

## Group oviposition in species of the genus *Urostylis* Westwood, 1837 (Heteroptera: Urostylididae)

### Групповые яйцекладки видов рода *Urostylis* Westwood, 1837 (Heteroptera: Urostylididae)

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КЛЮЧЕВЫЕ СЛОВА: клопы, Heteroptera, Urostylididae, отека, нимфы, родительская забота, групповые яйцекладки, Приморский край, *Quercus mongolica*.

ABSTRACT. Examples of group oviposition by females of three pentatomoid species — the bugs *Urostylis annulicornis* Scott, 1874, *U. lateralis* Walker, 1867, and *U. trullata* Kerzhner, 1966 — in habitats favorable for development of their offspring are reported in this article for the first time. Females lay egg clutches on the inner side of the rhytidome of Mongolian oak, *Quercus mongolica*, and coat them with a layer of jelly-like secretion. By spring, a small colony forms under the bark where overwintered nymphs of various species become provided with abundance of food and protection. The shapes of oothecae of the three species are compared and described; the season, timing, and duration of oviposition are indicated. Joint oviposition can lead to outbreaks in the abundance of *Urostylis* species in some years.

РЕЗЮМЕ. В статье впервые обсуждаются примеры групповых яйцекладок у самок трех видов щитников the bug *Urostylis annulicornis* Scott, 1874, *U. lateralis* Walker, 1867 и *U. trullata* Kerzhner, 1966 в благоприятных местах для развития потомства. Кладки, покрытые выделяемым самкой слоем желеобразного секрета, располагаются на внутренней стороне ритидома дуба монгольского. К весне под корой образуются небольшая колония, где после зимовки личинки разных видов обеспечены обильным питанием и защитой. Описаны сравнительные

формы кладок трех видов, указаны время сезона и продолжительность яйцекладок. Совместные кладки в отдельные годы могут приводить к вспышкам численности видов *Urostylis*.

### Introduction

The family Urostylididae is a group of hemipteran insects of the Old World distributed from India across the Eastern part of Russia to Japan and the countries of Southeast Asia. The family currently comprises eight genera and 172 species [Rider *et al.*, 2018]. Seven species of two genera have been recorded from the south of the Russian Far East: two species from the genus *Urochela* Dallas, 1850 and five species from the genus *Urostylis* Westwood, 1837 [Kanyukova, 1988, 2010].

The Urostylididae species living in crowns of tall oaks become visible to observers only after reaching the adult stage. The reproductive life history of bugs in nature is inaccessible to observation and, therefore, has remained unstudied for a long time. In a review of the species from this family [Kerzhner, 1966] and a publication on records of new species [Kerzhner, Petrova, 1975], overwintering bugs in the adult phase were mentioned, but those were *Urochela quadrinotata* (Reuter, 1881). Until recently, there has been lack of information about the biology of *Urostylis* species in Russia. Based

on the results of experiments conducted in their natural habitats, we have published a series of articles providing the features of ontogeny and development in *Urostylis annulicornis* Scott, 1874, *U. lateralis* Walker, 1867, and *U. trullata* Kerzhner, 1966 in the south of Primorsky Krai. We have described the places used for oviposition, the shapes of oothecae, the sequence of molts in nymphs of all instars, their feeding habits at different stages, timing of development of species, and their reproductive behavior [Kanyukova *et al.*, 2023a, b; 2024; Markova *et al.*, 2024].

As known, hemipterans have evolved both maternal and paternal care for offspring, manifested as protection of eggs and nymphs [Tallamy, Schaefer, 1997]. Maternal care is much more common than paternal among Heteroptera and is more frequently observed in Pentatomidae. It has been studied in Acanthosomatidae and Cydnidae and described from other Pentatomidae families [Schuh, Weihrauch, 2020].

