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Biology of *Bolitophagiella pannosa* (Lewis) newly reported from Korea (Coleoptera: Tenebrionidae)

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한국산 미기록종 가시넓적거저리[*Bolitophagiella pannosa* (Lewis)]의 생활사 연구

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ABSTRACT : A taxonomic review of a new record, *Bolitophagiella pannosa* (Lewis) in Korea is presented. Description of adult is presented and also we conducted laboratory and field observations of the life history and fungal hosts of the darkling beetle, *Bolitophagiella pannosa* (Lewis). A fungivorous tenebrionid beetle, *Bolitophagiella pannosa* (Lewis), was a rare inhabitant of fungi on deciduous trees (*Quercus, Robinia pseudoacacia* etc.) in Korea. Development from egg to adulthood took 3~10 months in nature and about 54 days in the laboratory at 25.5~26.1℃ and 63.5~64.5% relative humidity. Both larvae and adults overwintered in their host fungi or beneath the bark of the host tree near the host fungi. Sporophores of *Perenniporia medulla-panis* (Fr.) Donk and *Perenniporia frazinea* (Fr.) Ryv. were obligate feeding and breeding sites in Korea. Description, habitus photographs of adult and instar, and illustrations of diagnostic characters are provided.

KEY WORDS : *Bolitophagiella pannosa,* Tenebriondae, New record, Host fungi, Korea, Life history

초 록 : 넓적가시거저리[*Bolitophagiella pannosa* (Lewis)]는 국내에서 처음 보고되는 종으로 성충에 대한 기재문을 제공하였고, 야외관찰과 실내사육을 통해 다음과 같은 간략한 생활사를 밝혔다. 넓적가시거저리는 균식성 곤충으로 활엽수림에 나는 버섯, 특히 흰구멍장이속(*Perenniporia*)에 속하는 국내미기록종인 *P. medulla-panis* (Fr.) Donk와 아까시재목버섯[*P. frazinea* (Fr.) Ryv.]을 선호하였고, 성충과 유충이 혼재된 상태로 숙주버섯의 자실체 속이나 숙주버섯이 붙어있는 나무껍질 밑에서 월동하였으며, 실내사육(25.5~26.1℃; 63.5~64.5% RH)한 결과 알에서부터 성충까지 약 54일이 소요되었다.

검색어 : 넓적가시거저리, *Bolitophagiella pannosa* (Lewis), 미기록종, 생활사, 숙주버섯

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Introduction

Bolitophagiella Miyatake is a small genus of Bolitophagini in family Tenebrionidae, which is distributed in a relict area including Korea and Japan and consists of only one species of the world fauna (Miyatake, 1964). This genus was separated from *Bolitophagus* Illiger by characteristics of antennae, pronotum and tibiae (Miyatake, 1964).

A fungivorous tenebrionid, *Bolitophagiella pannosa* (Lewis) in the tribe Bolitophagini (Coleoptera: Tenebrionidae: Tenebrioninae), is recorded for the first time in Korea. *B. pannosa* is found in the mountain forests, where *Quercus* Linné and *Robinia* Linné are distributed. This species is associated with host fungi, generally order Aphyllophorales throughout its whole life. Especially both adults and larvae was inhabit on widespread fungi, *Perenniporia*, on deciduous trees in Korea. Apparently this species used obligately the fruiting bodies of *Perenniporia medulla-panis* (Fr.) Donk and *Perenniporia frazinea* (Fr.) Ryv. for breeding and feeding site (Jung, 2008).

It is difficult to study the ecology of fungivorous tenebrionids and other fungivorous beetles because they usually feed on the same sporophores until the fungi are completely destroyed and they also breed in the fruiting bodies of fungi, concealing their life histories (Jung and Kim, 2008). Thus, the biology of mycophagous tenebrionoids is poorly understood, although there have been a few studies of their life histories and larval development stages in Korea (e.g. Jung, 2008; Jung and Kim, 2008).

In this paper, a fungivorous tenebrionid, *Bolitophagiella pannosa* (Lewis) is recognized. A key, description, life history, host fungi, habitus photos of adult, drawings of aedeagus and developmental characteristics are provided.

