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Reproductive Behavior of the Bug *Molipteryx fuliginosa* Uhler (Heteroptera, Coreidae) in the South of the Russian Far East

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Abstract—Reproductive behavior of *Molipteryx fuliginosa* (Uhler) was investigated in Primorskii Territory of Russia. From 4 to 18 repeated copulations of one female lasting from 2 to 48 hours were recorded in cages. The behavior of ovipositing females and the stages of oviposition are described for the first time. The number of eggs laid between copulations varied from 1 to 13, the number of oviposition acts, from 4 to 11, and the total female fecundity, from 21 to 38 eggs. Caged females laid eggs on plants and also on dead substrates unsuitable for nymphal feeding, such as cloth, dry branches, and a wooden pole. Copulation of *M. fuliginosa* was also observed under natural conditions. The preferred mating places of *M. fuliginosa* in anthropogenically modified habitats and in small-leaved riparian forests were plants of *Rubus idaeus* L., *R. caesius* L., and *Rubus* sp. After mating, females migrated in search of places for oviposition. Single eggs were found on the following plants not known previously as hosts of this bug: *Solanum lycopersicum* L., *Carex* sp., *Elytrigia repens* (L.) Nevski, and *Taraxacum officinale* Wigg. The females seemed to lack selectivity in the choice of place for oviposition, which was not always associated with host plants, despite their abundance and availability.

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Leaf-footed bugs (Coreidae) are phytophages, and some of them are known as serious agricultural pests (Putshkov, 1972; Vinokurov, 2010, etc.). The fauna of Siberia and the Russian Far East includes 14 species from 10 genera of this family. *Molipteryx fuliginosa* (Uhler, 1860) is the only representative of its genus in the Russian fauna and one of the four species known from Southeast Asia. By now data on the distribution of *M. fuliginosa* in the Russian Far East have been summarized and its biotopic distribution in the south of Primorskii Territory has been described (Kerzhner and Kanyukova, 1998; Kanyukova and Vinokurov, 2009; Kanyukova, 2012; Kanyukova and Ostapenko, 2013; Markova et al., 2016a, 2016b).

The reproductive behavior of *M. fuliginosa* under laboratory conditions was studied in South Korea (Park, 1996). It was shown that a female laid 1–3 eggs a day and not less than 23 eggs during its lifetime. Eggs were mainly laid on leaves of *Rubus oldhami* Miquel but egg batches were also found in the insectarium on substrates unsuitable for feeding of nymphs, such as steel wire and soil. No eggs were found by the cited author under natural conditions and no observations of copulation or oviposition were carried out. On the Philippines, it was determined that females could select plants suitable for survival of the I instar nymphs during the first 10 days of their life (Panda and Khush, 1995).

The goal of our research was collection and summarizing of data on the reproductive behavior of *M. fuliginosa* in the south of the Russian Far East. Our results characterize the reproduction potential, abundance, population density, and the possibility of dispersal of this species in different types of habitats. The material was collected in Ussuriisk and Chuguyevsky districts of Primorskii Territory from April to October 2015 and 2016. For data comparison, we observed the bugs under near-natural conditions in cages and also under natural conditions in forest and anthropogenically transformed cenoses. The stationary cages

Figs. 1–4. Cages in the nature: (1) stationary cages on raspberry shrubs; (2) fastening of the cage; (3) a portable cage; (4) a temporary mini-cage.

(Fig. 1) were created by covering raspberry shrubs (*Rubus* sp., *Rubus idaeus* L.) 1.5 m tall with air-permeable, transparent zipped netting (Fig. 2), which extended to the ground and enclosed an area within a 1-m radius. This design allowed the insects to move and feed freely. During observations in such cages, we recorded the timing of copulation, the number of eggs per batch, and their position and way of attachment to the substrate. The duration of copulation was recorded using Reconyx digital trail cameras installed in the cages. To determine whether eggs could be laid on the soil surface, stationary mini cages of similar design but only 30 cm high were placed over the low raspberry shoots. Detailed observations of oviposition were carried out in portable cages made from plastic containers with a 17.5 × 13 cm base and 13 cm high, filled with soil and covered with air-permeable, transparent zipped netting fixed on a rectangular metal frame 30 cm off the soil level (Fig. 3). The bug eggs found in nature were placed in such cages together with plant fragments or covered with netting directly on the plants and left for further observation (Fig. 4). The cage volume permitting free movement of insects and their observation was 6825 cm^3. To provide sufficient food and oviposition substrate for the bugs, upper stem fragments of the common raspberry *R. idaeus*