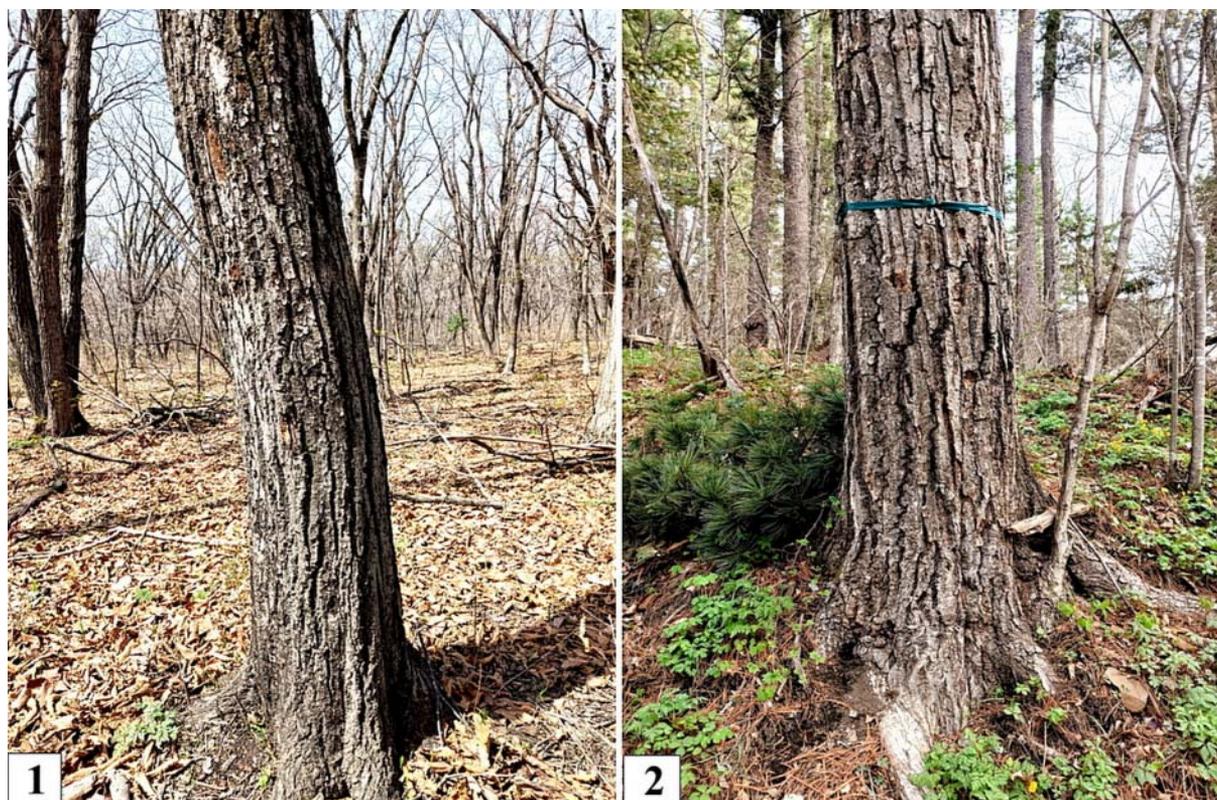
In *Urostylis* species, care for the offspring is observed during oviposition: female coats her eggs with a jelly-like secretion, thus, forming an ootheca that is protected from drying and freezing in winter. Besides protecting against mechanical damage and bacterial infection, it plays the role of a nutrient reserve, contains amino acids to support nymph's growth, and is supplemented by symbiotic intestinal bacteria transferred

to the nymphs [Kobayashi, 1953, 1965; Kaiwa *et al.*, 2014]. The eggs, having three respiratory horns, are laid in autumn in cracks in the bark outside the trunk or on the inner surface of the detached bark (rhytidome) of the host plant, where the ootheca overwinters. Such a parental care of offspring allows nymphs to start growing and developing very early in the spring season before the host plant (*Quercus* spp.) forms leaves [Kanyukova *et al.*, 2023a, b, 2024; Markova *et al.*, 2024]. Among Heteroptera, this method of reproduction is known only for a single family, Urostylidae.

## Material and methods

We conducted our study in forest biotopes in southern Primorsky Krai (Far East of Russia): Ussuriysky Urban Okrug, vicinity of the village of Kaimanovka (43°37'49" N; 132°13'49" E); vicinity of the village of Kamenushka (43°37'23" N; 132°13'50" E); the protected area of the Land of the Leopard National Park, Ussuriysky Nature Reserve (43°40'00" N; 132°30'00" E); and Vladivostok Urban Okrug, city of Vladivostok, Akademgorodok (43°19'09" N; 131°92'11" E). The study lasted from April through November, 2022–2024 (Figs 1–2).

