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Habitat Associations of the Larvae of the Genus *Sphegina* Meigen, 1822 (Diptera, Syrphidae) with Xylobiont Insects

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Abstract—The paper presents the first data on the life histories of the larvae of five species of the genus *Sphegina* Meigen, 1822 (Diptera, Syrphidae) and their habitat associations with other xylobiont larvae of ambrosia insects: xylomycetophagous bark beetles (Coleoptera, Curculionidae, Scolytinae), flies of the families Axymyiidae and Syrphidae (Diptera), and other insects. The biotopes of *Sphegina* larvae are divided into two types: the main biotope where larval development takes place and the additional biotope where pupation occurs.

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The genus *Sphegina* Meigen, 1822 (Diptera, Syrphidae) belongs to the tribe Chrysogasterini of the subfamily Eristalinae (Milesiinae). It is included in the subtribe Spheginina together with the genera *Neoascia* Williston, 1886 and *Spheginoides* Szilády, 1939 (Peck, 1988). The genus comprises two subgenera: *Asiosphegina* Stackelberg, 1975 and *Sphegina* Meigen, 1822. The first subgenus counts not more than 7–9 species, the second, over 40 species (Stackelberg, 1953, 1956a, 1956b; Mutin, 1984; Thompson and Torp, 1986; Peck, 1988; Vujic, 1990). At least 6 species of the first subgenus and over 25 species of the second are known in the territory of Russia, mostly in the eastern regions.

Biological data on these species are very incomplete, and the mode of life of adults remains almost unknown. All the Palaearctic representatives of *Sphegina* are typical inhabitants of broadleaved forests and the whole forest zone of Eurasia and also the light mountain forests of Central Asia where they occur on leaves of shrubs and on flowers, in particular those of umbellifers. The main habitats of adults are dense herbaceous vegetation and woody valleys of rivers and streams (Stackelberg, 1953).

Larvae of *Sphegina* must be obligate xylobionts since all the scanty published data witness their association with woody plants. Larvae occur under moist rotting bark of dying deciduous trees (*Betula*, *Quercus*, *Fagus*, *Populus*, *Ulmus*), in secreted sap (Hartley, 1961; Rotheray, 1990, 1993), and in the moist wood of conifers (Krivosheina and Mamaev, 1967; Rotheray, 1990).

The diagnostic characters of the larvae of *S. clunipes* (Fallén, 1816), *S. verecunda* Collin, 1937, and *S. kimakowiczi* (Strobl, 1897) have been published (Hartley, 1961), and also complete descriptions of the larvae of *S. clunipes* (Krivosheina and Mamaev, 1967) and the Nearctic species *S. keeniana* Williston, 1887 (Lavallee and Wallace, 1974).

While collecting material on xylobiont dipteran larvae we have obtained data on the larval biology of the genus *Sphegina*. Some of the collected larvae were fixed and others were left in the substrate to complete their development. Adult flies were identified by V.A. Mutin and A.A. Stackelberg. This paper summarizes data on the mode of life of larvae of 7 species; information for 5 of them has been obtained for the first time.

THE ECOLOGICAL CHARACTERISTIC OF LARVAE OF THE GENUS *SPHEGINA* MEIGEN

The ecological characteristic of the studied species includes two most important components: characteristic of habitats of larvae during their growth and development, and also during puparium formation, and the forms of interrelations between the larvae of *Sphegina* and those of the main groups of xylobionts in xylophilous associations.

The first feature worth noting is change of the habitat in the process of larval development of xylobiont dipterans. The collection sites of mature larvae and puparia of xylobionts do not always occur in the same biotope in which larval development really takes

Biotopic associations of larvae of hoverflies of the genus *Sphegina* Meigen, 1822

