0.74. EL/EW 1.52-1.66; in paratype, interval 3 of right elytron with 1 additional setigerous puncture at 2/5 from base. Male sternum 7 concave.

Male genitalia: Left pigmented band weakly sclerotized; right preapical lobe markedly small; left preapical lobe moderate; left apical lobe bifurcated with slender and narrowly rounded apices.

Type materials: Holotype, ♂, labeled 'Yashima Yuri Dist. (Akita) 7-VIII-1981 S. Kasahara leg.', in NSMT. Paratype, 1 ♂, labeled '5-8. Sept. 1994 (Tachikawa-chô, Nakamura) Yamagata, JAPAN K. Ishizuka leg.' in NSMT.

Localities: Yashima, the northeastern foot of Mt. Chôkai, Yurihonjô City, Akita Pref. (type locality); and Nakamura, the northern foot of Mt. Gassan, Shônai City, Yamagata Pref.

***Pterostichus (Nialoe) gassanus* sp. nov.**
(Figs. 7, 15)

Pterostichus macrogenys Bates: Tanaka 1985: 114; Kasahara 1988: 55.

This species is similar to *P. ohsawacavus*, but is distinguished by the darker body color and larger body size (cf. *P. ohsawacavus* ♂, BLI 13.3). It is probably sympatric with *P. chokaisanus* sp. nov. (Fig. 1), but is readily distinguished by its larger body (Figs. 5-7).

External structures: Body large (♂ BLM 19.0; BLI 17.0; BLc 16.4), stout, dark brown. HL/HW 0.86; antennal segment 2 with 1 seta. Pronotum cordate with smooth surface; PL/PW 0.66; PAW/PW 0.87; PPW/PW 0.76. EL/EW 1.55. Male sternum 7 fairly concave.

Male genitalia: Left pigmented band distinctly sclerotized; right preapical lobe widely swollen; left preapical lobe markedly large; left apical lobe large, stout.

Type material: Holotype, ♂, labeled '2. Sept. 1992 Tachikawa-chô (Riv. Tachiyazawagawa) Yamagata Pref. Higashitagawa-gun Asia C. coll.', in NSMT.

Type locality: River Tachiyazawa, the northern side of Mt. Gassan, Shônai City, Yamagata Pref.

***Pterostichus (Nialoe) eboshiyamanus* sp. nov.**
(Figs. 8, 16)

Pterostichus macrogenys Bates: Tanaka 1985: 114; Kasahara 1988: 55.

This species is similar to *P. chokaisanus* sp. nov., *P. kurikomasanus*, and *P. adatarasanus*, but can be distinguished from *P. chokaisanus* sp. nov. by the smooth pronotal surface and less-concave male sternum 7, from *P. kurikomasanus* by its larger body (cf. *P. kurikomasanus* ♂, BLI 15.0) and the stout right preapical lobe of the endophallus (Fig. 16; see also Sasakawa 2005a, Fig. 6), and from *P. adatarasanus* by the darker body color and the left apical lobe of the endophallus, the surface of which is not sclerotized (Fig. 16; see also Sasakawa 2005a, Fig. 7).

External structures: Body small (♂ BLM 14.1; BLI 12.9; BLc 12.4), slender, dark to reddish-brown. HL/HW 0.88; antennal segment 2 with 2 setae. Pronotum cordate, with smooth surface; PL/PW 0.65; PAW/PW 0.87; PPW/PW 0.72. EL/EW 1.68. Male sternum 7 slightly concave.

Male genitalia: Left pigmented band strongly sclerotized; right preapical lobe small; left preapical lobe large; left apical lobe bifurcated, with stout and widely rounded apices.

Type material: Holotype, ♂, labeled 'Pros' g adit (R) at Tokoro-zawa Koya Iide-machi// Yamagata Pref. NE JAPAN 27-IX-1986 S. Uéno leg.', in NSMT.

Type locality: River Tokorozawa (elev. 620 m) on the western slope of the Eboshiyama Hills, Iide City, Yamagata Pref. (see Uéno 1986, who describes a Trechinae carabid with the same

collection data).

***Pterostichus (Nialoe) yahikosanus* sp. nov.**
(Figs. 9, 17)

Pterostichus macrogenys Bates: Habu 1977: 13; Sakaguti 1981; Tanaka 1985: 114; Kasahara 1988: 55.

