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## **COCOON SPINNING BEHAVIOR OF *TRIOXYS CURVICAUDUS* MACKAUER, 1967 (HYMENOPTERA, BRACONIDAE: APHIDIINAE)**

First results on cocoon-spinning behavior of aphid parasitoid *Trioxys curvicaudus* Mackauer, 1967 are reported. Infested host aphids *Eucalipterus tiliae* (Linnaeus, 1758) were collected in May 2012 on *Tilia cordata* Miller. Last instar larva of *T. curvicaudus* inside aphid skin just before mummy formation were placed in Petri dish, where the larva started to spin a cocoon. The cocoon spinning behavior was videorecorded, and duration of all activities were measured with timer. Three steps in the process of cocoon spinning by *T. curvicaudus* last instar larva were distinguished: 1) attachment of the host aphid skin to the substrate; 2) spinning the outer layer of cocoon; 3) spinning the inner layers of cocoon. Two main phases in cocoon spinning behavior of the last instar larva inside aphid skin were allocated: the active phase and the resting phase. The active phase includes 3–6 cycles of spinning that last 1.5–2 seconds each, alternating with the movement of the larva to the next section of the inner surface of mummy; in the area between the abdomen and the thorax of the aphid, and in the case of defects in aphid skin the spinning lasts longer — 30–50 seconds. Further research is needed for detalization of the cocoon spinning process.

**Key words:** *Trioxys curvicaudus*, larva, behavior, cocoon spinning, Aphidiinae, Braconidae.

### **Introduction**

*Trioxys curvicaudus* Mackauer, 1967 belongs to subfamily Aphidiinae (Braconidae), all representatives of which are specialized koinobiont endoparasitoids of aphids (Давидьян, 2005, 2007; Тобиас, Кирияк, 1986). *T. curvicaudus* is common parasitoid of *Eucalipterus tiliae* (Linnaeus, 1758) on *Tilia* spp. (Yu et al., 2012) and was used in biocontrol of this species (Zuparko, 1983).

Aphidiines play an important role in aphid control in nature and agriculture. They infest aphids and develop inside during 12–18 days consuming host resources (Иванова-Казас, 1954, 1956; Sabri et al., 2011; Starý, 1970). Majority of aphidiine species pupates inside mummified aphid, except representatives of Praini, which spin their cocoons mostly under aphid mummy (Starý, 1970).

Despite high interest to process of mummy formation, its diversity, utility for aphidiine identification and systematics (Давидьян, 2009; Kavallieratos, Lykouressis, 2004; Legrand et al., 2004; Starý, 1970, 1974), we found only few general descriptions on aphidiine cocoon-spinning behavior, that include mostly information on the maner of

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attachment of parasitized aphids to substrate (Ainslie, 1909, 1917; Starý, 1970), more details on behavior are given in article concerning biology of *Praon exsoletum* (Nees, 1811) (Schlinger, Hall, 1960). We have recorded and described cocoon-spinning behavior of *T. curvicaudus*.

### Material and methods

Infested host aphids *E. tiliae* were collected in May 2012 on *Tilia cordata* Miller in the center of Kyiv City. The study was conducted under laboratory conditions. Last instar larva of *T. curvicaudus* inside aphid skin before mummy formation were placed in Petri dish. The larva started to spin a cocoon and attach the aphid skin through the cut on its ventral side to the glass that gave us the possibility to observe the process. The cocoon spinning behavior was videorecorded, and duration of all activities were measured with timer. From formed mummy imago of *T. curvicaudus* (♀) emerged.

Material is deposited in collection of I. I. Schmalhausen Institute of Zoology of National Academy of Sciences of Ukraine, Kyiv (SIZK).