Materials and Methods

Sampling. We collected 67 fruiting bodies of fungi associated with *B. pannosa* from 2005 to 2007. 52 eggs, 160 larvae and 141 adults were collected from a mass of host fungi, *Perenniporia medulla-panis* and *Perenniporia frazinea,* within a downed or snag trees (*Quercus, Robinia*) in Korea. To collect material effectively, we removed the host fungi from the substrate on the forest-floor with cloth or vinyl cloth and quickly transferred them into vinyl bags and sealed the bags. Eggs, larvae, and adults found on the fungi were brought to the laboratory and transferred to plastic containers (30 ×25×20 cm) or zippered vinyl bags, which were covered with black cloth to maintain darkness.

Identification of fungi. Host fungi collected for this study were identified using several illustrated mushroom books (Breitenbach and Kränzlin 1986, Lee 1988) and also with the assistance of a mushroom taxonomist, Dr. Seok S. J. (NIAST).

Rearing and observation. *B. pannosa* was reared in the laboratory in petri dishes (diameter = 9 cm, height = 1.5 cm) at room temperature (25.5~26.1℃) and at a relative humidity of 63.5~64.5%, and provided with pieces of the host fungus. Behavioral and developmental observations were made in the petri dishes and vinyl bags. Head width and body length of specimens were measured using an ocular grid micrometer. Field observations were also carried out once a month from April to August of 2006 in Mt. Chiak-san. Both adults and larvae of collected specimens were preserved in 70% ethanol and dry-mounted and then deposited in the Insect Collection of Sungshin Women's University (Seoul, Korea). We used a Stereomicroscope (MZ APO; Leica, Switzerland), a digital camera (Nikon D200, Japan), and a thermometer (Extech 4465CF) for measurements.

Results

[Taxonomic accounts]

Additional key to the genera of Korean Bolitophagini (Jung *et al.*, 2007)

1. Pronotum usually with horn in male and gibbose in female. All tibiae without spurs .... *Boletoxenus* Motschulsky
- Pronotum without horn in both sex. All tibiae with or without spurs 2
2. Antennomeres 4 or 5~10 enlarged inwardly, antennomere 11 free to 10. Pronotum flattened and strongly

serrate on both sides. Mid and hind tibiae without spurs. Male head with two long horns inside the eyes ..... *Byrsax* Pascoe

– Antennomeres 4 or 5~10 slightly enlarged inwardly, antennomere 11 weakly free to 10. Pronotum flattened and not strongly serrate on both sides. Mid and hind tibiae with spurs. Male head without two horns inside the eyes 3

3. Antennomeres 9 and 10 enlarged inwardly and outwardly, convex, with fine setae and shining on enlarged part, densely pubescent on apical part; apical antennomere tapered, fusiform, with dense pubescence on apical half. Mid and hind tibiae with one spur ..... *Parabolitophagus* Miyatake

– Antennomeres 4 or 5~10 enlarged inwardly, flattened; opaque on the enlarged part; apical antennomere round-fusiform, dense pubescence on the most part. Mid and hind tibiae with two spurs 4

4. Antennomeres 5~10 enlarged inwardly, increasing apically; densely pubescent on the enlarged part; antennomere 11 free to 10. Pronotum recticulately punctate; lateral sides strongly narrowed before basal angles, coarsely crenate. Mid and hind tibiae with two long subequal spurs ..... *Bolitophagus* Illiger

– Antennomere 3 strongly obtriangular; antennomeres 4~10 distinctly enlarged inwardly; without dense pubescence on the enlarged part; antennomere 11 embedded in the apex of 10. Pronotum finely punctate and coarsely nodulose; lateral sides strongly arcuate, obscurely crenate. Mid and hind tibiae with two small subequal spurs ..... *Bolitophagiella* Miyatake

Genus *Bolitophagiella* Miyatake 넓적가시거저리속(신칭)

Bolitophagiella Miyatake, 1964: 59

(Type species: *Bolitophagus pannosus* Lewis, 1894).

Distribution. Korea, Japan.

***Bolitophagiella pannosa* (Lewis) 넓적가시거저리(신칭) (Fig. 1 and 2)**

Bolitophagus pannosus Lewis, 1894: 384.

