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Phenology of *Forficula vicaria* Semenov, 1902 (Dermaptera, Forficulidae) in the South of the Russian Far East

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Abstract—The phenology of the earwig *Forficula vicaria* was studied in Primorskii Territory based on three-year observations in nature and in stationary cages. The species has a univoltine life cycle, with females and eggs overwintering in underground nests. The overwintered females protect their eggs and nymphs in spring, but later leave their nests and die in mid-June. The I instar nymphs appear since the middle third of May; the II instar nymphs, since the last third of May; the III instar nymphs, from the beginning of the middle third of June, and the IV instar nymphs, from the last third of June. The postembryonic development takes on average 65 days. Adult males appear in the beginning third of July, and adult females, in mid-July. Mating takes place from late August to mid-October, and oviposition, from late September to mid-October. The mean fecundity is about 60 eggs per female. Adults can be found on the soil surface and in natural shelters until the end of September. Males assist females in building the nests, but die after the first ground frost in October.

Keywords: earwigs, *Forficula vicaria*, copulation, postembryonic development, egg, nymphs, overwintering, Primorskii Territory, Dermaptera, Forficulidae

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The genus *Forficula* Linnaeus, 1758 is represented in the Russian fauna by seven species: *F. aetolica* Brunner von Wattenwyl, 1882 (Crimea), *F. auricularia* Linnaeus, 1758 (European Russia and West Siberia), *F. robusta* Semenov-Tian-Shanskij, 1908 (south of Amur Province and Khabarovsk Territory, Primorskii Territory), *F. scudderii* de Bormans, 1880 (Sakhalin Province: Moneron Island), *F. smyrnensis* Audinet-Serville, 1839 (Crimea, Caucasus), *F. tomis* (Kolenati, 1846) (European Russia and West Siberia), and *F. vicaria* Semenov, 1902 (south of Amur Province and Khabarovsk Territory, Primorskii Territory) (Bey-Bienko, 1936; Storozhenko, 1984, 2006). Two of these species, *F. auricularia* and *F. tomis*, can damage various crops (Bey-Bienko, 1972).

When describing a new species discovered in Korea, S.P. Semenov-Tyan-Shansky (Semenov, 1902) named it *Forficula vicaria* to emphasize the fact that this species replaces the widespread European earwig *F. auricularia* in the Far East. The range of the latter species covers Europe, North Africa, Asia Minor, the Caucasus, and Central Asia; moreover, the species has been introduced to North America, Australia, and New Zealand. The biology and ecology of *F. auricularia* have been quite well studied in Europe (Chapman, 1917; Brindley, 1918; Sullivan, 1943; Behura, 1950; Good, 1982a, 1982b; Shikov, 1988; Kocarek, 1998; Selivanova, 1998; Lazarev, 2004; Moerkens et al., 2009, 2010; Aleksanov, 2015), Australia (Hill et al., 2018; Kirkland et al., 2020, etc.), New Zealand (Burnip et al., 2002; Suckling et al., 2006), and North America (Beall, 1932; McLeod and Chant, 1952; Lamb and Wellington, 1974, 1975; Lamb, 1975, 1976; Zack et al., 2011). In contrast, there is no information on the life cycle, reproductive behavior, feeding, and other biological and ecological features of *F. vicaria*; the published data allow us only to outline the range

of this species, covering the southern continental part of the Russian Far East, Northeast China, and the Korean Peninsula (Bey-Bienko, 1936; Storozhenko, 1984; Nishikawa and Han, 2015).

This paper presents the results of our monitoring of postembryonic development, copulation, and overwintering of *F. vicaria*, providing new data on the phenology of this species.

MATERIALS AND METHODS

The study was carried out from early April to late October 2020–2022 in Primorskii Territory of Russia. Different types of natural and cultivated biocenoses were visually examined, and earwigs were shaken off woody and herbaceous plants in order to assess the level of their infestation. In agrocenoses, the leaves of plants were examined, the fruits were dissected, traces of feeding damage and insect excrement were found, and baits were placed on the soil to attract earwigs. The potential shelters of earwigs were examined. For experimental purposes, the insects were kept in special cages (Markova et al., 2018). Glue traps were installed in natural and cultivated biocenoses, on the soil and on the branches 2–3 m above the ground. The collected insects at all the development stages were measured and photographed. At least 10 specimens were measured at each stage of earwig development.

