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Neuropteran Assemblage (Insecta) of a Pine Forest in the Republic of Tatarstan Revealed by Crown Bait Traps

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Abstract—The Neuroptera of the pine Tanaika Forest in the Republic of Tatarstan were studied using five beer-and-sugar bait crown traps operated continuously from April 30 to October 1, 2021. The chrysopids *Apertochrysa prasina* and *Chrysotropia ciliata* clearly dominate among 1043 collected specimens (17 species). The number of species stenotopic for pines (*Chrysopa dorsalis* and *Wesmaelius concinnus*) is very low. The large number of Chrysopidae in this forest, normally characteristic of a deciduous forest, and the rarity of species characteristic of pines, can be explained by the fact that the traps mainly attract Neuroptera that feed at the imaginal stage on pollen and honeydews, whereas almost all species characteristic of pines are predators. In addition, the traps on pine trees were located at a relatively low height (4–5 m from the ground), so they attracted more specimens from the nearest deciduous trees and deciduous undergrowth than from pines, whose canopies are located much higher. Eleven species of Neuroptera are recorded from the Republic of Tatarstan for the first time; 32 species are now known from the region.

Keywords: Neuroptera, the Republic of Tatarstan, fauna, pine forest, neuropteran assemblage

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The study of neuropteran assemblages of various ecosystems in Russia (different types of forests, steppes, tundra, agrocenoses, urban cenoses, etc.) is of great scientific interest and important both in theoretical and applied terms. Neuropteran assemblages of agrocenoses (e.g., Kovrigina and Malysheva, 1986; Krotova, 1989; Arefin and Kholin, 1992; Timraleev, 1992; Bokina, 2010) and urban cenoses (Kovrigina, 1979; Makarkin, 1985b; Kaverzina and Pleshanov, 2008; Kaverzina, 2012) have been studied more or less regularly. However, less attention is paid to the study of lacewing assemblages in natural ecosystems of Russia. Published works (Bukovsky, 1936; Pleshanov, 1979; Kovrigina, 1983, 1986, 1993; Makarkin, 1985a; Rokhletsova, 2003; Kaverzina, 2011; Shchurov and Makarkin, 2021) are mostly of a general nature, and the data presented in them are scattered and often incomplete; most importantly, they lack quantitative data (with the exception of the excellent work of V.I. Bukovsky (1936)). In fact, neuropteran assemblages of natural ecosystems in Russia have not yet been studied.

This includes the neuropteran assemblages of pine forests. The only significant study of this insect assemblage was carried out in the Republic of Komi (Yurkina, 2004, 2007). Unfortunately, it is very incomplete with regard to Neuroptera; only six species have been recorded, including *Myrmeleon formicarius* L., an antlion species not directly associated with pines. Significant data on lacewings living on pines in Russia are contained in some faunistic articles (Makarkin, 1987a, 1987b; Makarkin and Ruchin, 2020a, 2020b, 2021a, 2021b).

Pine forest crowns are high, so their inhabitants are difficult to see and collect. Net sweeping allows only collecting the material from the lower branches of trees. Light traps act indiscriminately, attracting individuals from very distant places. We used crown bait traps, which attract individuals from a more limited area, to collect the material.

The Tanaika Forest (*Pinetum hylocomiosum*) in Tatarstan is a good model for studying the pine forest insect assemblage. This is a compact, isolated forest of 956 ha, bounded in the south by the Kama River, in the north and east by settlements (the city of Elabuga and the village of Tanaika), and in the west by extensive grass meadows (a floodplain to a greater extent

and dry land to a lesser extent). Therefore, there are no extensive deciduous forests near it.

MATERIAL AND METHODS

The research was carried out in the Tanaika Forest on the right bedrock bank of the Kama River, which is a part of the Nizhnyaya Kama National Park (Republic of Tatarstan, Yelabuga District). The forest is considered man-made, since most of it was restored in the period of 1920–1960s from a small pine forest of natural origin.