Bolitophagiella pannosa: Miyatake, 1964: 59.

Description. Body length 4.5~5.0 mm. Body oblong-oval, strongly convex dorsally, with tubercles; black with reddish brown antennae. Head without horn in both sex; frons rugose, with transverse groove; third antennomere strongly obtriangular, nearly twice longer than 2nd antennomere; 4th to 10th antennomeres distinctly transverse and enlarged inwardly; apical antennomere embedded in apex of 10th; fronto-clypeal suture strongly impressed. Pronotum irregularly and coarsely nodulose, and rugose; distinctly transverse, widely extended on lateral sides; lateral margins strongly arcuate and crenate; basal margin bisinuate, strongly produced before scutellum. Elytra oblong, strongly convex; lateral margins finely serrate; striate-punctates with small tubercles, forming longitudinal rows in some part; interstices with tubercles and numerous nodules; 1st interstice with weak row of small tubercles, second interstice tubercles larger, 3rd interstice with carinae at base and tuberculated at apex; 4th to 6th interstices with similar tubercles, forming striae with numerous small nodules between tubercles. Femora with short and shallow grooves; tibiae tricarinate with two

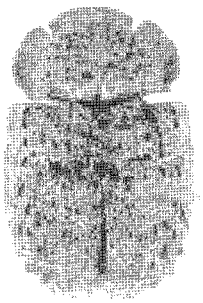

Fig. 1

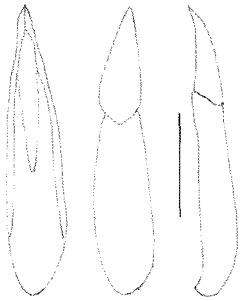

Fig. 2

Figs. 1, 2. *Boliotophagiella pannosa.*
1. Habitus; 2. Aedeagus (Left: ventral view; Middle: dorsal view; Right: lateral view; scale bar = 0.2 mm).

fine spurs, in male more conspicuous and tapered apically, in female inconspicuous; tarsi relatively robust.

***Specimens examined. SSWU*: <GW>** 24 exs. near Temp. Guryong-sa, Wonju-si, Gangwon-do, 12 IV 2006, B.-H. Jung and A.-Y. Kim, in *Perenniporia frazinea*; 12exs. Temp. Guryong-sa, Wonju-si, Gangwon-do, 15 V 2006, B.-H. Jung, in *Perenniporia frazinea*; **<GG>** 1♀ Gwanggyo, Suwon-si, Gyeonggi-do 30 VI 1987; more than 100 exs. Gwangreung, Pocheon-gun, Gyeonggi-do, 10 X 2006, B.-H. Jung, in *Perenniporia medulla-panis*; 20 exs. Myeongryun-dong, Seongbuk-gu, Seoul, J.-I. Kim in *Perenniporia frazinea*; **<JB>** 13 exs. Piagol, Mt. Jiri-san, Gurye-gun, Jeollanam-do, 7 IX 1977, K.-S. Woo, in *Fomitopsis*; 30 exs. Mt. Naejang-san, Jeongeup-si, Jeollabuk-do, 11 X 2007, B.-H. Jung in *Perenniporia frazinea*; **<JJ>** 1♀ Samjiyeon, Jeju-do, 11 VIII 1977.

Distribution. Korea, Japan.

[Biology of *Bolitophagiella pannosa*]

The Egg Stage

Egg oval-oblong with 0.4~0.6 mm in length and 0.2~0.3 mm in diameter (Table 1), opaque-white and finely rugose shiny surface. Egg development under laboratory conditions lasted 3~5 days.

The Larval Stage

Most larvae passed through 4 instars, or rarely 3 or 5 instars. The larval development period from 1st instar to last instar took about 30 days in the laboratory conditions: 1st to 3rd larval development period about 22 days, last larval development period about 8 days (Table 3). The body length of 1st and last instars averaged 1.73 mm and 7.50 mm, and the head width of 1st and last instars 0.20 mm and 0.95 mm respectively (Table 2).

