Notes on Biology, Taxonomy and Distribution of the Aphidophagous Pyralid, *Dipha aphidivora* (MEYRICK) comb. nov. (Lepidoptera: Pyralidae)

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(Received August 17, 1987)

Up to the present, only two species have been recorded as aphidophagous Phycitine in the world. One is *Conobathra aphidivora* (MEYRICK), and the other is *Cryptoblates aphidivora* YOSHIYASU and ÔHARA. In 1986, we found two aphidophagous pyralid larvae at Shuri, Naha, Okinawa: “*Conobathra aphidivora*” feeding on the sugar cane woolly aphid *Ceratovacuna lanigera* (ZEHNTER) and “*Cryptoblates aphidivora* YOSHIYASU and ÔHARA” feeding on *Pseudoregma bambucicola* (TAKAHASHI). The results of a crossing experiment between the “two species” suggested that they are conspecific. The morphological and biological characteristics of “*Cryptoblates aphidivora*” were also identical with those of “*Conobathra aphidivora*”. We interpret these results as indicating that “*Cryptoblates aphidivora* YOSHIYASU and ÔHARA” is synonymous with “*Conobathra aphidivora* (MEYRICK)”. A new genus, *Dipha* YOSHIYASU, is proposed for *aphidivora* MEYRICK. The species is widely distributed in the Ryukyu Islands and all developmental stages were recognized all the year round.

INTRODUCTION

In the family Pyralidae (Lepidoptera), the larvae of most species are phytophagous, and only a few have been known to be entomophagous (YOSHIYASU and ÔHARA, 1982). To date, only two species have been recorded as aphidophagous Phycitine in the world. One is *Conobathra aphidivora* (MEYRICK) (= *Thiallela* sp.), the other is *Cryptoblates aphidivora* YOSHIYASU and ÔHARA.

LOPEZ (1930) and TAKANO (1934) reported that the larva of *Thiallela* sp. is a common predator of the sugar cane woolly aphid, *Ceratovacuna lanigera* (ZEHNTER), which is one of the important pests of sugar cane in Southeast Asia. *Conobathra aphidivora* is so far known from India, Thailand, Indonesia, Philippines and Taiwan.

In July 1986, we found many pyralid larvae feeding on *Ceratovacuna lanigera* on sugar cane leaves at Shuri, Naha city, Okinawa Prefecture, Japan. They were collected and reared in the laboratory at Okinawa Prefectural Agricultural Experiment Station. The species was identified as “*Conobathra aphidivora* (MEYRICK).”

On the other hand, YOSHIYASU and ÔHARA (1982) recorded a new aphidophagous pyralid, *Cryptoblates aphidivora*, which feeds on the aphid, *Pseudoregma bambucicola* (TAKAHASHI) colonizing on the bamboo, *Bambusa glaucescens* SIEB. ex MUNRO: (Japanese name, Hôrai-chiku) at Kaseda city, Kagoshima Prefecture, Japan. In November 1986, we

again found many pyralid larvae of "*Cryptoblabes aphidivora*" on the aphid, *P. bambucicola* colonizing on the bamboo, *B. glaucescens* at Shuri.

From external appearance, we could find no differences between these two "sympatric species." Therefore, the question arises whether they are the same or distinct species, or does crossing occur between these two forms?

This paper reports some preliminary observations on "*Conobathra aphidivora*." We also ascertain the taxonomic relationships of the "two species" by biological and morphological studies. Their distribution in the Ryukyu Islands and the developmental stages recognized in each collection are also described.

MATERIALS AND METHODS

Preliminary observations of the biology of "Conobathra aphidivora." The study site selected was the sugar cane field in the vicinity of Okinawa Prefectural Agricultural Experiment Station (26°12'N, 127°43'E) in July, 1986. The sugar cane in the site (var. NCo 310) was seriously infested with the aphid *Ceratovacuna lanigera*. Leaves with aphidophagous pyralid larvae or eggs were brought into the laboratory. The egg size and larval head-width of "*Conobathra aphidivora*" were measured using an ocular micrometer attached to a stereoscopic dissection microscope.

Prey effect on the development and crossing experiment of the "two species." In November of 1986, we collected the pupae of "*Conobathra aphidivora*" at Nakaza, Gushichan Village, Okinawa Island and also collected the pupae of "*Cryptoblabes aphidivora*," the larvae of which were feeding on *P. bambucicola* at Shuri. They were reared under natural light condition at room temperature. Diluted honey absorbed on a small piece of cotton was placed in a cup as the adult food.