and the European dewberry *R. caesius* L. were placed in the cages in water-filled sample bottles. These stems were renewed regularly to maintain the natural environment and supply food to the insects. At the end of oviposition the adult bugs were removed from the cage but the eggs were left to observe the maturation and subsequent molt of nymphs.

In addition, observations of bugs in the forest and secondary anthropogenic cenoses were carried out during the field season, and copulating pairs were recorded under natural conditions. Males and females were color-marked with paint applied on the lateral pronotal lobes, which allowed us to record the duration of presence of each individual in a given habitat and also the changes of habitats and mates (Fig. 5). The route examination of biotopes was performed using a camera, a voice recorder, and a GPS unit. Measurements were made using coordinate paper and an electronic digital caliper.

Most species of the family Coreidae overwinter as adults with undeveloped gonads; copulation and oviposition begin in May (Putshkov and Putshkova, 1956). In Primorskii Territory, overwintered adults of *M. fuliginosa* were recorded by us from the end of the second decade of May, while mating and oviposition were observed from the last decade of May to the first decade of August. Similar to many other insects, adults of *M. fuliginosa* mate repeatedly, and considerable time may pass between mating and actual egg fertilization. To study the process of oviposition, a mating pair was placed in a portable cage at 11 a.m. on 25.VI.2016; its copulation, which started under natural conditions and continued in the cage, lasted for a total of 36 h. The female laid 13 eggs in the subsequent period (25–26.VI.2016). The eggs were laid openly, singly, in discrete portions; the timing of oviposition is given in Table 1. Oviposition took place in daylight time, with intervals varying from 20 min to 5 h 20 min. The time from the end of copulation to laying the first egg was 3 h 25 min, that from the end of oviposition to the next copulation, 1 h 50 min.

The eggs of *M. fuliginosa* are rather large, rounded-cuneate, rounded-triangular in cross-section, on average 2.55 mm long, 1.74 mm wide, and 1.59 mm high. The more rounded anterior and slightly pointed posterior ends can be distinguished, and also the dorsal (facing the substrate and somewhat depressed) and ventral surfaces (Markova et al., 2017). The eggs laid with shorter intervals, down to 20–25 min, were more angular. The eggs were bronze-brown in color and often covered with pale female's secretion flowing downwards and congealing on the egg surface. If the egg remained clean, the reticulate sculpture of its chorion and also a thin micropylar ring located closer to the anterior end could be discerned. All the eggs were laid on the netting and the wire frame of the cage despite the presence of a host plant (Fig. 6). Similar data on caged females ignoring plants and laying eggs on gauze netting were reported by Putshkova (1955), who noted at the same time that oviposition might be suspended in the absence of the host plant.

Table 1. Duration of oviposition of *Molipteryx fuliginosa* (Uhler) in a portable cage

No. of observation	Time of oviposition	Interval between successive acts of oviposition
25.VI.2016		
1	14.25	3 h 25 min after copulation
2	15.35	1 h 10 min after the first egg
3	15.55	20 min after oviposition
4	16.20	25 min after oviposition
5	17.30	1 h 10 min after oviposition
6	18.40	1 h 10 min after oviposition
7	20.00	1 h 20 min after oviposition
26.VI.2016		
8	07.00	11 h after oviposition
9	07.20	20 min after oviposition
10	07.50	30 min after oviposition
11	08.50	1 h after oviposition
12	14.10	5 h 20 min after oviposition
13	15.40	1 h 30 min after oviposition

According to our observations, the process of oviposition included several stages:

(1) active movement of the female over the cage for 15–40 min in search of a suitable place;

(2) stopping and feeling the substrate with the end of the abdomen and the tip of the ovipositor, accompanied by release of sticky secretion. The female makes 2 or 3 such stops before finally choosing the place;

(3) oviposition proper, taking about 10 min. During this process the egg appears from the ovipositor, then moves back in, and finally is pushed out while the female continues to release sticky secretion from the top of the abdomen.