The early first instar does not feed, is not sclerotized in its mouthparts, and the inner part of its body ranges from transparent to visible. The last instar is cylindrical in shape (Fig. 3) and weakly sclerotized on its surface, with well-developed a pair of urogomphi in the ninth abdominal tergite. After hatching from eggs, *B. pannosus* in the first instar remained under the egg capsules for a long time before burrowing into the fruiting body of fungi, after which they crawled moved into the context of fruiting body through the crack or hymenium (tube) in the fungus surface. During this time, it appeared that the instar fed on the capsular material, since the capsule was not found on the hymenium layers any more. While molting, instars of each developmental stage moved slowly, did not feed, and evacuated food residues during the apolysis period for molting preparation. The post-molting period was characterized by less sclerotization.

The Pupal Stage

Prepupae. The C-shaped prepupal body was smaller than the last instar. Prepupae rarely moved, inactive, and did not feed in their chambers. If disturbed, they stretched their C-shaped bodies and then twisted from side to side

Table 1. Sizes of egg, pupal chamber and emergence hole of *B. pannosa* (n = 5)

Character	Egg		Pupal chamber		Emergence hole		Dung
	Length	Width	Length	Width	Length	Width	
Size (mm)	0.5	0.25	9.0	3.0	4	0.5	Granule

Table 2. Size of larval and pupal stages of *Bolotophagiella pannosa* (n = 10)

Life stage	Larval stage				Pupae
	1st	2nd	3rd	4th	
Body length (mm)	1.73 ± 0.15	NA	NA	7.50 ± 0.71	4.00 ± 0.3
Head width (mm)	0.20 ± 0.10	NA	NA	0.95 ± 0.07	0.50 ± 0.3

NA: not available

and shook slowly.

Pupae. The body colored milky white. The body size of pupae ranged from 4.0~4.3 mm in length (Table 2), and their development in the laboratory took 8~10 days (Table 3). Pupae did not move or feed, but if disturbed, they became very active, rapidly rotating clockwise and counter-clockwise and thrashing their abdomens. With the approach of eclosion, their eyes, mouthparts, elytra, tarsal claws and pronotum developed a dark brownish tinge and became visible through the integument. Pupation was occurred in the chamber of the hymenium of host fungus, which they gnawed out of the fungal tissue just below the surface.

The Adult Stage

Imagines. Young adults emerging from pupae were reddish yellow with a soft integument and gradually became reddish brown, and then brownish black. Normal sclerotization and color were acquired within 10~11 days (mean = 11 days; Table 3). During this period, they usually remained in the chamber until the integuments is completely sclerotized.

Mating and Oviposition. We were unable to observe mating patterns in detail or to determine the number of eggs deposited during a season in nature because reproductive events were concealed in fungal fruiting bodies. The occurrence of fungi at any time of the year and the concurrent collection of instars of different larval stages suggests that *B. pannosa* mates and deposits eggs repeatedly during the season. Mating was first observed from early April to late of May in nature, while in the laboratory, *B. pannosa* copulated year-round. Most mating occurred at night in this nocturnal species, but mating also occurred in daytime on the shadowy surface of fruiting body, and in crevices in the tree bark attached to the fungi. In the laboratory, *B. pannosa* copulated for a few minutes in dark areas formed by overlapping fungi. Mostly they mate on the surface of fruiting body, posed climbing on the female's back. After mating, they deposited their eggs in fungal tissue, mostly on or into the pore of hymenium of the fruiting body one at a time.

Overwintering. *B. pannosa* was observed overwintering in both the larval and adult stages in rotten wood and beneath the bark attaching fungal fruiting bodies and mycelia to trees. Overwintering larvae and adults were collected in late October to November in 2005~2007 in Gyeonggi-do province (Table 4).

Generation time. Development from egg to adulthood in nature took 3~10 months. Individuals hatched from spring egg complete development over about three months. Individuals hatched from deposited eggs of new emerging adults in summer(June~July) which overwintered in the different larval stages complete their development in the following spring (May~June). Their development lasted about 10 months). In the laboratory, development from egg to adulthood took about 54 days.