We examined Mongolian oak trees (*Quercus mongolica* Fisch. ex Ledeb.) to estimate their occupancy by bugs of the family Urostylidae and described and collected hemipteran oothecae. We carried out continuous observations on the reproductive behavior and oviposition of *U. annulicornis*, the



**Figs 1–2.** Examined biotopes: 1 — oak forest (Vladivostok, Akademgorodok); 2 — coniferous/deciduous forest with *Quercus mongolica* (Ussuriysky Nature Reserve). Photo by M.V. Maslov.

**Рис. 1–2.** Исследованные биотопы: 1 — дубовый лес (г. Владивосток, Академгородок); 2 — хвойно-широколиственный лес с *Quercus mongolica* (заповедник «Уссурийский»). Фото М.В. Маслова.

development and molt of nymphs of *U. annulicornis*, *U. trullata*, and *U. lateralis*, with measurements and photography. The methodology of the study was described in detail in our earlier publications [Markova *et al.*, 2018, 2024; Kanyukova *et al.*, 2023a, b, 2024].

We collected a total of 33 egg clutches of *Urostylis* species in forest biotopes and obtained five more clutches of *U. annulicornis* in stationary cages set up in natural habitats. In this paper, we provide examples of arrangement of egg clutches of *Urostylis* and the observed variations in the behavior of females when choosing micro-habitats for oviposition under a single bark fragment. For reliable identification of species, we reared the egg clutches collected from each rhytidome fragment, laid both jointly and singly, to the winged adult stage. The information about group oviposition of different *Urostylis* species is here reported for the first time.

The material was deposited in the collection of the Zoological Museum of the Far Eastern Federal University (FEFU, Vladivostok).

In the study, we used photographs and short communications provided by Yu.A. Semeykin.

The abbreviation “m” used in the text is mean value.

## Results

Reproductive activity of adult bugs was observed in autumn, with the onset of night frosts, from early September to late October. In nature, active adults were found under the bark on oak trunks in forest biotopes, where their presence was detected by the characteristic sharp bug odor (the secret containing cimicic acid emitted by the scent glands of representatives of Heteroptera) until mid-November. A male performed post-copulatory protection of a female, maintaining a tandem (pair) for a long time, thereby preventing her from mating with other males. Oviposition of wintering eggs, made repeatedly, began after the first ten days of October at a range of daily temperatures from +2.0 to +23.4 °C. The female laid portions of eggs next to the previous one or forming a new row without returning to the previous clutch.

Egg clutches (oothecae) were placed on the inner surface of the oak rhytidome. The diameter of the examined trees ranged from 0.2 to 0.7 m, and the thickness of the rhytidome over the egg clutches ranged from 0.3 to 1.4 cm. The egg clutches were usually located at a

height of 0.2 to 1.7 m (m = 1.2 m) above the ground. In most cases, the clutches were located on the southern side of the trunk. The distance between the trees with egg clutches ranged from 0.2 to 250 m. The entire egg mass was evenly covered with a dense gelatinous (jelly-like), olive-colored membrane.

In the course of our study, we collected single and group egg clutches of three species, as well as egg clutches that contained oothecae of two (*U. annulicornis* + *U. trullata*) and three different species (*U. annulicornis* + *U. trullata* + *U. lateralis*) at a time. The proportion of group egg clutches was 18.2% of the total number recorded.

When the clutches were located under a single bark fragment, the following variants were distinguished:

(1) clutches with “gaps”: parallel arrangement of two oothecae in width, or continuation of one clutch above the other in length, with a break or at some distance from each other;

(2) clutches arranged in “tiers”, at a distance from each other, where bugs use the layered structure of the rhytidome.

In most cases, the rows were oriented vertically relative to the ground (Figs 3–5).

The shape of *U. annulicornis* egg clutch was elongated, sausage-like (see Fig. 3). The ootheca (egg mass) length varied from 7.5 to 16 mm (m = 8.8); the width, from 2.5 to 3 mm (m = 2.2) (a single row of eggs) or from 5.4 to 7 mm (m = 6.2) (two or three parallel rows of eggs). Eggs in the ootheca formed at least two horizontal layers located one above another). The number of eggs in clutches was from 26 to 109 (m = 50) (Table 1).