Figs. 5–8. *Molipteryx fuliginosa* (Uhler): (5) marked male and female; (6) eggs on cage netting; (7) eggs on the lower side of a raspberry leaf; (8) eggs on a raspberry leaf close to the stalk.

Having laid one egg the female quickly moved away. During oviposition, the female always moved along the walls from top to bottom and placed the eggs with the anterior end toward the earth surface. The total fecundity, i.e., the number of eggs laid by one female during its lifespan in stationary cages, varied from 21 to 38 (on average 28.4; $n = 5$) (Table 2).

Overwintered females mated from 4 to 18 times till the moment of death. Each copulation lasted from 2 to 48 h, and the interval between copulations was from 2 h to 3 days. The smallest number of eggs laid between copulations was 1, the greatest one, 13 (on average 3.8); the number of separate egg portions varied from 4 to 11 (on average 7.8) (Tables 1, 2).

Females kept in stationary cages laid eggs not only on host plants but also on those which had not been recorded earlier in the diet of the species: *Elytrigia repens* (L.) Nevski, *Taraxacum officinale* Wigg., and also on dead substrates which would be unsuitable for feeding of nymphs, such as netting, dry twigs, and a wooden pole (Table 3). These facts support the suggestion of Putshkova (1955) that the choice of substrate is determined by the suitability of the surface for egg attachment.

Table 2. Timing and duration of copulation and oviposition of *Molipteryx fuliginosa* (Uhler) in stationary cages

Date	No. of couple				
	1	2	3	4	5
22.V.2016	C (36 h)	–	C (36 h)	C	C (48 h)
23.V.2016	–	C	–	C_{cont} (30 h); O	–
24.V.2016	O (12)	–	–	O_{cont} (12)	–
25.V.2016	–	–	O (12)	–	O (12)
26.V.2016	–	C_{cont} (48 h); O (4)	–	O	–
27.V.2016	C (7 h)	C (24 h)	C (24 h)	C_{cont} (10 h); O	–
28.V.2016	–	O (8)	O (2)	O_{cont} (5)	C (10 h)
29.V.2016	O (5 h); C	C (8 h); O	C (8 h); O	–	–
30.V.2016	C_{cont} (18 h)	O_{cont} (3)	O_{cont} (3)	C	O (6); C
31.V.2016	O (4)	–	–	C_{cont} (10 h); O (2)	C_{cont} (12 h); O(4)
01.VI.2016	–	C (24 h)	C (10 h)	–	–
02.VI.2016	–	O	O	C (12 h); O (1)	–
03.VI.2016	C (6 h); O (1); C	C_{cont} (6)	C_{cont} (4)	–	C (6 h)
04.VI.2016	C_{cont} (24 h)	Death	–	C (24 h)	O (3); C
05.VI.2016	C (5.5 h); O (1)		C (15 h)		C_{cont} (24 h); O (2)
06.VI.2016	C (17.5 h)		O (1)	C (5 h); O (1)	C (12 h); O (2)
07.VI.2016	C (13 h)		C (3 h)	C (10 h)	C (13 h)
08.VI.2016	O (1); C (20 h)		O (1)	C (20 h); C (1)	C (16 h)
09.VI.2016	–		–	–	C (1)
10.VI.2016	–		Death	C (16 h); C (2 h); O (2)	–
11.VI.2016	C (17 h); C (2.5 h); O (4)			–	–
12.VI.2016	C (2 h); C (14 h); O (3)			C (5 h); O (1)	C (14 h)
13.VI.2016	C (5 h); O (3)			C (2 h); O (1)	O (2)
14.VI.2016	C (20.5 h)			C (2 h)	C(20 h); O (1)
15.VI.2016	C (2 h); O (2)			–	C (6 h); O (1)
16.VI.2016	C (4 h); O (2)			–	C (4 h)
17.VI.2016	C (2 h)			–	–
18.VI.2016	–			Death	–
19.VI.2016	–				Death
20.VI.2016	Death				
Number of laid eggs	38	21	23	26	34

C, copulation; C_{cont}, continued copulation (total duration is given in parentheses); O, oviposition; O_{cont}, continued oviposition (number of laid eggs is given in parentheses); dash, absence of reproductive activity.