The dominant species is Scotch pine (*Pinus sylvestris* L.), and there are areas of birch forest (*Betula pendula* Roth). White poplar *(Populus alba* L.) was noted in the coastal strip. Associated deciduous species are aspen (*Populus tremula* L.), rough elm (*Ulmus glabra* Huds.), heart-shaped lime (*Tilia cordata* Mill.), and Norway maple (*Acer platanoides* L.). The undergrowth mainly includes mountain ash (*Sorbus aucuparia* L.), apple (*Malus domestica* Borkh.), bird cherry (*Padus avium* Mill.), hazel (*Corylus avellana* L.), honeysuckle (*Lonicera xylosteum* L.), and euonymus *(Euonymus verrucosus* Scop.).

Five crown bait traps (CBTs) were placed on pine and apple trees on April 30, trapping insects continuously to 1 October 2021. Beer with sugar served as a bait, which soon naturally fermented (Ruchin et al., 2020). The traps were checked after 7–15 days.

CBT no. 1 (55.72881° N, 51.96900° E): on a pine at a height of 4.0 m; pine forest (density 0.5); in addition to pine, the canopy is formed by heart-shaped lime, Norway maple, rough elm, and aspen; the shrub stratum includes hazel, honeysuckle, mountain ash, and bird cherry.

CBT no. 2 (55.72528° N, 51.97698° E): on a pine at a height of 4.0 m; pine forest (density 0.4–0.5); next to it is a small area of Siberian larch (*Larix sibirica* Ledeb.); the shrub stratum is dense—acacia *Caragana arborescens* Lam., cotoneaster *Cotoneaster melanocarpus* Fisch. ex Blytt, wild rose *Rosa majalis* Herrm., and cherry *Prunus cerasus* L.

CBT no. 3 (55.73151° N, 51.98206° E): on a pine at a height of 4.0–5.0 m; old-growth, sparse pine forest (density 0.2–0.3); from the south there is a wide ravine with cherry, apple trees, and acacia.

CBT no. 4 (55.73046° N, 51.96269° E): on an apple tree (4 m high) at a height of 2.5 m (in the crown); a clearing behind the office building of the national park, surrounded by a pine forest (the age of the forest is 80 years).

CBT no. 5 (55.74358° N, 51.98314° E): on an apple tree (4 m high) at a height of 2 m (in the crown); pine forest (canopy density 0.3) with sparse aspen undergrowth (up to 10 m); the shrub stratum is sparse, represented by honeysuckle, currant *Ribes nigrum* L., and gooseberry *Ribes uva-crispa* L.

The material was determined by the first author using various sources (monographs, keys, articles describing individual species, etc.). It is deposited in the Federal Scientific Center of the East Asia Terrestrial Biodiversity (Vladivostok, Russia).

RESULTS

Among the 1043 lacewing specimens of 17 species collected in traps in the Tanaika Forest (11 of which are the first recorded from Tatarstan), the green lacewings *Apertochrysa prasina* and *Chrysotropia ciliata* clearly dominate (Table 1). *Chrysoperla carnea* is also very numerous. *Apertochrysa ventralis, Chrysopa gibeauxi, Nineta alpicola,* and *Cunctochrysa cosmia* are rather numerous. *Nineta vittata, N. flava, Chrysopa dorsalis, Apertochrysa flavifrons,* and *Cunctochrysa albolineata* are relatively common. Other species are rare or represented by a single specimen.

The composition of lacewings on coniferous (pine) and deciduous (apple) trees in this forest is approximately the same, but the relative abundance of some species (especially per tree) differ significantly. *Ch. ciliata, A. ventralis,* and *N. alpicola* are clearly more abundant on the apple trees, while *Ch. gibeauxi* and *C. cosmia* were on pines. The total number of lacewings per tree on apple trees is significantly higher than on pines.