The clutch of *U. trullata* was elongated, flatter than the sausage-like one, sometimes in the form of an irregular, zigzag row (Fig. 4). The ootheca length varied from 8 to 12 mm (m = 10.2); the width, from 2.5 to 3 mm (m = 2.8). Eggs in the ootheca formed up to 3–4 parallel rows and 2–4 layers. The number of eggs in clutches was from 10 to 62 (m = 27.4). When a female placed several clutches at the same rhytidome site, the maximum number of eggs in them reached 135.

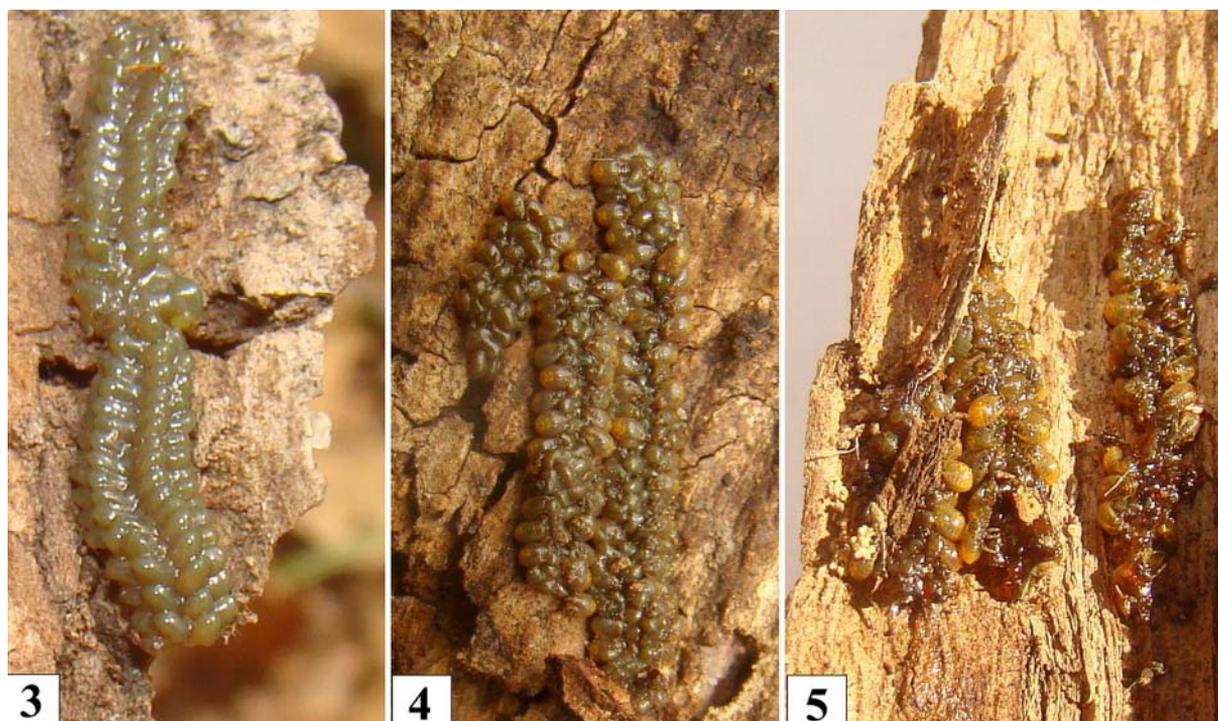
The clutch of *U. lateralis* was elongated in shape (only a single isolated egg clutch was obtained). The ootheca was 3 mm in length, 2.5 mm in width, and was

**Table 1.** Characteristics of egg clutches in *Urostylis* species.  
**Таблица 1.** Характеристики яйцекладок видов *Urostylis*.

Species	Ootheca length, mm	Ootheca width, mm	Number of parallel rows	Number of horizontal layers	Number of eggs per clutch
<i>U. annulicornis</i>	7.5–16 (m = 8.8)	2.5–3 (m = 2.2) (single row) 5.4–7 (m = 6.2) (two or three rows)	3–4	2–3	21–109 (m = 50)
<i>U. trullata</i>	8–12 (m = 10.2)	2.5–3 (m = 2.8)	3–4	2–4	10–62 (m = 27.4)
* <i>U. lateralis</i>	3	2.5	3	2	17

