POLIA NEBULOSA AND *HYBOMA ADAUCTA* (LEPIDOPTERA: NOCTUIDAE) COLLECTED FROM NESTS OF THE SIBERIAN FLYING SQUIRREL *PTEROMYS VOLANS ORII* (MAMMALIA: RODENTIA: SCIURIDAE)

SAKURA KOJIMA[1], NATSUKI HIRAKIZAWA[1], HAYATO KIKUCHI[1], KOHEI KOYAMA[1, 2], TATSUO OSHIDA[1], AND TAKEO YAMAUCHI[1]*

[1]Obihiro University of Agriculture and Veterinary Medicine, Inada-cho Nishi 2-11, Obihiro, Hokkaido, 080-8555, Japan

[2]Present address: Asahikawa Campus, Hokkaido University of Education, Hokumon-cho, Asahikawa, Hokkaido, 070-8621, Japan

*Corresponding Author Email: tyamauchi@obihiro.ac.jp

ABSTRACT. *Polia nebulosa* and *Hyboma adaucta* (Lepidoptera: Noctuidae) were collected from nest boxes of the Siberian flying squirrel *Pteromys volans orii* (Mammalia: Rodentia: Sciuridae) in Obihiro, Hokkaido, Japan. This is the first record of moths collected from nests of flying squirrels (tribe Pteromyini). These two species probably used the nests of *P. volans orii* as overwintering sites since all the moths found were in an overwintering state when collected, both moth species do not feed on detritus, and the temperature in the nests is assumed to be higher than that of the outside.

Additional Key words: moth, immature stage, Pteromyini, mammal nest, overwintering

It has long been known that some moths inhabit bird nests in nature, but nest-dwelling moths were not well documented until the mid-20th century (Robinson 2004). There have been many reports of moths from bird nests worldwide (Buszko and Pacuk 2010; Sato et al. 2019; Jaworski et al. 2021). At present, however, records of moths from mammalian nests are very few. As far as we know, moths from mammalian nests are limited to the families Bucculatricidae, Depressariidae, Oecophoridae, Pyralidae, and Tineidae from the nests of squirrels (Goater 1986; Gryz et al. 2021; Jaworski et al. 2021), as well as the families Oecophoridae and Tineidae from the nests of the European fat dormouse *Glis glis* (Linnaeus) (Jaworski et al. 2021). In this paper, we report two moth species of the family Noctuidae emerged from nest boxes used by the Siberian flying squirrel *Pteromys volans orii* (Kuroda).

MATERIALS AND METHODS

Thirty nest boxes, which had been installed since 2016 in Obihiro University of Agriculture and Veterinary Medicine in Obihiro, Hokkaido, Japan (42°52'N, 143°10'E, about 80 m above sea level), were removed in November 2021. The nest boxes were wooden, 22 cm high, 9 cm wide, and 12 cm deep with a 4 cm × 4 cm square entrance attached, and were placed on a trunk about 1.5 m above ground level. Nest material in nest boxes was visually examined, and larvae and a pupa of moths were collected. Nest boxes, from which larvae and a pupa were collected, contained thinly torn bark, characteristic of nests of *P. volans orii*, or *P. volans orii* themselves inside. Therefore, these nest boxes were considered to have been used as nests by *P. volans orii*, which usually nest in tree cavities. Larvae and a pupa collected from nest boxes were reared in plastic cups (6.6 cm in diameter and 3.6 cm in height) filled with bark of the nest material under natural day length. As a food of larvae, the leaves of bitter dock *Rumex obtusifolius* L. (Polygonaceae) collected in a garden adjacent to the university, were put on the nest material in the cups. When rearing larvae, nest materials that had become unsanitary

due to dregs and feces were discarded and replaced with tissue paper. The larvae were reared at room temperature or at ambient temperature for a certain period of time before rearing at room temperature. The pupa was reared at room temperature. Emerged adults (Figs. 1, 2) were identified by Eda and Yanagida (2011) and Yoshimatsu (2011a). The scientific names of plants in this paper follow Yonekura and Kajita (2003).

RESULTS

By visual inspection of nest material, two pre-last instar larvae and one pupa were collected from each of the three nest boxes, which were located in three separate sites. Two nest boxes, from which the larvae were collected, were located in a riparian forest dominated by Asian white birch *Betula platyphylla* Sukaczev var. *japonica* (Miq.) H. Hara and willows, and the nest box, from which the pupa was collected, was located in a row of *B. platyphylla* along a road on the campus of the university. Nest material of the three nest boxes consisted of dry, fine bark with a few small mammalian body hairs. The larvae and pupa were reared, and emerged adults were identified. The pre-last instar larvae were males of *Polia nebulosa* (Hufnagel) (Fig.1), and the pupa was a male of *Hyboma adaucta* (Warren) (Fig. 2).