Species	Main biotope (A)	Additional biotope (B)	Co-occurring xylobiont species
S. claviventris Stackelberg, 1956	Sap-soaked bast of a fallen larch trunk on a stream bank (Tuva)	Dust in bark fissures	Phloeophagous larvae of *Gnophomyia lugubris* (Zett.) (Limoniidae); larvae of *Hammerschmidtia ingrica* Stack. (Syrphidae)
S. clunipes (Fallén, 1816)	Larval galleries of Axymyiidae and *Temnostoma* in spruce wood, soaked in sap and secretions of ambrosia fungi (Transcarpathia)	Moist wood of fallen spruce trunks on stream banks	Larvae of *Mesaxymyia kerteszi* (Duda) (Axymyiidae) and *Temnostoma bombylans* F. (Syrphidae)
S. elegans Schummel, 1843 (= *kimakowiczi* Strobl, 1897)	Galleries of ambrosia insects with tree sap and secretions of ambrosia fungi (Transcarpathia)	Moist bark and wood of barkless trunks of beech, aspen, and alder	Larvae of *Temnostoma bombylans* (F.) and *Mesaxymyia kerteszi* Duda
S. latifrons (Egger, 1865)	Galleries of ambrosia beetles with tree sap and secretions of ambrosia fungi (Azerbaijan)	Moist bark and wood of deciduous trees	*Xyleborus dispar* F. and *X. dryographus* Ratz.
S. montana Becker, 1921 (= *eoa* Stackelberg, 1953)	Galleries of ambrosia insects, sap under bark (Kunashir Island)	Moist bark and bast of fallen larch trunks	*Trypodendron lineatum* Ol.; larvae of *Temnostoma* sp. and *Gnophomyia lugubris* (Ztt.)
S. spiniventris Stackelberg, 1953	Galleries of ambrosia insects (South Primorye)	Dust in the thick of bark and dust of bast above the sapwood layer	*Temnostoma angustistriatum* Kriv., *Protaxymyia melanoptera* Mam. et Kriv., *Libnotes kariyana* Al.
S. tenuifemorata Mutin, 1984	Fresh aspen bast soaked in sap (South Primorye)	Dust in bark fissures of fallen aspen trunks	*Temnostoma angustistriatum* Kriv., *Libnotes kariyana* Al., *Gnophomyia acheron* Al.

place. Change of biotopes by xylobionts during ontogenesis is especially typical of forms living in liquid and semi-liquid media, such as wood soaked in sap or partly submerged in water, flooded tree holes, etc. Before pupation, mature larvae migrate to dryer substrates; for xylobionts these are the surface layers of tree trunks, various cavities and fissures in the bark, old tunnels of various insects, and in case of development in fallen trunks, the bark surface and the surrounding litter where puparia are often to be found.

For more adequate analysis of ecological data, it would be feasible to consider two types of biotopes: the main biotope (A) and the additional biotope (B). The main biotope is the place of active growth and development of the larva where it feeds intensively and accumulates the reserves needed for transformation into the pupa and adult. The additional biotope is the place where pupation and adult emergence take place after completion of larval feeding (see table).

The second component of the ecological characteristic of the studied species describes the relations between *Sphegina* larvae and other xylobiont larvae accompanying them.

Sphegina claviventris Stackelberg, 1956

Material: 2 males, larvae: **Russia:** *Tuva*, Ishtii-Khem, 10.VI.1979 (N. Krivosheina). The larvae were found under the bark of a fallen larch trunk lying on a stream bank.

The species was described from Khabarovsk Territory and recorded in the southern regions of Siberia, the Far East, and the Korean Peninsula; within Siberia, the westernmost locality of *S. claviventris* is the Sayan Mountains, where its larvae were found in the territory of Tuva. The species is also known from Latvia and Lithuania and from the Komi Republic of Russia (Peck, 1988).

According to our data, the main biotope of this species is larch bast soaked in sap, in which the *Sphegina* larvae co-occur with the phloeophagous larvae of *Gnophomyia lugubris* (Zetterstedt, 1838) (Limoniidae) and the sapronecrophagous larvae of *Hammerschmidtia ingrica* Stackelberg, 1952 (Syrphidae). Before pupation, mature larvae usually move to bark fissures filled with wood dust, which should be regarded as the additional biotope.

Sphegina clunipes (Fallén, 1816)

Material: 1 male, 1 female, 3 larvae: **Ukraine:** *Transcarpathia*, env. of Rakhov, No. 8 and 18, 23.V.1966 (N. Krivosheina). The larvae were found in moist spruce wood; adults emerged on 13.VI.1966.

The species is widely distributed in Europe including European Russia, in Transcaucasia, the Russian Far East, and Japan.

In Transcarpathia larvae of *S. clunipes* were found in a spruce forest with a small admixture of alder, in a heap of barked spruce logs on a stream bank. The main biotope is moist and hard wood of such logs. Larvae of *S. clunipes* are practically always recorded together with those of *Mesaxymyia kerteszi* (Duda, 1930); in the thick of wood, they move along *Mesaxymyia* galleries moistened with secretion from the wood and ambrosia fungi lining the walls. Before pupation, mature larvae move to the additional biotope, namely the surface wood layers. In very moist and dense wood of barkless trunks, *S. clunipes* larvae inhabited the larval tunnels of *Temnostoma bombylans* (Fabricius, 1805). In addition, Hartley (1961) reported development of larvae of *S. clunipes* in secreted elm sap, where they co-occurred with larvae of *Brachyopa* Meigen, 1822, and in the moist bast of dead elm trees. In view of these data, both secreted sap and larval galleries of Axymyiidae should be considered as the main biotopes.