In this experiment, we examined the effect of prey aphids on the oviposition or larval growth by changing host aphids: "*Conobathra aphidivora*" (predator of *Ceratovacuna lanigera*) was provided with the aphid, *P. bambucicola*, and "*Cryptoblabes aphidivora*" (predator of *P. bambucicola*) with the aphid, *Ceratovacuna lanigera*. Copulated females were kept individually in a transparent plastic cup (dia., 11.3 cm, height, 9.8 cm). The cup contained a piece of plant with the respective aphid species. The base of the plant piece was set in a water-pot to avoid wilting. Ten newly hatched 1st instar larvae were reared with each aphid.

Crossing experiment between the "two species." Two newly emerged males and one female of each species were kept together in a transparent plastic cup (dia., 11.3 cm, height, 9.8 cm) containing a plant piece with host aphids. Each treatment procedure had five replicates. The number of copulating pairs, eggs and the hatchability were recorded. The test adults were kept together with new plants and a sufficient number of aphids changed every three days until the adults died. Ten F₁ larvae of each group were reared with the aphids, *Ceratovacuna lanigera*. The plant with aphids was renewed every three days until pupation.

Morphology and taxonomy of the "two aphidophagous species." To determine and compare the "two species" the junior author examined the larvae and adults of "both" species as follows. All the specimens were collected by N. ARAKAKI.

3♂, 9♀, Shuri, Naha, Okinawa Is., 14.xi.1986, on *Ceratovacuna lanigera*, (as "*Conobathra aphidivora*" (MEYRICK)) (in alcohol).

22 ♂, 13 ♀, Nakaza, Gushichan, Okinawa Is., 3.xii.1986 (pupae), 4–8.xii. em., on *Ceratokaca lanigera* (as “*Conobathra aphidivora* (MEYRICK)”).

2 ♂, 6 ♀, Shuri, Naha, Okinawa Is., 10.xi.1986, on *Pseudoregma bambucicola* (as “*Cryptoblabes aphidivora* YOSHIYASU & ÔHARA”) (in alcohol).

16 larvae and 6 pupae, Shuri, Naha, Okinawa Is., 27.vi.1986, on *Pseudoregma bambucicola* (as “*Cryptoblabes aphidivora* YOSHIYASU & ÔHARA”).

Furthermore, the junior author examined the paratype of *Conobathra aphidivora* (MEYRICK), in the British Museum (Natural History) (BMNH) with the male genitalia to compare with the Japanese species. The holotype of *Conobathra automorpha* MEYRICK, genus type of *Conobathra*, with the genital slide No. 11812 (BMNH) was also checked to confirm the identification of the genus.

Local distribution. In the Ryukyu Islands, the geographical distributions of “*Conobathra aphidivora*” and “*Cryptoblabes aphidivora*” were surveyed at five large islands: Okinawa Is., Kume Is., Miyako Is., Ishigaki Is. and Iriomote Is. from June 1986 to May, 1987. “*Conobathra aphidivora*” was collected at the sugar cane field infested with the aphid *Ceratokaca lanigera*, while “*Cryptoblabes aphidivora*” was collected from bamboo (*B. glaucescens*) bushes infested with the aphid *P. bambucicola*, and the developmental stages in each collection were recorded.

RESULTS

Preliminary observations of the biology of “Conobathra aphidivora”

Egg. The eggs were flat and elliptical (Fig. 1), the average size being 0.72×0.45 mm ($N=20$). Newly deposited eggs were milk white colored and fertilized eggs became pink in two days. The adults laid eggs singly along the marginal part of the under surface of mature sugar cane leaves colonized densely by aphids.

Larva. The frequency distribution of the head width of larvae clearly showed 4 separate peaks (Fig. 2). This may indicate that the larval stages have 4 instars. DYAR’s formula fitted to the growth of head width was: $\log Y = 0.207X - 0.87$ ($r=0.999$, $N=11-40$, $p<0.01$). The larvae constructed silken runways among the aphids in the large dense colonies on the sugar cane leaves (Fig. 1); they were constructed just after larval hatching. With the growth of larvae, the runways enlarged gradually. Sometimes the larvae appeared outside the runways to catch an aphid prey. After capturing, they brought the aphid into the runway and ate it there. As some runways are united, several larvae could frequently be seen in a common runway.

Pupa. Pupation took place in a thick cocoon which was usually spun along the midrib of the under surface of sugar cane leaves or interstices between the stalk and sheath.

Prey effect on the development and the crossing experiment of the “two species”

The experiment showed that even the host aphid species were altered, the females of both “*Conobathra aphidivora*” and “*Cryptoblabes aphidivora*” laid eggs and hatched larvae grew normally feeding on host aphids which were different from their respective natural ones.