***Polia nebulosa* (Hufnagel).**

Both larvae were collected on November 10, 2021. The distance between the two nest boxes, from which they were collected, was approximately 300 m. The nest boxes were located on *B. platyphylla* and Jack Pine *Pinus banksiana* Lamb. Both larvae were pre-last instar larvae, approximately 30 mm long (Fig. 3). Both larvae were kept in plastic cups from the next day (November 11). Larva A was kept indoors from the first day. The other, larva B was kept in a bay window at ambient temperature until December 1 and then kept indoors. The rearing process of both individuals is shown in Table 1.

Both larvae did not appear to feed on the bark of the nest material, but fed on the leaves of *R. obtusifolius*. Larva A started feeding *R. obtusifolius* from November 12, on the other hand, larva B did not start feeding until December 4, after larva began to be kept indoors. So, larva A developed earlier than larva B. The larvae behaved in a light-avoiding manner and exclusively fed at night. When the light in the rearing room was switched on, the larvae burrowed under nesting material and leaves. Larva A and larva B molted on each day November 29, December 10. Last instar larvae were darker in body color than the pre-last instar larvae (Fig. 4). The larvae successfully cocooned, larva A pupated on December 20, larva B did on December 29 (Fig. 5). The pupa had a bifurcated protrusion on the cremaster (Fig. 6). Adults moths emerged on January 2022.

***Hyboma adaucta* (Warren).**

The pupa of *H. adaucta* was collected on 19 November 2021. The nest box in which the pupa was collected was placed on *B. platyphylla*. The pupa was naked in the nest material (Fig. 7). The pupa was placed in a plastic cup with the nest material from November 20. The pupa was reddish brown in color, and eight hooked setae (Yamamoto 1965) were observed on the cremaster (Fig. 8). An adult emerged on 17 March 2022.

DISCUSSION

Polia nebulosa is distributed from Hokkaido to the mountainous areas of central Honshu in Japan, and adults emerge in July and August (Sugi 1982). The larvae of *P. nebulosa* are broad-eating, feeding on Asteraceae, Ranunculaceae, Polygonaceae, and Rosaceae. *Rumex obtusifolius* (Polygonaceae) has already been reported as a food plant of *P. nebulosa* (Kogi 1984). *Polia nebulosa* overwinters in the pre-last instar larval stage (Kogi 1984). In the present study, two individuals of *P. nebulosa* emerged

96 in mid-January (Table 1), a very cold season, probably because they were reared at room temperature,
97 which interrupted their dormant overwintering.
98 *Hyboma adaucta* is distributed from Hokkaido to Kyushu in Japan. In Hokkaido, adults of *H.*
99 *adaucta* emerge in late June to early July. The larvae of *H. adaucta* feed on Rosaceae and overwinter
100 as pupae (Yoshimatsu 2011b). *Hyboma adaucta* makes cocoons by binding wood chips in cracks in
101 branch trunks (Yoshimatsu 2011b), but the individual collected in the present study was naked.
102 According to Yanagawa (1999), *P. volans orii* use the bark of ivy plants such as the crimson glory vine
103 *Vitis coignetiae* Pulliat ex Planch. for nest material, so it is unlikely that the pupa was mixed in with
104 the nest material. It is unknown why the pupa was naked without a cocoon.
105 There is very little documentation of moths found in mammal nests in the world, with only nine
106 moth species from five families having been recorded (Table 2). The present study is the first record
107 of moths collected from the nests of mammals of the tribe Pteromyini in the family Sciuridae, and also
108 the first record of the family Noctuidae from the nests of mammals.
109 Some moth species overwinter in the nests of birds or mammals (Buszko and Pacuk 2010; Jaworski
110 et al. 2012). Among the five moth species from the nests of the Eurasian red squirrel *Sciurus vulgaris*
111 (Linnaeus), non-detritus feeders, *Agonopterix* sp. (Depressariidae) and *Bucculatrix thoracella*
112 (Thunberg) (Bucculatricidae) probably used the nest boxes for overwintering (Gryz et al. 2021).
113 According to Sinclair and Chown (2006), the temperature inside the nests of the wandering albatross
114 *Diomedea exulans* (Linnaeus), which incubates eggs and chicks during the winter, is higher than that
115 of the outside. This probably help the growth rate and survival rate of moths in the nest. Temperatures
116 inside nests made by *P. volans orii* in tree cavities show small daily fluctuations compared to outside
117 temperatures. Moreover, there have been cases where the use of nests by *P. volans orii* has resulted in
118 even higher nest temperatures (Kikuchi unpublished). The winter temperatures in Obihiro are below
119 freezing, which suggests that the nest boxes of *P. volans orii* are a suitable environment for moths to

overwinter.