Sphegina elegans Schummel, 1843
(= *kimakowiczi* (Strobl, 1897))

Material: 1 male, 2 females, 1 larva. **Ukraine:** *Transcarpathia*, env. of Rakhov, 14.VI.1966 (N. Krivosheina). The larvae live under the bark of aspen trees, in the waterside zone of a stream bank.

The species was described from Romania. It is widely distributed in Europe, recorded in Transcarpathia and Kharkov Province of Ukraine and in Leningrad Province of Russia.

The main biotope of larval development is tunnels of ambrosia insects, first of all *Mesaxymyia kerteszi* (Axymyiidae) and *Temnostoma bombylans* (Syrphidae) (see table). Mature larvae were found together with larvae of Cecidomyiidae and Scatopsidae in the bark and bast fiber layers of fallen aspen trunks, which constitute the additional biotope. Development of the species in moist bast under the bark of dead trees was also reported (Hartley, 1961).

Sphegina latifrons Egger, 1865

Material: 3 females, 3 larvae, 2 puparia: **Azerbaijan:** Lenkoran, No. 119, 4.V.1980 (N. Krivosheina). The larvae were collected under maple bark; adults emerged on 9.V.1980.

The species is widely distributed in Central and South Europe but has not been recorded before in Transcaucasia.

The larvae were found in a partly submerged maple trunk lying on a river bank. Their main biotope is galleries of the ambrosia beetles *Xyleborus dispar* (Fabricius, 1792) and *X. dryographus* (Ratzeburg, 1837) (Scolytinae), soaked in tree sap and secretions of ambrosia fungi. Before pupation, mature larvae migrate into wood dust pockets in the thick of the bark and wood; in secondary biotopes they co-occur in the bast with larvae of *Mycetobia pallipes* Meigen, 1818 (Mycetobiidae).

Sphegina montana Becker, 1921
(= *eoa* Stackelberg, 1953)

Material: 1 male, larvae: **Russia:** *Sakhalin Prov.*, Kunashir Island, Mendeleevo, No. 30, 10.IX.1972 (N. Krivosheina). The larvae were found under fir bark; adults emerged on 16.II.1973.

The species was described from Austria and is also known from Finland, the former Czechoslovakia, Bulgaria, and the Korean Peninsula; in Russia it was recorded in the European part and in the south of Siberia and the Far East.

The larvae were found in fir trunks with sufficiently fresh, light or brownish bast, lying on the ground in a bamboo thicket. Their main biotope includes galleries of ambrosia insects, namely bark beetles and hoverflies of the genus *Temnostoma* Lepeletier et Serville, 1828, and also sap accumulated under the bark. Along its whole length, the trunk was inhabited by larvae of two bark beetle species, one of which was *Trypodendron lineatum* (Olivier, 1795), and in places

also by larvae of *Temnostoma* sp. Larvae of *S. montana* commonly occur in galleries of these insects.

The larvae were also quite frequently found in very moist bast, together with the sapromycetophagous larvae of *Mycetobia pseudogemella* Mamaev, 1987 (Mycetobiidae), the phloeophagous larvae of *Gnophomyia lugubris* (Limoniidae), and the predaceous larvae of *Chrysopilus nigrifacies* Nagatomi, 1968 (Rhagionidae). More detailed data on this environment are absent.

Sphegina spiniventris Stackelberg, 1953

Material: 1 male, 2 females, 3 larvae: **Russia:** *Primorskii Territory*, Ussuri Nature Reserve, No. 98, 26.IV.1969 (larvae under aspen bark); No. 262, 30.V.1969 (larvae in aspen wood); No. 35, 13.IV.1967 (larvae in maackia wood) (N. Krivosheina).

The species was described based on material from Lake Baikal region (Irkutsk Province); it is distributed in the southern regions of Siberia and also in Khabarovsk and Primorskii territories.

The larvae were found in the moist wood of fallen branches and trunk segments of broadleaved trees (aspen and elm), on low elevations along the Kamenushka River bank. In barkless trunk segments, larvae were found in the larval galleries of *Temnostoma angustistriatum* Krivosheina, 2002 (Syrphidae) and *Protaxymyia melanoptera* Mamaev et Krivosheina, 1966 (Axymyiidae). They occurred both in inhabited galleries and in abandoned ones, where they continued to feed on the secretions of fungi growing on the walls (the main biotope; see table).