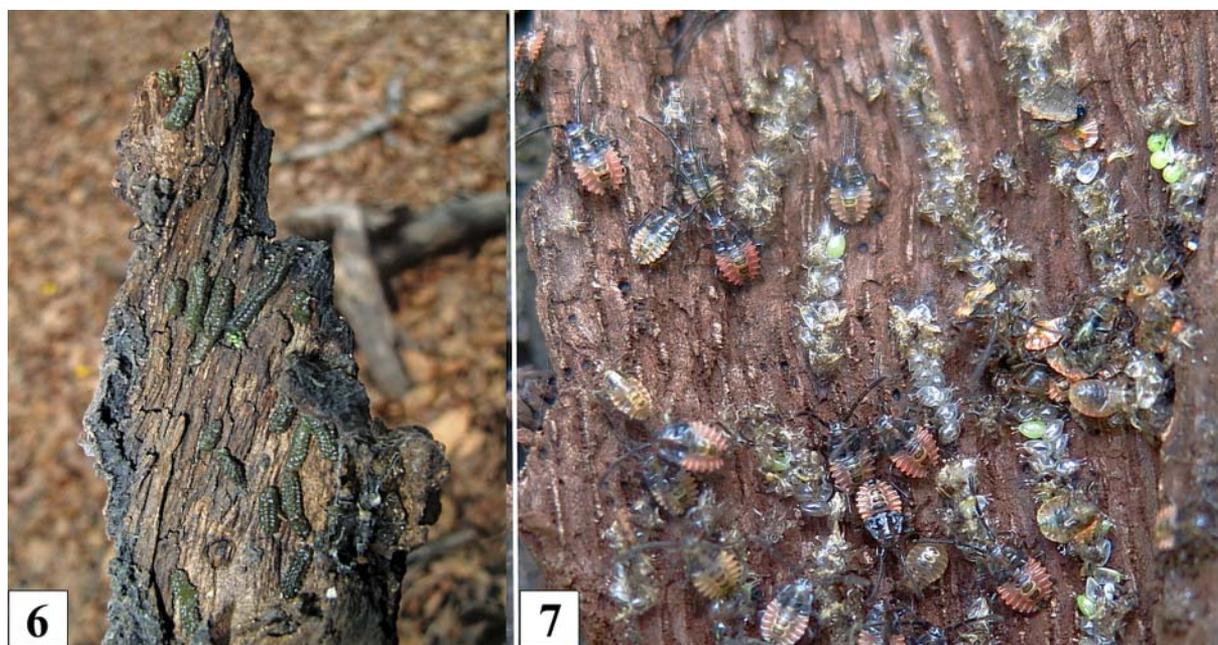
Note: \* one isolated egg clutch was obtained.

Примечание. \* получена изолированно 1 яйцекладка.



**Figs 3–5.** Egg clutches of *Urostylis* species: 3 — arrangement of one egg clutch of *U. annulicornis* above another in length; 4 — clutch of *U. trullata* arranged in a zigzag row (eggs and instar I nymphs are visible); 5 — group egg clutches of *U. trullata* (left) and *U. annulicornis* (right) (eggs and instar I–II nymphs are visible). Photo by M.V. Maslov.

**Рис. 3–5.** Яйцекладки видов *Urostylis*: 3 — расположение одной кладки *U. annulicornis* над другой в длину; 4 — кладка *U. trullata* в виде зигзагообразного ряда (видны яйца и личинки I возраста); 5 — групповые яйцекладки *U. trullata* (слева) и *U. annulicornis* (справа) (видны яйца и личинки I–II возраста). Фото М.В. Маслова.



**Figs 6–7.** Egg clutches and nymphs of *Urostylis* sp.: 6 — arrangement of oothecae on a bark fragment, March 31, 2015; 7 — instar III nymphs, May 10, 2015, Vladivostok, Akademgorodok. Photo by Yu.A. Semeykin.