It is possible that *P. nebulosa* and *H. adaucta* used the nests of *P. volans orii* for overwintering, since all three individuals were in an overwintering state when collected, neither species appeared to be a detritus feeder, and the temperature inside the nests of *P. volans orii* was possibly higher than outside.

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163 **Table 1.** Development of *Polia nebulosa* (Hufnagel)

	Larva A	Larva B
Collected	10 Nov. 2021	10 Nov. 2021
Start feeding	12 Nov. 2021	4 Dec. 2021
Molting	29 Nov.	12 Dec.
Cocooning	16 Dec.	25 Dec.
Pupation	20 Dec.	29 Dec.
Eclosion	17 Jan. 2022	23 Jan. 2022

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Table 2. Moths recorded from mammal nests

Moth	Nest owner				References
	Sciuridae			Gliridae	
	Sciurus vulgaris (Linnaeus)	squirrel (species name unknown)	*Pteromys volans orii* (Kuroda)	*Glis glis* (Linnaeus)	
Tineidae					
Niditinea striolella (Matsumura)				○	Jaworski et al. (2021)
Tinea pellionella (Linnaeus)	○				Gryz et al. (2021)
Bucculatricidae					
Bucculatrix thoracella (Thunberg)	○				Gryz et al. (2021), Jaworski et al. (2021)
Depressariidae					
Agonopterix sp.	○				Gryz et al. (2021)
Oecophoridae					
Borkhausenia minutella (Linnaeus)	○				Gryz et al. (2021), Jaworski et al. (2021)
Hofmannophila pseudospretella (Stainton)				○	Jaworski et al. (2021)
Pyralidae					
Aphomia sociella (Linnaeus)	○				Gryz et al. (2021), Jaworski et al. (2021)
Hypsopygia costalis (Fabricius)		○			Goater (1986)
Orthopygia glaucinalis (Linnaeus)		○			Goater (1986)
Noctuidae					
Hyboma adaucta (Warren)			○		Present study
Polia nebulosa (Hufnagel)			○		Present study

Figures 1-2. Emerged adults from nests of *Pteromys volans orii*

1. *Polia nebulosa* (Hufnagel); **2.** *Hyboma adaucta* (Warren).

Figures 3-6. Immature stages of *Polia nebulosa* (Hufnagel). **3.** Pre-last instar larva (Larva B); **4.** Last instar larva (Larva A), feeding on leaves of *Rumex obtusifolius* L.; **5.** Pupa (larva B); **6.** Cremaster of pupa (Larva B).

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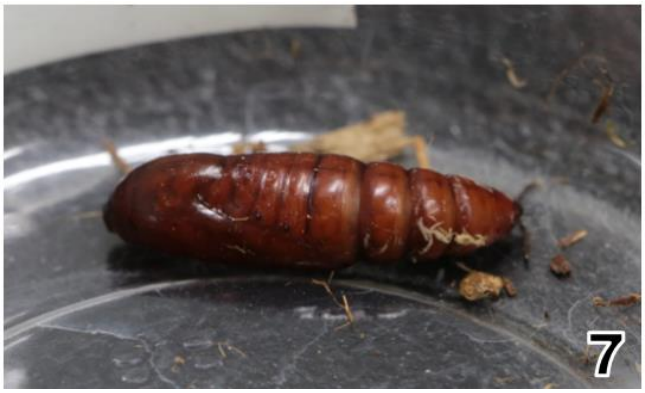

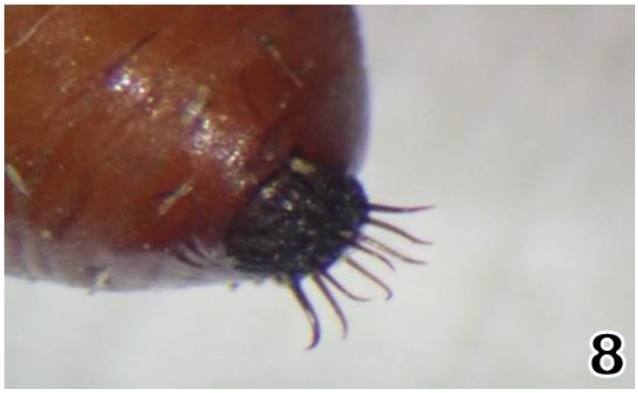

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181 **Figures 7-8.** Pupa of *Hyboma adaucta* (Warren). **7.** Habitus, lateral view; **8.** Cremaster of pupa.