To determine the timing of development, nymphs of *F. vicaria* were collected in nature and kept in individual Petri dishes until their molt to adults. Small invertebrates inhabiting the earwig collection sites, cut plant shoots, inflorescences, and fruits were offered to the nymphs as food. The nymphal instar was determined by the number of antennal segments: nymphs of *Forficula* species have 8 segments at the I instar, 10 at the II instar, 11 at the III instar, and 12 segments at the IV instar (Fulton, 1924; Bey-Bienko, 1936).

The wintering conditions of *F. vicaria* were studied by observation of the insects building their underground wintering nests and excavation of the soil around them. Three sample plots of 1 m^2 were marked out in autumn and winter, and the earwigs emerging from the soil were collected. The females were dissected to detect mature eggs.

A total of 118 adults and 54 nymphs of *F. vicaria* were collected under natural conditions.

Material. Russia. *Primorskii Territory*: Ussuriisk Urban District, Kaimanovka, household plot, in cages with larvae of Geometridae and Noctuidae on common ragweed *Ambrosia artemisiifolia* L. (Asteraceae), 9.VIII–5.IX.2020, 9 adults; in cages with egg clutches and nymphs of bugs *Molipteryx fuliginosa* (Uhler), *Coreus marginatus orientalis* (Kir.), and *Urostylis annulicornis* Scott (Heteroptera, Coreidae, Urostylididae) on common raspberry *Rubus idaeus* L. (Rosaceae), Russian dock *Rumex confertus* Willd. (Polygonaceae), and Mongolian oak *Quercus mongolica* Fisch. ex Ledeb. (Fagaceae), 6–21.VII.2021, 12 nymphs of IV instar; 15–16.VIII.2021, 3 adults; 29.VI.2022, 2 nymphs of III instar; 6.VII.2022, 4 nymphs of IV instar; under the stump bark, on bird cherry *Padus avium* Mill. (Rosaceae) and *Viburnum sargentii* Koehne (Caprifoliaceae), 6–21.VII.2021, 12 nymphs of IV instar; 18–26.VII.2021, 6 adults; 7.VIII.2021, 2 adults; 1.IX.2021, 1 adult; 17.IX.2022, 4 adults; on leaves of cucurbit crops containing aphid colonies, 17–30.VIII.2021, 6 adults; in sweet peppers, 18.VIII.2021, 1 adult; 8.IX.2021, 3 adults; 12.IX.2021, 1 adult; under corn husk, 21.VIII.2021, 1 adult; between leaves of cabbage head, 26.VIII–1.IX.2021, 4 adults; 1.IX.2021, 1 adult; 29–30.VII.2022, 4 adults; on aster inflorescence, 27.VIII.2021, 3 adults; in glue traps on *Actinidia arguta* (Siebold et Zucc.) Planch. ex Miq. (Actinidiaceae), bird cherry, apple tree *Malus* sp. (Rosaceae), Amur maple *Acer ginnala* Maxim., purplebloom maple *A. pseudosieboldianum* (Pax) Kom. (Aceraceae), 26.VII–10.VIII.2022, 16 adults; in shelters (under rocks, weedmat, in compost), 29.VIII–16.IX.2021, 10 adults; in underground nests, 16–19.IX.2021, 41 adults; on soil near underground nests, 20–24.IX.2021, 3 adults; env. of Kamenushka, floodplain forest along Barsukovka River, side of forest road, on mugwort *Artemisia* sp. (Asteraceae), willow *Salix* sp. (Salicaceae), and bird cherry, 17.VIII.2021, 4 adults; mixed forest, on Mongolian oak, 7.VII.2022, 1 nymph of IV instar (T.O. Markova and M.V. Maslov).