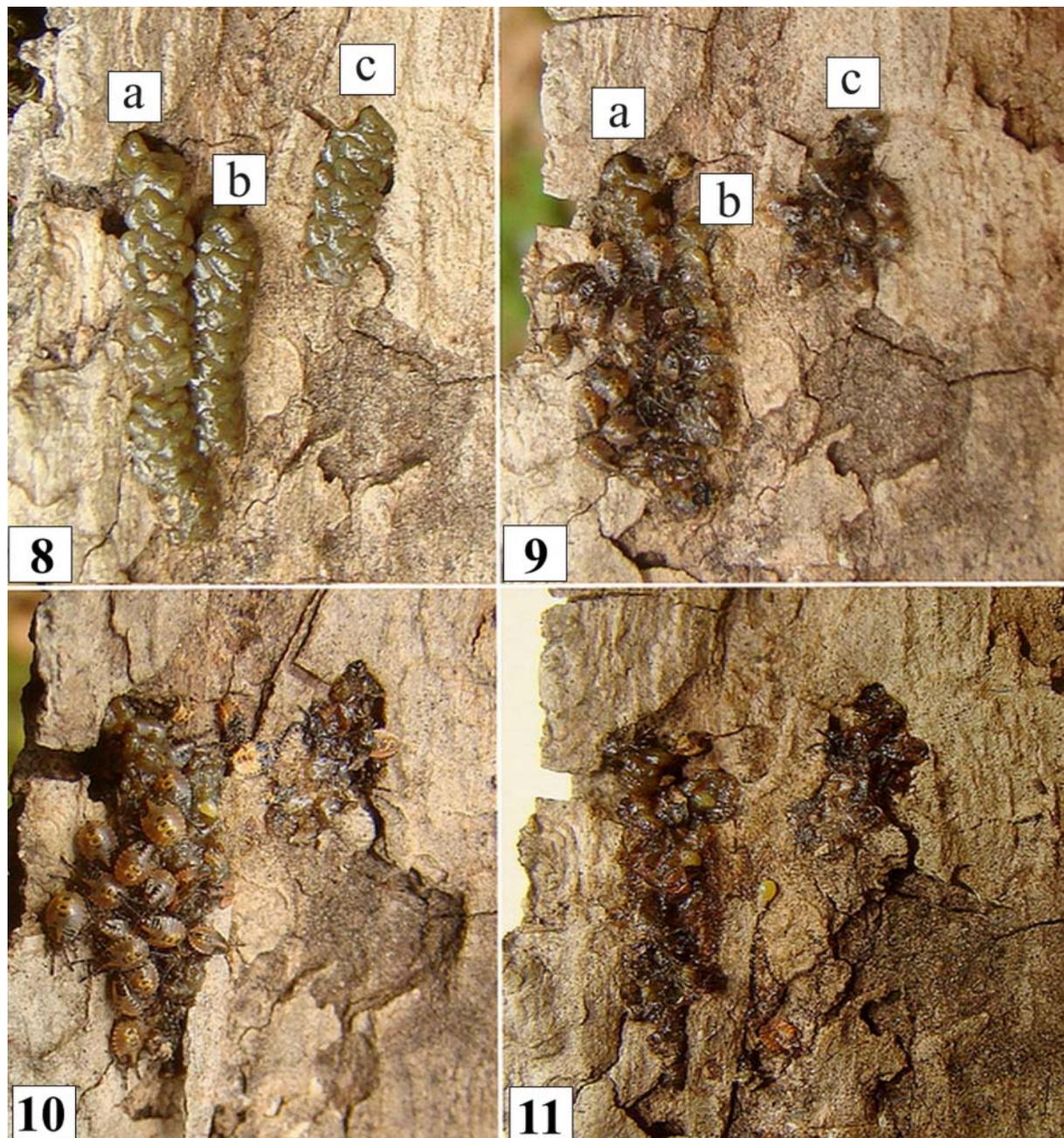
**Рис. 6–7.** Яйцекладки и личинки *Urostylis* sp.: 6 — расположение оотек на фрагменте коры, 31.III.2015, 7 — нимфы III возраста, 10.V.2015, г. Владивосток, Академгородок. Фото Ю.А. Семейкина.

formed by 3–4 parallel rows of eggs. The number of eggs per clutch was 15–18.

Single egg clutches were placed over an area from 7.2 to 62 mm<sup>2</sup> of the rhytidome ( $m = 23.5$ ). When a female added clutches under the same fragment to continue the previous clutch, the occupied area in *U. annulicornis* increased to 0.6 and 0.9 cm<sup>2</sup>; in *U. trullata*, to 9.6 and 11.5 cm<sup>2</sup>. The total area occupied by all clutches

of different species was from 0.3–0.6 to 11.5–12 cm<sup>2</sup> and more.