DISCUSSION

Composition of the pine forest neuropteran assemblage. The codominance of *Ch. ciliata* in the neuropteran assemblage of this pine forest was absolutely unexpected. It is known throughout the southern Palaearctic as a relatively hygrophilous species, living exclusively on deciduous trees and shrubs (Gepp, 1974, 1977; Zelený, 1984; Makarkin, 1985a; Tsukaguchi, 1995; Volkovich, 2001; Monserrat, 2016), and as an exception on spruce (Gepp, 1977). However, we have previously collected this species on pines by similar crown bait traps in various regions of the Volga Region in mixed and pine forests (Makarkin, Ruchin, 2020a, 2020b, 2021a, 2021b), but its abundance there was much lower (Table 1).

The relative abundance in the pine forest of three species of the genus *Nineta* (especially *N. alpicola*) was also unexpected. It is believed that these species are only found on deciduous trees (Zelený, 1984; Makarkin, 1985a; Tsukaguchi, 1995; Monserrat, 2016), but previously they were regularly caught by crown bait traps on pine trees (Makarkin and Ruchin, 2020a, 2020b, 2021a, 2021b).

The four green lacewing species mentioned above are the most typical lacewing species of deciduous forests, and their abundance on deciduous trees is indeed much greater than on pines (Makarkin and Ruchin, 2020a, 2020b, 2021a, 2021b).

Table 1. Neuroptera collected by crown bait traps on pines and apple trees in the pine Tanaika Forest in 2021 (the number of individuals per tree is in parentheses) and on pines in mixed and pine forests in other regions of the Volga Region in 2019–2020 (summarized data from Makarkin, Ruchin, 2020a, 2020b, 2021a, 2021b), number of individuals

	Species of Neuroptera	Pine Tanaika Forest (Tatarstan)			Other parts of the Volga Region
		pines	apple trees	total	
	Chrysopidae (green lacewings)				
1	*Apertochrysa prasina* (Burmeister, 1839), s.l.	217(72.3)	162(81.0)	379	309
2	*Chrysotropia ciliata* (Wesmael, 1841)*	123(41.0)	185(92.5)	308	23
3	*Chrysoperla carnea* (Stephens, 1836), s.l.	62(20.7)	69(34.5)	131	94
4	*Apertochrysa ventralis* (Curtis, 1834)*	11(3.7)	41(20.5)	52	8
5	*Chrysopa gibeauxi* (Leraut, 1989)*	35(11.7)	7(3.5)	42	10
6	*Nineta alpicola* Kuwayama, 1956*	14(4.7)	22(11.0)	36	19
7	*Cunctochrysa cosmia* (Navás, 1918)*	19(6.3)	6(3.0)	25	–
8	*Nineta vittata* (Wesmael 1841)*	7(2.3)	10(5.0)	17	4
9	*Chrysopa dorsalis* Burmeister, 1839	7(2.3)	7(3.5)	14	–
10	*Apertochrysa flavifrons* (Brauer, 1851)*	10(3.3)	3(1.5)	13	31
11	*Nineta flava* (Scopoli 1763)*	6(2.0)	6(3.0)	12	4
12	*Cunctochrysa albolineata* (Killington, 1935)	5(1.7)	2(1.0)	7	1
13	*Chrysopa perla* (Linnaeus, 1758)	1(0.3)	1(0.5)	2	1
14	*Nothochrysa fulviceps* (Stephens, 1836)	1(0.3)	1(0.5)	2	–
15	*Chrysopa pallens* (Rambur, 1838)*	–	1(0.5)	1	–
16	*Chrysopa walkeri* McLachlan, 1893	–	–	–	3
	Hemerobiidae				
17	*Drepanepteryx phalaenoides* (Linnaeus, 1758)*	–	1(0.5)	1	–
18	*Wesmaelius concinnus* (Stephens, 1836)*	–	1(0.5)	1	1
	Total	518 (172.7)	525 (262.5)	1043	508

* Recorded for the first time from Tatarstan.