The crossing experiment revealed that they could copulate normally in all hetero-specific combinations; hatchability was high and no different from that of the control

Fig. 1. Photographs showing developmental stages of the pyralid moth "*Conobathra aphidivora*" in the colony of the aphid *Ceratovacuna lanigera* on a sugar cane leaf. A, eggs (4 eggs in a circle); B, 4th instar larvae and their silken runways; C, 4th instar larva; D, adult (female).

Fig. 2. Frequency distribution of head width of "*Conobathra aphidivora*" larvae sampled at the sugar cane field, Shuri, Naha, Okinawa in July, 1986. *Mean $\pm$ SD (mm).

conspecific combinations (Table 1). The F_1 larvae grew normally feeding on the aphid *Ceratovacuna lanigera* and the hatchability of the eggs laid by F_1 adults was also high (Table 1). The F_2 larvae also grew normally.

Morphological examination of the "two species" and comparison with the type species of Conobathra

Table 1. Results of crossing experiment between two aphidophagous moths

Mating combination ^a ♀ ♂	Total pairs tested	Copulating pairs	No. of eggs oviposited/♀ Mean ± SD	Mean hatchability %
C × C	5	5	203.0 ± 46.8	97.7
C × P	5	5	197.4 ± 41.5	97.2
P × C	5	5	185.8 ± 30.8	96.8
P × P	5	5	176.2 ± 46.4	96.9
F ₁ (C × P)	2	2	161.5 ± 6.4	97.0
F ₁ (P × C)	2	2	147.0 ± 43.8	96.7

^a C: "*Conobathra aphidivora*" (predator of *Ceratovacuna lanigera*).

P: "*Cryptoblabes aphidivora*" (predator of *Pseudoregma bambucicola*).

NS: The difference was not significant

(ANOVA: $p > 0.05$).

Fig. 3. Map showing the localities where "*Conobathra aphidivora*" and "*Cryptoblabes aphidivora*" were recognized on the two host aphid species. Solid circles represent "*Conobathra aphidivora*" feeding on the aphid, *Ceratovacuna lanigera*, and open circles, "*Cryptoblabes aphidivora*" on the aphid, *Pseudoregma bambucicola*.

Table 2. Collection records of each developmental stage of "*Conobathra aphidivora*" in the field

Sampling date		Host aphid: <i>C. lanigera</i>		Host aphid: <i>P. bambucicola</i>	
		Sampling ^a locality	Developmental stage(s)	Sampling ^a locality	Developmental stage(s)
1986	July	St. 2	Egg, Larva, Pupa	—	—
	August	St. 2	Egg, Larva, Pupa	—	—
	September	St. 4	Egg, Larva, Pupa	—	—
	October	St. 4	Egg, Larva, Pupa	—	—
	November	Sts. 1, 5	Egg, Larva, Pupa	Sts. 2, 3	Egg, Larva, Pupa
	December	Sts. 9, 10, 13	Egg, Larva, Pupa	Sts. 2, 7, 11, 12, 14	Egg, Larva, Pupa
1987	January	St. 8	Larva, Pupa	St. 3	Larva
	February	St. 8	Egg, Larva, Pupa		
	March	St. 6	Pupa		
	April	St. 2	Egg, Larva, Pupa		
	May	St. 2	Egg, Larva, Pupa		

^a Sampling locality is as shown in Fig. 3.

The morphological characters of the "two aphidophagous species" from the Ryukyus were the same and identical to *Conobathra aphidivora* (MEYRICK). The larvae of the "two species" collected in Okinawa Is. were also the same and were identical to the larvae of "*Cryptoblades aphidivora* YOSHIYASU & ÔHARA".

On the other hand, *Conobathra aphidivora* (MEYRICK) was different from *Conobathra automorpha* MEYRICK in fundamental points which will be mentioned in detail in the discussion.

Local distribution

In the Ryukyu Islands, "*Conobathra aphidivora*" was distributed in Okinawa Is., Miyako Is., Ishigaki Is., and Iriomote Is. (Fig. 3). All developmental stages of "*Conobathra aphidivora*" were recognized all the year round (Table 2). "*Cryptoblades aphidivora*" was recognized in Okinawa Is., Kume Is., Ishigaki Is. and Iriomote Is. It was not found in Miyako Is. This may be because we did not recognize the host aphid, *P. bambucicola*, probably due to the scarcity of the bamboo there. Mr. T. TERUYA of the Fruitfly Laboratory of Okinawa Prefectural Agricultural Experiment Station, kindly provided us with a small twig of the bamboo with *P. bambucicola* from Kume Is. on 23 December, 1986 on which we found two eggs of this moth.