The III instar nymphs of *F. vicaria* were collected on 29.VI.2022 and placed in cages; they molted to the IV instar on 2.VII.2022 and then to adults, on 19 and 22.VII.2022 (2 ♀). The IV instar nymphs were collected on 6–21.VII.2021, 6.VII, 7.VII, and 28–30.VII.2022; they molted to adults on 9–11.VII.2021 (3 ♂), 15–18.VII.2021 (4 ♂), 16–17.VII.2021 (2 ♀), 21–23.VII.2021 (3 ♂), 14–18.VII.2022 (2 ♂, 3 ♀), and 29–30.VII.2022 (2 ♂, 2 ♀).

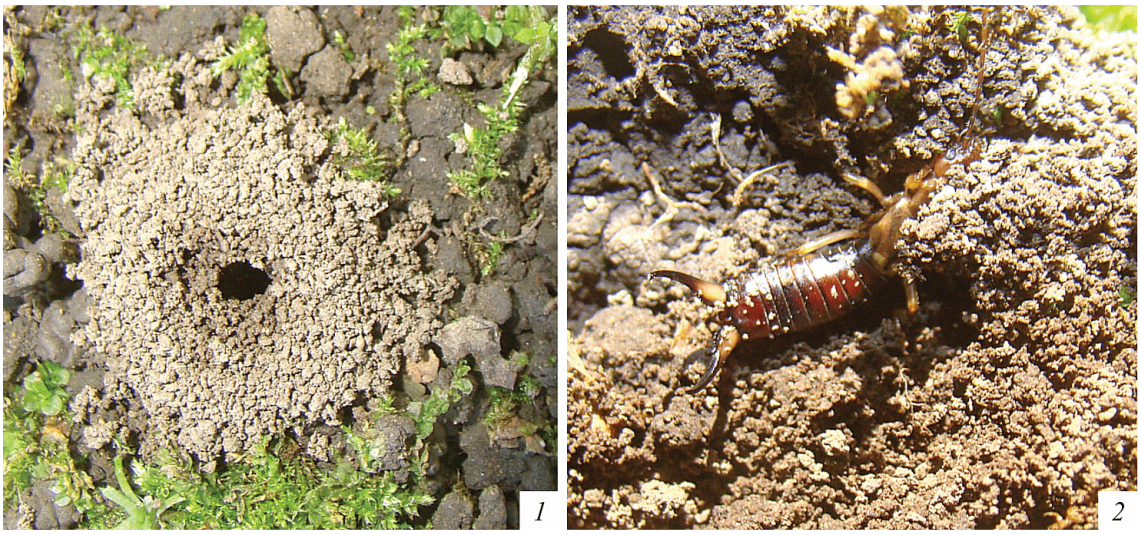

Fig. 1. Overwintering of *Forficula vicaria* Semenov under natural conditions: (*1*) wintering shelter; (*2*) male in an excavated tunnel.

RESULTS

The complete life cycle of earwigs (the period of active life and diapause) includes three stages: embryonic, nymphal, and adult. Under the conditions of Primorskii Territory, *Forficula vicaria* is a univoltine species hibernating at the adult and embryonic stages. In autumn, the male builds an underground nest on its own or together with the female (Fig. 1), and the female lays eggs in it. The female subsequently drives the male out of the nest or closer to the soil surface, where the male dies after the first frost, while the female and its egg clutch overwinter. We found nests with overwintered females and eggs at a depth of 1 to 3 cm, and dead males at a depth of up to 1 cm and near the soil surface in our sample plots, starting with the end of the middle third of April. In May, females of the overwintered generation remain in the nests and protect the I and II instar nymphs; then they leave the nests and can be found on the soil surface from late May to mid-June.