Chrysopa dorsalis is the only green lacewing species characteristic of pines. Its rarity in the collections made by CBTs is due to its being a predator (see below).

The relatively high abundance of *Cunctochrysa cosmia* in the pine Tanaika Forest is not surprising, because in Western and Eastern Europe it was collected mainly from pine trees (Monserrat et al., 2014; Dobosz, Junkiert, 2018). However, in Russia, it was previously observed mainly on deciduous trees (Makarkin and Ruchin, 2021a). Therefore, the ecology of this species in our country (the eastern part of the area) is not yet fully understood.

Chrysopa gibeauxi is rather common on pines (Table 1) (Makarkin, 1987a, b (reported as *Ch. septempuctata* Wesm.)). This is one of the few species of the genus (along with *Ch. pallens*) that have a mixed diet, feeding on both pollen and small arthropods. Therefore, its relative abundance in CBTs is quite understandable. The main part of the range of *Ch. pallens* is located further south, and this can explain its rarity in the Tanaika Forest.

The finding of two specimens of the large lacewing *Nothochrysa fulviceps* in a pine forest is rather accidental. The species is typical for broad-leaved forests, where it lives mainly in the crowns of oaks, and much more rarely on other species of deciduous trees (Zelený, 1984; Monserrat and Marín, 1994; Makarkin and Ruchin, 2019; Makarkin and Egorov, 2020; Makarkin and Mikhailenko, 2021). The capture of two other green lacewing species (*Chrysopa perla* and *Ch. walkeri*) by CBTs is also accidental; they are predators and live in the shrub and grass strata.

Other species of green lacewings, including the codominant *Apertochrysa prasina,* occur mainly on different species of deciduous trees and shrubs, but they may be found regularly on conifers (including pines) and are sometimes quite abundant (especially *Chrysoperla carnea*). All are phytophagous and glycophagous.

Adult Hemerobiidae are predators and are reasonably very rare in the CBT. Of these, *Drepanepteryx phalaenoides* is a eurytopic species that lives on both coniferous and deciduous trees, and *Wesmaelius concinnus* is a stenotopic species characteristic of pines.

Investigations into the entomofauna of pine forests in Europe using other methods of collection (Moer-

icke traps, flight interception traps, and net sweeping) show that lacewings are often found there (Klomp and Teekink, 1973; Czechowka, 1985, 1994, 1995, 1997; Saure and Kielhorn 1993; Monserrat and Marín, 1994; Burmeister et al., 2007; Gruppe, 2008). However, the abundance of many species on pines is small; they are either eurytopic in varying degrees or their occurrence on pines is accidental. There are few stenotopic species characteristic only of pines; these are mainly *Hemerobius stigma* Steph., *H. nitidulus* F., *Sympherobius fuscescens*, and *Wesmaelius concinnus* among Hemerobiidae; *Chrysopa dorsalis* among Chrysopidae; and *Parasemidalis fuscipennis* (Reuter) among Coniopterygidae. Although these may be occasionally found on other conifers and deciduous trees, they clearly prefer pines. The European species *Cunctochrysa cosmia* is also thought to live predominantly on various species of pines (Dobosz and Junkiert, 2018).

In Transbaikalia, pine trees are generally inhabited by the same neuropteran assemblage as in Europe (Makarkin, 1987a). Sixteen species of Hemerobiidae and five of Chrysopidae, including *Chrysopa dorsalis, Ch. gibeauxi* (reported as *Ch. septempunctata*), *Apertochrysa prasina,* and *Chrysoperla carnea,* were collected by net sweeping the lower branches of two pine species (*Pinus sylvestris* and *P. sibirica* Du Tour) in several places in Transbaikalia (from the border with Mongolia in the south to the southern coast of Baikal Lake and the vicinity of Chita in the north). In Transbaikalia, *Hemerobius stigma, H. nitidulus, Sympherobius fuscescens, Wesmaelius concinnus,* and *Ch. dorsalis* were found only on pines, i.e., almost the complete set of stenotopic species characteristic of pine.