Habits. Instars of all larval stages burrowed inside the fungus and fed on the hymenial layers. They wiggle move slowly back and forth in the fruiting body. As instars developed, their chambers were filled with frass, and tunnels and chambers were built largely. Only one instar

Table 3. Average developmental period of *B. pannosa* under laboratory conditions from middle May to late June, 2006

Stage	Egg	Larval stage				Pupa	Pigmentation	Life cycle (D)
		1st	2nd	3rd	4th			
Duration (Days)	4	22			8	9	11	54

Table 4. Observation on wintered *B. pannosa*

Date	Distribution	Host Fungi	Host Tree	Life Stage
17-X-2006	Mt. Chiak-san, Gangwon-do	*Perenniporia frazinea*	*Quercus aliena*	Adults / Larvae
25-X-2006	Gwangreung, Gyeonggi-do	*Perenniporia frazinea*	*Robinia pseudo-acacia*	Adults / Larvae
30-X-2006	Mt. Naejangsan, Jeollabuk-do	*Perenniporia frazinea*	*Albizzia julibrissin*	Adults / Larvae

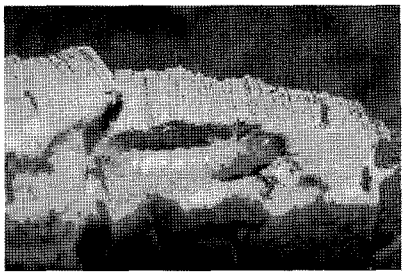

Fig. 3

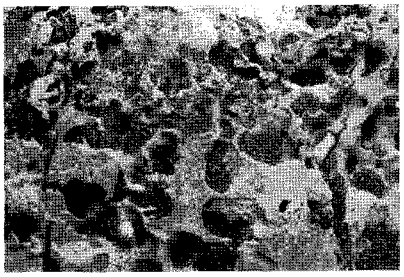

Fig. 4

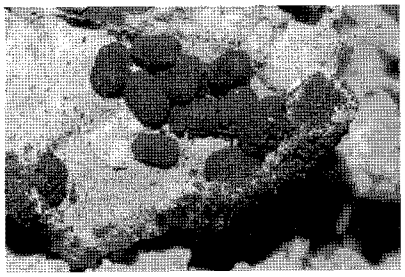

Fig. 5

Figs. 3-5. *Boliotophagiella pannosa.* 3. Last larval instar and its chamber; 4. Chambers of last larval instars; 5. Adults.

was present in any particular chamber (Fig. 3). Their chamber in these hymenium layer contained great quantities of frass. The instars only fed internally in the hymenium, while adults fed internally in crevice of the fungus or on the exposed pore surface on the shadowy bottom of the fungus. Dung of adults is granular. Both adults and larvae display negative phototropism and have cryptic lifestyles, preventing detailed observation of their lives. *B. pannosa* is nocturnal. Multiple adults typically colonized the same host fungus (Fig. 5). During day, the adults colonized under the fungi, or in the basal part of the fungi, or in crevices of hard fungi or in the bark of the tree or log on which the fungi were attached.

Behavior. The adults moved by walk about the fungus. When disturbed, they responded with the death feint, releasing a defensive secretion (repugnatorial secretion) which has been shown in some to contain benzoquiones (Eisner and Meinwald, 1966). The adults frequently occupied the pupal chambers for some time after emergence from the pupa. However, never more than one individual occupied each chamber. The newly emerging adults escaped from the fungus by chewing to the outside. Density of chamber in the hymenium was very high (Fig. 4). Chambers of last instars (n = 10) were oval and measured with 0.4 cm (width) × 0.5 cm (length). Total 16 chambers were counted in the area per 2 cm×2 cm (n = 5).

Relationships with host fungi. Larvae and adults of *B. pannosa* were monophagy which they fed only one genera of host fungus, *Perenephoria.* Especially *B. pannosa* was observed feeding and breeding on sporophores of *Perenniporia frazinea,* associated with old trees mainly in old broad-leaf forests dominated by *Quercus* and *Robinia*. Their host fungi, *Perenniporia frazinea* and *Perenniporia medulla-panis,* were 10 mm~50 mm (Breitenbach and Kränzlin, 1986; Lee, 1988) in thickness and perenial enough to make the chamber and inhabit in the fruiting bodies until completing their life cycle.

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