Nymphs of *F. vicaria* pass through four instars before turning into adults (Table 1). The consecutive instars differ mainly in body size and the number of antennal

Table 1. Phenology of *Forficula vicaria* Semenov under natural conditions and in stationary cages in Primorskii Territory of Russia, by months and 10-day intervals: data of 2020–2022

Stage	May			June			July			August			September			October		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Egg	+	+	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	+
Nymph:																		
I instar	–	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–	–	–
II instar	–	–	+	+	+	+	+	+	–	–	–	–	–	–	–	–	–	–
III instar	–	–	–	–	+	+	+	+	–	–	–	–	–	–	–	–	–	–
IV instar	–	–	–	–	–	+	+	+	+	+	–	–	–	–	–	–	–	–
Adult:																		
Male	–	–	–	–	–	–	+	+	+	+	+	+	+	+	+	+	+	+
Female	+	+	+	+	+	–	–	+	+	+	+	+	+	+	+	+	+	+

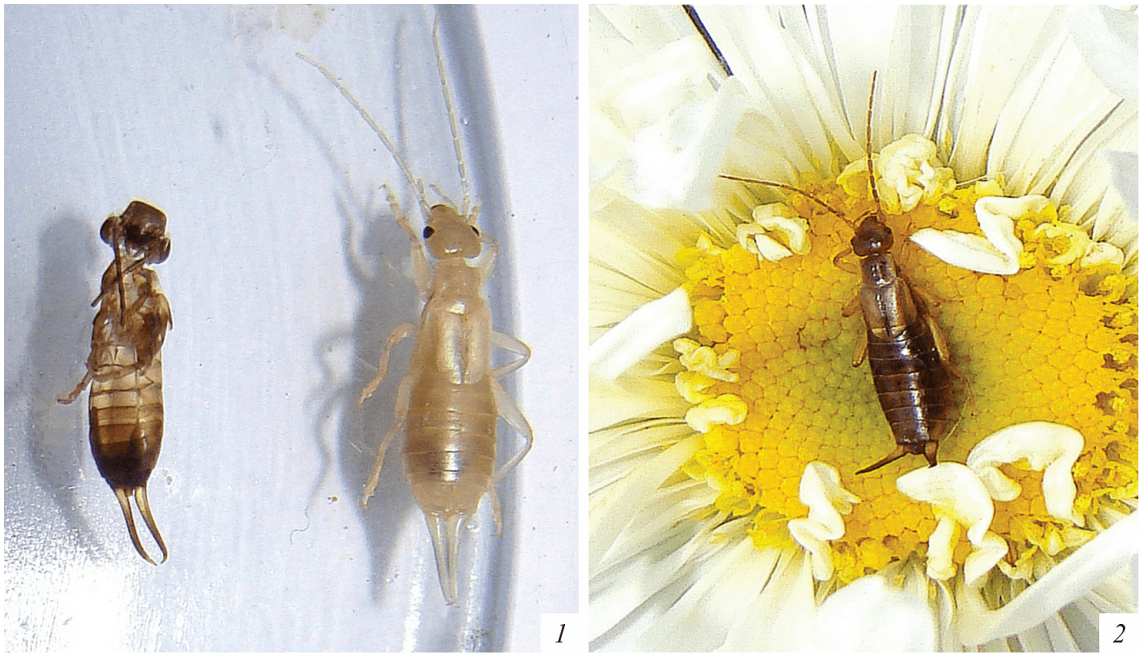

Fig. 2. *Forficula vicaria* Semenov: (*1*) freshly molted female and its exuvia; (*2*) female on an aster flower head.

segments. The wing rudiments in the IV instar nymphs are visible as the lateral edges of the meso- and metanotum extending posteriad.

Hatching of the I instar nymphs was recorded from the end of the middle third of May to the end of June (see Table 1). The body length of the nymphs was 2.5–3.2 mm (m = 2.9), the length of their cerci was slightly less than 1 mm. The developmental time of the I instar was 12–13 days.

The II instar nymphs were found from the last third of May to the end of the middle third of July. They were 4.2–5.0 mm long (m = 4.4) and had cerci 1.0–2.0 mm long (m = 1.48). The developmental time of the II instar was about 20 days.