Mature larvae were constantly recorded in the rotten bast fibers and in detritus accumulated in the bark fissures, on the wood surface or below. Puparia were found in the litter, together with the larvae of *Fannia* sp. (Fanniidae), *Telmatoscopus* sp. (Psychodidae), *Dasyhelea* sp., and *Forcipomyia* sp. (Ceratopogonidae). In fallen trunks with preserved bark, *Sphegina* larvae co-occurred with the phloeophagous larvae of *Gnophomyia acheron* Alexander, 1950 and *Libnotes kariyana* (Alexander, 1947) (Limoniidae).

Sphegina tenuifemorata Mutin, 1984

Material: 1 male, 4 females, 1 larva: **Russia**: Primorskii Territory, Ussuri Nature Reserve, No. 22, 16.IV.1969 (N. Krivosheina). The larva was collected in an aspen trunk.

The species was described based on the material from Sikhote-Alin Nature Reserve (Primorskii Territory) and is known only from Primorye.

The larvae develop in fallen aspen trunks with light moist bast and soft sapwood showing traces of activity of larvae of Cerambycidae. Larvae of *S. tenuifemorata* and *Temnostoma angustistriatum* were found at the boundary between bark and soil on the lower side of the trunk, in rounded tunnels normal to the trunk surface (the main biotope; see table). In these parts of the trunk, the bast layer was inhabited by the phloeophagous larvae of *Libnotes kariyana* and *Gnophomyia acheron*, and the thick of the wood, by the saproxylophagous larvae of *Elephantomyia subterminalis* Alexander, 1954 (Limoniidae). Larvae of *Discobola marginata* Alexander, 1924 (Limoniidae) were found in dense silky tubes covered with substrate particles on the bark surface with a whitish mycelial film.

Mature larvae were found in bark fissures with black dust; they were always accompanied by larvae of *Hammerschmidtia ingrica* (Syrphidae), *Solva* spp. (Xylomyidae), Scatopsidae, and Ceratopogonidae.

DISCUSSION

In view of the new data on their larval biology (table), the species of *Sphegina* can be divided into two ecological groups associated with different types of biotopes.

One group of species accompanies xylophagous insects, including ambrosia xylomycetophages (Buchner, 1953; Mamaev, 1966, 1977), in particular, ambrosia beetles of the genera *Trypodendron* Stephens, 1830 and *Xyleborus* Eichhoff, 1864 (Stark, 1952), relict flies of the family Axymyiidae (Mamaev and Krivosheina, 1966), and hoverflies of the genus *Temnostoma* (Krivosheina and Mamaev, 1962). The scheme of the gallery formation by ambrosia beetles and their association with ambrosia fungi were described by Stark (1952). *Sphegina* larvae mainly inhabit tunnels located in the wood where they feed on secretions of specific ascomycetes developing on tunnel walls. The larvae prefer tunnels directed normal to the longitudinal trunk axis, which are especially typical of the larvae of timber beetles and *Temnostoma* flies.

Two species, *Sphegina latifrons* and *S. montana*, were shown to be associated with bark beetles. Such associations obviously involve much more species of *Sphegina* and bark beetles but revealing them requires thorough and prolonged observations in nature.

The habitat associations between larvae of *S. clunipes*, *S. elegans*, and *S. spiniventris* with those of *Mesaxymyia kerteszi* and *Protaxymyia melanoptera* (Axymyiidae) have been established. The latter species commonly occurs in the habitats of the larvae of *Temnostoma angustistriatum*.

The larvae of *S. elegans*, *S. montana*, and *S. spiniventris* are regularly found in the habitats of larvae of the genus *Temnostoma*, which provide *Sphegina* larvae with specific trophic resources: mycelium and secretions of ascomycetes.

The second group of *Sphegina* species regularly accompanies the specific group of phloeophagous insects whose larvae process the bast of recently fallen tree trunks. As the result of their activity, semi-liquid substrates rich in microorganisms and lower fungi are formed under the bark. These are larvae of the genera *Libnotes* Westwood, 1876 (Limoniidae) (Krivosheina, 2008) and *Acanthonevra* Macquart, 1843 (Tephritidae) (Krivosheina, 1982).

The activity of phloeobiont insects, first of all such as larvae of the genus *Libnotes*, provides favorable conditions for development of *S. spiniventris* and *S. tenuifemorata* (see table).

Revealing the habitat associations between larvae of *Sphegina* and other xylobiont larvae, including those of ambrosia insects, and also differentiation between the main and secondary biotopes will allow the researchers to describe more precisely the conditions of development of *Sphegina* larvae and their role in xylophilous communities.

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