DISCUSSION

Biologies of "two aphidophagous species" and their distribution

There have been some investigations of sugar cane woolly aphid in Japan (AZUMA and OSHIRO, 1971; AZUMA, 1977), but they reported nothing about "*Conobathra aphidivora*". In the sugar cane field in the Okinawa Islands, the larvae live and hide themselves in the silken runways which are camouflaged white in color among the white woolly covering of aphid colonies. This may explain why they had not been discovered.

"*Cryptoblades aphidivora*" feeding on *P. bambucicola* showed no difference from "*Cono-*

bathra aphidivora" on *Ceratovacuna lanigera* in their biology. In the host aphid exchanging experiment, females of the "two moth species" laid eggs, and larvae grew normally on the unusual aphid prey. The results strongly suggest that these "two moths" are not host specific different species. Furthermore, in the crossing experiment, they copulated quite normally and hatchability was as high as after conspecific copulations (Table 2).

The facts mentioned in the foregoing line suggest that "*Conobathra aphidivora*" and "*Cryptoblates aphidivora*" are conspecific. If this suggestion is accepted, then "*Conobathra aphidivora*" would be distributed widely in India, Thailand, Indonesia, Philippines, Taiwan and Japan. Also "*Conobathra aphidivora*" feeds on three aphid species: *Ceratovacuna lanigera*, *P. bambucicola* and *P. alexanderi*.

These three aphid species belong to the tribe Cerataphidini. *P. bambucicola* and *P. alexanderi* produce soldiers which attack predators using frontal horns (AOKI et al., 1981). On the other hand, *Ceratovacuna lanigera* produce monomorphic nymphs that also attack predators using frontal horns (AOKI et al., 1984). These defensive behaviors are not effective against the moth larvae, which are a specialized predator that can break such a defense. The moth larvae live in a silken runway to avoid the aggressive aphids.

Each developmental stage of "*Conobathra aphidivora*" was recorded throughout the year in the Ryukyu Islands (Table 2). The host aphids, *Ceratovacuna lanigera* and *P. bambucicola*, also occur throughout the year although there are large seasonal population fluctuations. From these results, "*Conobathra aphidivora*" seems to be active throughout the year without aestivation or hibernation.

Taxonomy of the "two aphidophagous Phycitinae" on sugar cane and bamboo aphids in the Ryukyus

The junior author described a new aphidopagous phycitine species bred on *Pseudoregma bambucicola* as *Cryptoblates aphidivora* (YOSHIYASU & ÔHARA, 1982), without reference to ROESLER's work (1981). In his paper, ROESLER treated the aphidophagous Phycitinae, *Conobathra aphidivora* (MEYRICK, 1934), and he also synonymized the genus *Melitene* RAGONOT, 1888, to which the species *aphidivora* MEYRICK, 1934 was assigned, with *Conobathra* WALKER, 1863. As mentioned in our "Results", *Cryptoblates aphidivora* YOSHIYASU & ÔHARA and *Conobathra aphidivora* (MEYRICK) were conspecific, although slight intraspecific differences were recognized. So we have to treat the species *aphidivora* YOSHIYASU & ÔHARA, 1982 as a junior synonym of *aphidivora* MEYRICK, 1934.

We found that the "two species" from the Ryukyus, one bred on sugar cane aphid and the other on bamboo aphid, were conspecific and finally determined them to be *Conobathra aphidivora* (MEYRICK), not only by the crossing experiment between them but also by the morphological characters in this study.

The general characters of *Conobathra aphidivora*, however, were different from those of *Conobathra automorpha* MEYRICK, although the two species have similar wing marking (Fig. 4). The differences are shown in the following table (female genitalia was not compared in this time).

	<i>aphidivora</i> MEYRICK	<i>automorpha</i> MEYRICK
1. Antenna	—male without process	—male with a distinct process at base
2. Wing venation	—M ₂ and M ₃ separate, but approximated each other at base	—M ₂ and M ₃ stalked

Fig. 4. A, *Conobathra automorpha* MEYRICK (♂) (Holotype); B, *Dipha aphidivora* (MEYRICK) (♀), bred on *Ceratovacuna lanigera* (Gushichan, Okinawa Is.).

Fig. 5. Wing venation of *Dipha aphidivora* (MEYRICK) comb. nov. (♂). Scale: 5.0 mm.