The III instar nymphs were observed from the middle third of June to mid-July. They were 5.4–7.2 mm long (m = 6.3) and had cerci 1.5–2.0 mm long (m = 1.8). The developmental time of the III instar was about 14 days.

The IV instar nymphs were recorded from the last third of June to early August. They were 6.7–13.0 mm long (m = 9.1) and had cerci 2.0–2.5 mm long (m = 2.3). Their developmental time was 17–21 days. According to our data for Primorskii Territory, the IV instar nymphs that did not have enough time to complete development and molt to adults died by early August.

Adults of the new generation appeared at the end of the beginning third of July (males) or in mid-July (females) (Fig. 2). The final molt lasted 1.5–2 h, including 30 min for shedding the exuvia and 60 min for darkening of the integument and sclerotization of the abdomen. The adults did not feed 12–24 h after molting. The body length of adults was 10.0–14.0 mm in males (m = 11.8) and 9.0–13.0 mm in females (m = 10.9); the length of the cerci was 3.0–4.0 mm in males (m = 3.4) and 2.0–3.0 mm in females (m = 2.5).

Mating of *F. vicaria* in the south of Primorskii Territory was observed from the end of the middle third of August to mid-October. Oviposition in stationary cages occurred from the end of September to mid-October (Fig. 3). One female laid from 50 to 71 eggs (m = 58.4; n = 5).

Adults were found until the end of September on the soil surface, in natural shelters, under warm stones in sunlit areas, and near shrubs of orchard crops. Males were also observed in late September and early October near the underground nests. No earwigs appeared on the soil surface after the first autumn ground frost.

Fig. 3. *Forficula vicaria* Semenov: (*1*) mating couple; (*2*) female with its egg clutch.

DISCUSSION

The earwigs *Forficula vicaria* and *F. auricularia* have similar life cycles. The duration of post-embryonic development of *F. auricularia* in British Columbia (Canada) varies from 56 to 85 days. In northwestern Europe, the I and II instar nymphs appear in April or May, depending on climatic conditions, and are guarded by the female (Buxton and Madge, 1974; Lamb, 1976). The development of the I instar nymphs of *F. auricularia* takes on average 12–14 days, that of the II and III instars, 2 weeks each, and that of the IV instar, about 3 weeks (Lamb and Wellington, 1975; Meunier et al., 2012; Aleksanov, 2015). There are also some differences between the two species. Only one generation a year was observed in *F. vicaria* in Primorskii Territory. The populations of *F. auricularia* in the highlands and continental regions of Europe and North America are also univoltine, but this species produces two generations a year in the southern Mediterranean, Australia, and New Zealand (Kocarek, 1998; Wirth et al., 1998; Burnip et al., 2002; Moerkens et al., 2010; Zack, 2011; Meunier et al., 2012; Kirkland et al., 2020).

CONCLUSIONS

Under the conditions of monsoon climate in the south of the Russian Far East, the earwig *Forficula vicaria* is a univoltine species overwintering at the adult and embryonic stages. The overwintered females care for their eggs and the I and II instar nymphs in May, then leave the underground nests and die by mid-June. The nymphs appear on the soil surface in early June.

Hatching of the I instar nymphs from overwintered eggs was observed in Primorskii Territory since the end of the middle third of May; the earliest II instar nymphs appeared in the last third of May; the III instar nymphs, in the middle third of June; the IV instar nymphs, in the last third of June. The total time of nymphal development was about 65 days. Adult males were found since the end of the beginning third of July, and females appeared a little later, in mid-July.

Mating of *Forficula vicaria* was observed from the end of the middle third of August to mid-October. Males and females built underground nests in autumn. Oviposition took place from the end of September to mid-October. The female laid on average about 60 eggs, drove the male out of the nest, and overwintered while protecting the eggs; the males died after the first autumn frost.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest. The authors declare that they have no conflict of interest.

Statement on the welfare of animals. All the applicable international, national, and/or institutional guidelines for the care and use of animals were followed. All the procedures performed in studies involving animals were in accordance with the ethical standards of the institution or practice at which the studies were conducted.

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