Table 3. Localization of eggs of *Molipteryx fuliginosa* (Uhler) on different substrates in stationary cages

Number of eggs	*Rubus idaeus* L.				*Elytrigia repens* (L.) Nevski	*Taraxacum officinale* Wigg.	Wooden pole	Cage netting
	leaves		stems	dry branches				
	upper side	lower side						
	4	37	18	4	12	1	2	123
Total	201							

Table 4. Localization of eggs of *Molipteryx fuliginosa* (Uhler) on plants in nature

Plant	Biotope	Part of plant	Height above soil surface, cm	Number of eggs
Taraxacum officinale Wigg.	Countryside household plot	Upper side of leaf	15	2
Elytrigia repens (L.) Nevski		Both sides of leaf	27–30	4
Solanum lycopersicum L.		Stem	25–30	1
Rubus idaeus L.		Lower side of leaf	60	1
Carex sp.	Broad-leaved forest with oak		12	1
Total				9

Of all the laid eggs, 61.2% were located on the cage netting (Fig. 6). Of the eggs laid on *R. idaeus*, 58.7% were recorded on the lower side of the leaves (Fig. 7) and 28.6%, on the stems. The eggs were always positioned singly, separate from one another. At the same time, the female could return to the same egg batch for several days and place new eggs close to those laid earlier (Fig. 8), sometimes forming indistinct rows (Fig. 6). Comparison of the number of laid eggs, empty chorions, and hatched I instar nymphs in stationary mini-cages showed that females of *M. fuliginosa* did not lay eggs on the soil surface.

In nature, copulation in *M. fuliginosa* was observed in anthropogenically modified cenoses, such as homestead lands, farmland, and landscaped countryside areas, and also in small-leaved riparian forests. The preferred places for copulation in these cenoses were plants of *Rubus idaeus* L., *R. caesius* L., and *Rubus* sp. Marking of adults showed that, unlike males, females actively moved into other cenoses, including forest ones, in search of places for oviposition. Eggs of *M. fuliginosa* were found by us for the first time under natural conditions (Table 4).

Only single eggs were found in forest and anthropogenically modified cenoses. No selectivity with regard to host plants was recorded in spite of their abundance and availability. For instance, plantings of *Solanum lycopersicum* and single plants of *Taraxacum officinale* on the household plot were located at a distance of 1.5–3 m from *R. idaeus*, whereas *Carex* sp. was at a distance of 3–5 m from the great burnet *Sanguisorba officinalis* L. and the roadside agrimony *Agrimonia striata* Michx., earlier recorded in the diet of *M. fuliginosa* nymphs in an oak-broadleaved forest (Markova et al., 2016a). Both in nature and in cages, the female in most cases positioned eggs with the rounded anterior end towards the soil surface.

CONCLUSIONS

As the result of our studies the following features of reproductive behavior of *M. fuliginosa* were observed.

1. Extended periods of copulation and laying eggs in separate portions.

2. The absence of specialization with regard to family, genus or species of host plants and also to the type of dead substrate.

3. In nature, single eggs were observed only on plants and never on non-organic (dead) substrate or soil surface under plants.

4. Plants with single eggs were located at a distance from each other, which increased the possibility of dispersal of the species in biocenoses.

5. Mating was observed in anthropogenically modified cenoses and also in small-leaved riparian forests.

6. In anthropogenically modified cenoses the preferred places for copulation were plants of *Rubus idaeus* L., *Rubus caesius* L., and *Rubus* sp.

7. Copulation stimulated females to migration in search of places for oviposition and they moved to other stations, including forest ones.

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