This species is readily distinguished from locally adjacent species (*P. ohsawacavus*, *P. sumondakensis*, and *P. falcispinus*; Fig. 1) by its longer pronotum (cf. Habu 1977, table 2) and undeveloped sexual characteristics of male sternum 7. In the structures of the male endophallus, it is closely similar to *P. shirakamisanus* (Sasakawa 2005a, Fig. 2), but is distinguished by its larger reddish-brown body and

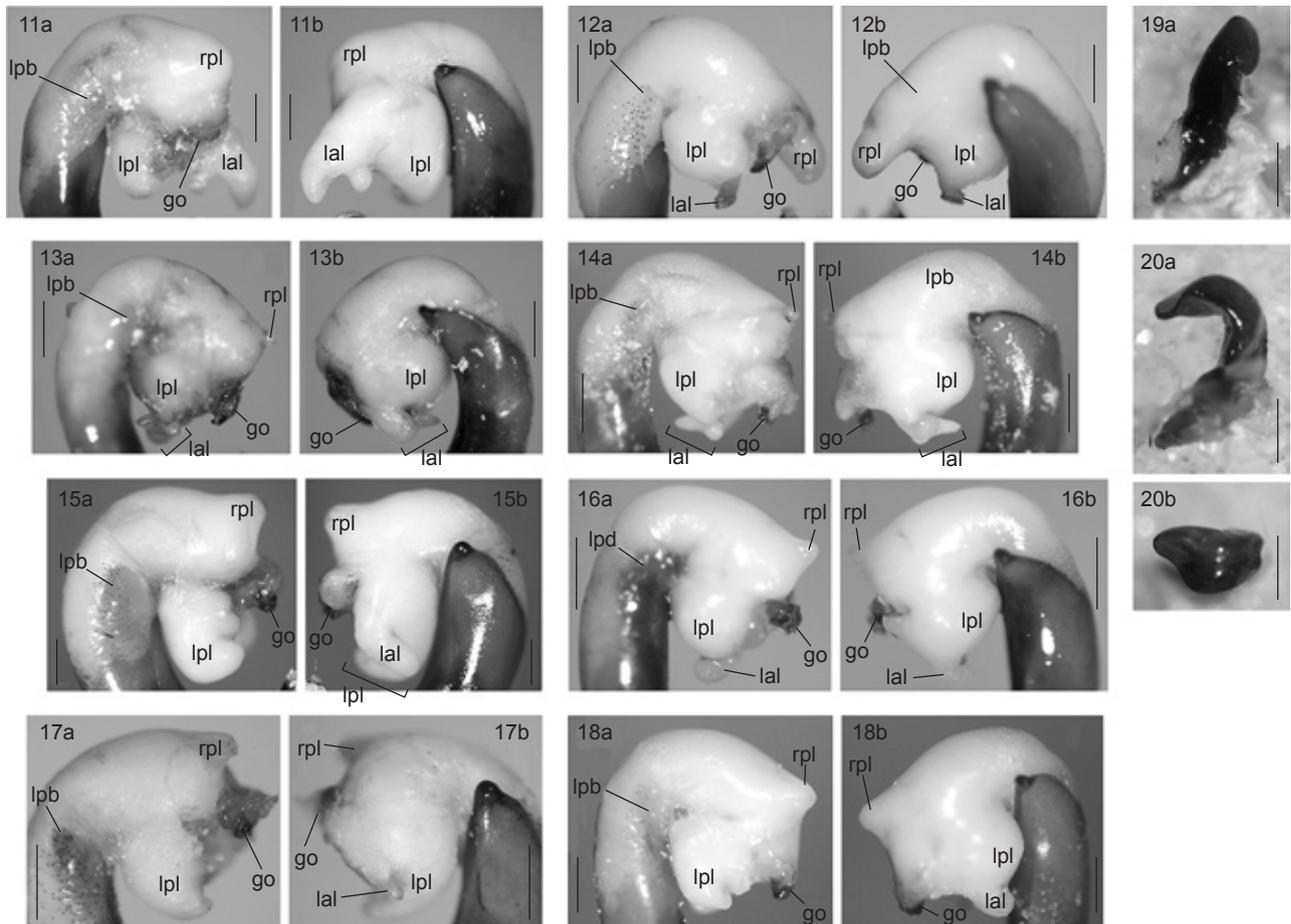
longer pronotum (Figs. 2, 9).

External structures: Body small (δ BLm 13.6; BLI 13.1; BLc 12.6), slender, reddish-brown. HL/HW 0.95; antennal segment 2 with 2 setae. Pronotum less cordate, with smooth surface; PL/PW 0.72; PAW/PW 0.88; PPW/PW 0.76. EL/EW 1.63. Male sternum 7 almost flat, barely concave.

Male genitalia: Left pigmented band strongly sclerotized; right preapical lobe small; left preapical lobe moderate; left apical lobe markedly small and slender.

Type material: Holotype. δ , 'Mt. Yahiko, M-Echigo 28, X, 1971 Col. K. Baba', in NIAES.

Type locality: Mt. Yahiko, on the border among Yahiko, Nagaoka, and Niigata Cities, Niigata Pref.