As we noted earlier (Makarkin and Ruchin, 2019), crown bait traps attract mostly phytophagous and glycophagous lacewings, which feed in the imaginal stage mainly on pollen and honeydew; among Neuroptera, these are mainly green lacewings (Chrysopidae). The results of this study are consistent with this. However, adults of almost all species stenotopic for pines (*Chrysopa dorsalis* and Hemerobiidae species) are predators and feed mainly on aphids. Only *Cunctochrysa cosmia* is phytophagous. Therefore, the neuropteran assemblage of this pine forest shown by CBTs is only a part of the actual assemblage living there.

Comparing the neuropteran assemblage of the pine Tanaika Forest with the those of our previous collections on pines in other regions of the Volga Region using CBTs, we can state that this consists in general of the same species (Table 1). Therefore, this assemblage undoubtedly reflects the actual species composition of phytophagous and glycophagous lacewings in the pine forests of the Volga Region.

The results of this study also show that CBLs attract individuals from a relatively limited area. In particular, the large number of lacewings collected in the pine Tanaika Forest, which are typical for a deciduous forest, such as *Chrysotropia ciliata, Nineta alpicola,* and *N. vittata*, can be explained by the fact that the traps on pine trees were located at a relatively low height (4–5 m from the ground). They definitely attracted more specimens from the nearest deciduous trees and from the undergrowth (shrubs and undergrowth of deciduous trees) than from pines canopies, which are located much higher. Although the data do not reflect the real ratio of the abundance of species living on pines, they significantly expand our knowledge of the pine forest lacewing assemblage.

Neuropteran fauna of Tatarstan. Previously, 21 species of 5 families of lacewings were known from Tatarstan: Chrysopidae (11 species), Myrmeleontidae (5 species), Hemerobiidae (3 species), Sisyridae (1 species), and Ascalaphidae (1 species) (Hagen, 1858; Jakowleff, 1869; Kovrigina, 1978; Zakharenko, 1988; Shafigullina, 2006a, 2006b; Krivokhatsky, 2011; Leontiev, 2013, 2014; Shulaev, 2016a, 2016b). Of these, the record of *Chrysopa septempunctata* is unreliable, since this species is currently divided into *Chrysopa pallens* and *Ch. gibeauxi*. In this article, 11 species of Chrysopidae and Hemerobiidae are recorded for the first time from the region, and now 32 species of Neuroptera are known in Tatarstan. Of these, *Cunctochrysa cosmia* was only recently recorded for the first time from Russia (Ulyanovsk and Penza oblasts and Mordovia) (Makarkin and Ruchin, 2021a). In these regions, it was found on oak, birch, pine, and spruce.

Chrysopa perla is one of the most common species of the family in central European Russia, also common in Tatarstan (Kovrigina, 1978; Shafigullina, 2006a; Leontiev, 2013; Shulaev, 2016a). Therefore, its inclusion in the Red Data Book of Tatarstan is a misunderstanding, which was noticed after its 2nd edition (Anikin, 2007). However, the species still appears in the 3rd edition (Shulaev, 2016a), which undoubtedly greatly discredits the significance of the Red Data Books in general.

CONCLUSIONS

This study made it possible to reveal the contradictory features of crown bait traps using fermented beer as the bait. On one hand, the lacewings collected in this way undoubtedly reflect the real assemblage of phytophagous and glycophagous lacewings in the insect community of the ecosystem; on the other hand, it is impossible to study the whole assemblage of lacewing predators of this ecosystem using only this method. To completely evaluate the neuropteran assemblages of such forests, crown bait traps must be supplemented by other methods of collection.

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CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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