Yu.A. Semeykin, who photographed oothecae and nymphs of *Urostylis* sp., reported as follows: “the clutches were located all along the circumference of the trunk in places where the bark came off, starting almost from the base of the trunk to a height of 1.5 m.” An analysis of the photographic material provided by Semeykin



**Figs 8–11.** Development of two *Urostylis* species from group egg clutches: 8 — parallel positions of oothecae of *U. trullata* (a, c) and *U. annulicornis* (b), April 9, 2022; 9 — aggregation of instar II nymphs and egg remains, April 25, 2022; 10 — aggregation of instar III nymphs, April 30, 2022; 11 — instar III nymphs left the shelter, with remains of dead eggs and nymphs visible, May 7, 2022. Photo by M.V. Maslov.

**Рис. 8–11.** Развитие двух видов *Urostylis* из совместных яйцекладок: 8 — параллельное расположение оотек *U. trullata* (а, с) и *U. annulicornis* (b), 9.IV.2022; 9 — скопление нимф II возраста и остатки яиц, 25.IV.2022; 10 — скопление нимф III возраста, (а, b, с), 30.IV.2022; 11 — нимфы III покинули убежище, видны остатки погибших яиц и личинок, 7.V.2022. Фото М.В. Маслова.

showed that at least 16 clutches were located within an approximately 50 cm<sup>2</sup> of one of the bark fragments (Figs 6–7). According to the material that the authors collected in 2023 in the same biotopes, group oviposition could involve 2–3 species of *Urostylis*.

According to our observations on oviposition by *U. annulicornis* in stationary conditions, each female laid 2–3 clutches with the numbers of eggs from 15 to 43 per each. The process of laying 15–26 eggs lasted for up to 24 h. Laying more eggs lasted for 1.5 days. The total oviposition time under a single bark fragment took from 2.5 to 4 days. The total number of eggs laid by one female before her natural death by the time when night temperatures dropped to below zero values (–4.5 °C) ranged from 50 to 85. In forest biotopes, the number of eggs in clutches of *U. annulicornis* under a single bark fragment ranged from 21–33 to 50–109 (and from 10–62 to 135 in *U. trullata*). By summarizing data, we came to the conclusion that females of *Urostylis* in forest biotopes can place all eggs under a bark fragment of a single trunk during 2.5–5 days or lay eggs in portions for 1–1.5 days, moving to trunks of other trees.

Instar I nymphs of all species hatch in the following spring before the onset of the oak vegetation season and develop without leaving the bark, feeding on the gelatinous, jelly-like mass of their ootheca. Instar II nymphs were recorded since the end of the second ten-day period of April, and their movement and distribution under the bark in small groups of 6–8 individuals was observed since the beginning of the third ten-day period of April. Nymphs continued to feed on the remaining jelly-like membrane of the ootheca until late April. When a large number of individuals gathered under a single fragment, the nymphs also consumed the membrane of a neighboring ootheca that included remains of dead eggs or undeveloped nymphs, which was obviously an evidence of cannibalism (Figs 8–11).

The quantity and quality of secretion was sufficient to support the nutrition and growth of nymphs up to the instar III age. As oak leaves germinated in early May, instar III nymphs left their shelter, began to feed on sap of unfolding leaves, and moved upward into the tree crown.

## Conclusion

We may assume that the group oviposition by females of several species ensures the maximum use of convenient places favorable for the development of their offspring. The females probably mark the sites with their scent, thus, attracting other members of the genus. Different species aggregate here and, as a result, a small colony is formed under the bark where nymphs, after overwintering, become provided with abundance of food and protection.

In earlier reviews [Kanyukova et al., 2023a], we mentioned population outbreaks of these bugs in Primorsky Krai. V.N. Kuznetsov [2000] reported the mass breeding of *U. annulicornis* and *U. trullata* in the Sikhote-Alin Nature Reserve in 1998 and the noticeable damage they

caused to oak foliage. He also mentioned the presence of these species on other broad-leaved trees.

It is likely that the outbreaks of abundance of *Urostylis* bugs observed in some years included a few, rather than one, species of this genus. Due to the overpopulation, the insects developed a herd instinct, and *Urostylis* bugs made mass flights from forests to open spaces. In July 2022 (according to entomologist M.E. Sergeev), they were observed on the sea coasts in southeastern Primorye, where thousands of bugs were found washed up on shore.

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**Competing interests.** The authors declare no competing interests.

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