Figs. 11-20. Endophallus (11-18; a, left lateral view; b, right lateral view) and right paramere (19, 20; a, right lateral view; b, dorsal view of apical 1/3) of *Pterostichus* spp. **11, 19.** *Pterostichus shirakamisan* sp. nov. (holotype); **12, 20.** *P. takadateyamanus* sp. nov. (holotype); **13.** *P. chokaisanus* sp. nov. (holotype); **14.** ditto (paratype from Nakamura near Mt. Gassan); **15.** *P. gassanus* sp. nov. (holotype); **16.** *P. eboshiyamanus* sp. nov. (holotype); **17.** *P. yahikosanus* sp. nov. (holotype); **18.** *P. iwakiensis* sp. nov. (holotype). go, gonopore; lal, left apical lobe; lpb, left pigmented band; lpl, left preapical lobe; rpl, right preapical lobe. Scale bar = 1.0 mm.

***Pterostichus (Nialoe) iwakiensis* sp. nov.**
(Figs. 10, 18)

Pterostichus macrogenys Bates: Tanaka 1985: 114; Kasahara 1988: 55.

This species is similar to *P. yamizosanus*, but is distinguished by the right preapical lobe of the endophallus, which is not bifurcated (Fig. 18) and the female vagina without conspicuous pigmentations on its surface (in *P. yamizosanus* there are 2 large pigmentations on the surface of the vagina).

External structures: Body small- to moderate-sized ($\delta/\text{♀}$ BLM 14.1/16.2; BLI 12.9/14.8; BLC 12.3/14.2), slender, black. HL/HW 0.83-0.87; antennal segment 2 with 2 setae. Pronotum less cordate with smooth surface, except for laterobasal impressions; laterobasal impressions weakly punctuate; PL/PW 0.68-0.70; PAW/PW 0.85-0.86; PPW/PW 0.71-0.72. EL/EW 1.49-1.57. Male sternum 7 weakly concave. Female 1st fore tarsomere without adhesive hairs on ventral side.

Male genitalia: Left pigmented band weakly sclerotized; right preapical lobe small; left preapical lobe large; left apical lobe bifurcated with apices widely rounded.

Female genitalia: Vagina without conspicuous pigmentations; spermatheca and median oviduct each with a sclerotized apophysis on the basal part; spermatheca cylindrical and almost straight; apical part of spermatheca differentiated at part connected to spermathecal gland.

Type materials: Holotype, δ , labeled 'Iritōno Iwaki City Fukushima Pref. 27. v. 1990 S. Zenba leg.', in NSMT. Paratype, 1 ♀ , same data as for holotype, in NSMT.

Type locality: Iritōno, Mts. Abukuma, Iwaki City, Fukushima Pref.

DISCUSSION

This study describes 7 new species from the *P. macrogenys* group in Chubu and Tohoku Districts: *P. shirakamisan* sp. nov., *P. takadateyamanus* sp. nov., *P. chokaisanus* sp. nov., *P. gassanus* sp. nov., *P. eboshiyamanus* sp. nov., *P. yahikosanus* sp. nov., and *P. iwakiensis* sp. nov. Sasakawa (2005a) revised this group and recognized 14 species in the region. Thus, together with this study, 21 species are now recognized in the district (Fig. 1). These species are externally similar to one another (Figs. 2-10) and cannot be distinguished

without examining the male endophallus (Figs 11-18). In this study, the taxonomic status of some populations was indeterminable due to the unavailability of male specimens (see asterisks in Fig. 1). Further studies that include males would aid in clarifying their taxonomic status and also provide useful information on the species relationships within this group, as endophallic structures are useful phylogenetic characters in the subgenus *Nialoe* (Nemoto 1988 1989, Sasakawa 2005a-c).

In addition to identifying and describing 7 new species in this group, this study also revealed a peculiar distribution pattern in Tohoku District, which may provide further insights into the species-level taxonomy. There were 2 instances where 2 different-sized species were obtained from localities close to each other: *P. shirakamisan* sp. nov. and *P. shirakamisanus* from Mts. Shirakami (2, 3 in Fig. 1), and *P. gassanus* sp. nov. and *P. chokaisanus* sp. nov. from Mt. Gassan (8, 9 in Fig. 1). In both cases, the large species (Figs. 3, 7) was 1.4 times larger than the small species (Figs. 2, 6), suggesting character displacement in body size between the 2 species. This is in contrast to the other species that present no conspicuous body-size differences among parapatric species (e.g., Figs. 4, 8-10). Since body-size differences play important roles in the coexistence of related species in some carabids (*Carabus*: Sota et al. 2000a b; *Pterostichus*: Sasakawa and Kubota 2005 2006), it is possible that the 2 species mentioned above also exhibit sympatric distributions. If this is verified by reliable data such as fine-scale field research, the result would support the current species-level taxonomy of this group, i.e., members of the group are not subspecies of a single species (i.e., geographical races), but several distinct species (Sasakawa 2005a).

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