3. Male genitalia	—uncus bilobed at apex	—uncus not bilobed
	—valva without ampulla process	—valva with a distinct ampulla process
	—transtilla formed at middle of anellus, with a central process	—transtilla separated on both sides of anellus

By these characters and the comparison with another genera, the junior author has come to the conclusion that it is better to establish a new genus for *Conobathra aphidivora* (MEYRICK). The description:

Fig. 6. Male genitalia of *Dipha aphidivora* (MEYRICK), comb. nov. A, ventral view; B, uncus, dorsal view (based on a specimen bred on *Ceratovacuna lanigera*, 3. xii. 1986, Gushichan, Okinawa Is.). Scale: 0.5 mm.

Fig. 7. Male genitalia of *Conobathra automorpha* MEYRICK (Holotype).

Dipha YOSHIYASU, gen. nov. (feminine)

(type species: *Melitene aphidivora* MEYRICK, 1934)

Male & female. Head with frons rounded. Vertex not prominent. Labial palpus rather long, upturned, the 3rd segment as long as the 2nd, conical and acute at apex. Maxillary palpus short, dilated at apex by scales. Antenna in male ciliate, a little flattened, without any tuft or process at base; that in female similar to male, but shorter and not flattened. Ocellus distinct. Legs short, without any tuft on tibia; inner spur about twice as long as outer one.

Wing shape and venation (Fig. 5): Forewing with costa almost straight; apex rather angulate; termen evenly curved to tornus. Vein R_2 connated with R_{3+4} ; M_1 curved, just behind R_{3+4} ; M_2 and M_3 separated but approximating each other at base; CuA_1 from near posterior angle of discoidal cell; 3A indistinct; discocellulars erect.

Hindwing with apex pointed, termen weakly undulate and produced at ends of veins M_2 and CuA_1 . Vein $Sc+R_1$ connated with R_s at base; M_1 curved; M_2 and

M₃ separated but approximating each other at base; CuA₁ as in forewing; CuP to 3A distinct; discocellulars curved and discoidal cell less than half of wing length.

Male genitalia (Fig. 6): Tegumen short. Fenestrullae rather broad. Vinculum wide, longer than height of tegumen. Saccus undeveloped. Uncus short and wide, parallel sided, bilobed at apex with many marginal spine like setae; while in *Conobathra automorpha* uncus trigangular, and not bilobed at apex (Fig. 7). Gnathos narrow, with a central process (cochlear) extending upwards. Valva narrowing to apex, without ampulla seen in *Conobathra*. Transtilla present in center of anellus and producing a process at middle. Phallus short, with cornuti.

Female genitalia: Bursal ring undeveloped. Corpus bursae stout, with a relatively large signum. Spermatheca with lagena. Eighth tergum short but well developed. A narrow sclerite formed in a place corresponding to 8th sternum near ostium bursae; apophysis anterioris short. Papilla analis rather large, with apophysis posterioris almost as long as the anterioris.

Remarks. The new genus is not close to *Conobathra* (tribe Phycitini AGENJO, 1954)). However, the venation with the veins M₂ and M₃ separated in both wings and the male genitalia with the bilobed uncus indicate a relative affinity to *Cryptoblabe* ZELLER, 1848 (tribe Cryptoblabini ROESLER, 1973). However, the male of the new genus has no process in the antenna and no special tuft of scales on the valva in the genitalia as are seen in *Cryptoblabe* species.

Dipha gen. nov. may contain *Ephestiopsis shiva* ROESLER, 1981 because of the close resemblance in the male genitalia of the two species. However the female genitalia is different from the type of the new genus in some points, and decision on this is withheld pending future study.

According to this study, *Conobathra aphidivora* (MEYRICK) is hereinafter treated as follows.

Dipha aphidivora (MEYRICK, 1934) comb. nov.

Melitene aphidivora MEYRICK, 1934, Exotic Microlep. 4: 498.

Conobathra aphidivora: ROESLER, 1981, Beitr. naturk. Forsch. SüdwDtl., 4: 25.

Cryptoblabe aphidivora YOSHIYASU & ÔHARA, 1982, Tyô to Ga, 33: 52. syn. nov.

ACKNOWLEDGMENTS

The senior author wishes to thank Dr. M. NISHIHARA, University of the Ryukyus, for his critical reading of the manuscript, Mr. M. NAGAMINE and Dr. K. FUJISAKI, Okinawa Prefectural Agricultural Experiment Station, for their valuable advice. The junior author expresses his thanks to Mr. Michael SHAFFER, British Museum (Natural History), for his kind arrangement for the loan of the holotype of *Conobathra automorpha* MEYRICK and the paratype of *Conobathra aphidivora* (MEYRICK).

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