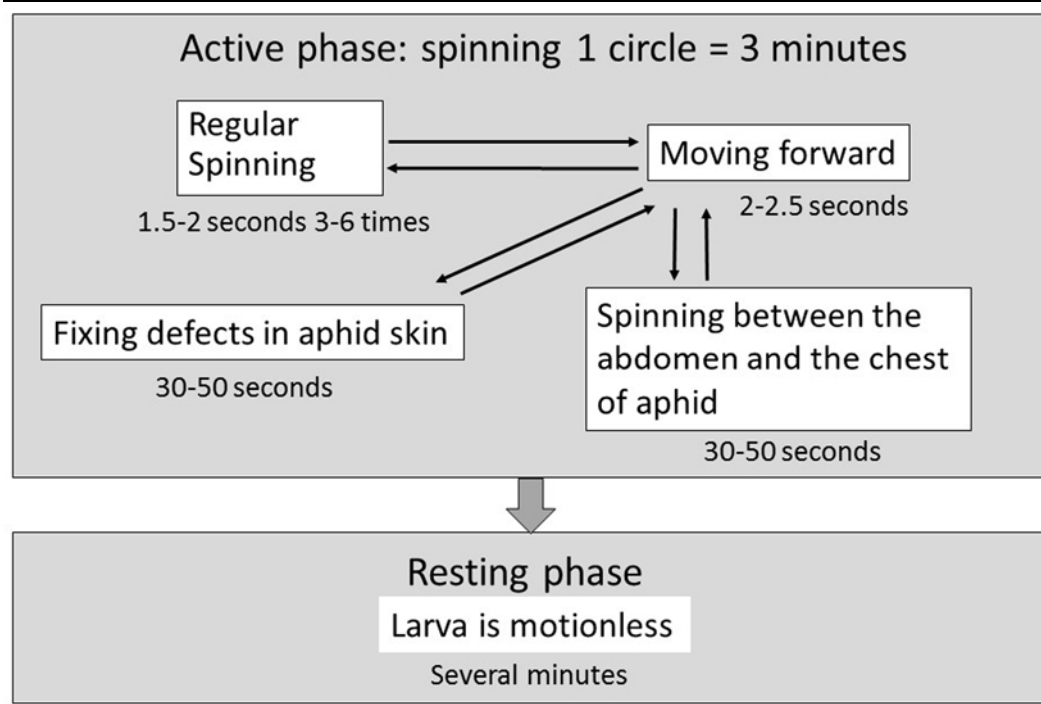
### Results and discussion

In a process of mummy formation, when empty skin of consumed aphid is still soft, last instar larva makes a longitudinal cut on the medium of its ventral side. The larva slightly widens previously made cut and attaches the mummy to the surface of the substrate with silky glands secretions (fig. 1). Constantly moving inside the mummy in a circular pattern larva gives it a spherical shape. The larva moves horizontally clock-wise and then in an opposite direction. Movement of the larva head resembles the figure of eight ( $\infty$ ): <movement to the substrate>—<attaching>—<movement to the mummy>—<attaching>. When moving inside mummy the larva is curved with its ventral part outwards, it makes one full circle in about 3 minutes. In 20 minutes, the material of *T. curvicaudus* cocoon slightly closed the cut in the aphid skin, and cocoon spinning was prolonged. During one hour of cocoon spinning observation larva rested several times;



**Fig. 1.** *Trioxys curvicaudus* spins cocoon inside *Eucalipterus tiliae*: 1 — beginning of process; 2 — after 20 minutes.

In cocoon spinning behavior of the last instar larva of *T. curvicaudus* inside aphid skin, two main phases were allocated: the active phase and the resting phase (fig. 2). The active phase includes 3–6 cycles of spinning (1 cycle: <movement to the substrate>—<attaching>—<movement to the mummy>—<attaching>) lasting 1.5–2 seconds each and alternating with the movement of the larva to the next section of the inner surface of mummy. In the area between the abdomen and the thorax of the aphid, and in the case of defects in aphid skin, the cocoon spinning activity lasts longer — 30–50 seconds — for covering these gaps. At the resting phase, the larva was motionless (inactive) during several minutes.



**Fig. 2.** Two main phases in cocoon spinning behavior of the last instar larva of *Trioxys curvicaudus*.

aphid skin became more rounded and strong and started to remind mummy.

Our observations in general confirm data of previous authors (Ainslie, 1909, 1917; Schlinger, Hall, 1960; Starý, 1970). E. I. Schlinger and J. C. Hall (1960) described five steps of cocoon construction for *P. exsoletum*. In the process of cocoon spinning of *T. curvicaudus* we can distinguish 3 steps: 1) attachment of the host aphid skin to the substrate; 2) spinning the outer layer of cocoon; 3) spinning the inner layers of cocoon. These steps are analogous with those allocated by E. I. Schlinger and J. C. Hall (1960) accept the aspect connected with pupation under aphid skin that is characteristic for *Praon* spp.

There is the difference in data for timing of last instar larva activities. Their length may be specific to certain species and on the opinion of C. N. Ainslie (1909) can be determined by climatic conditions and internal state of larva.

We give new information on *T. curvicaudus* larva spinning behavior phases. Nevertheless, because our observation were made only on one larva, more detailed research is needed to follow the process in controlled climatic conditions and on greater number of specimens. In addition, there is a need to study direction-changing behavior of larva in the process of cocoon spinning.

### Conclusion

In the process of cocoon spinning of *T. curvicaudus* last instar larva three steps were distinguished: 1) attachment of the host aphid skin to the substrate; 2) spinning the outer layer of cocoon; 3) spinning the inner layers of cocoon. In cocoon spinning behavior, we allocate the active phase and the resting phase. Further research is needed to confirm timing of the phases and investigate direction-changing behavior of larva.

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ПОВЕДІНКА ПІД ЧАС ПЛЕТІННЯ КОКОНА *TRIOXYS CURVICAUDUS* МАСКАУЕР, 1967 (HYMENOPTERA, BRACONIDAE: APHIDIINAE)

Наведено перші результати з вивчення поведінки під час плетіння кокона паразитоїдом попелиць *Trioxys curvicaudus* Маскауер, 1967. Заражені попелиці-хазяї *Eucalipiterus tiliae* (Linnaeus, 1758) були зібрані в травні 2012 на *Tilia cordata* Miller. Личинку останнього віку *T. curvicaudus* всередині шкірки попелиці до утворення мумії було поміщено у чашку Петрі, де вона почала плести кокон.

Поведінку під час плетіння кокона було записано на відео, тривалість усіх дій виміряно за допомогою секундоміра. У процесі плетіння кокона личинкою *T. curvicaudus* останнього віку виокремлено 3 етапи: 1) прикріплення шкірки попелиці-хазяїна до субстрату; 2) плетіння зовнішнього шару кокона; 3) плетіння внутрішніх шарів кокона. У поведінці личинки останнього віку під час плетіння кокона всередині шкірки попелиці виділено 2 фази: активну фазу та фазу спокою.

Активна фаза включає в себе 3–6 циклів плетіння по 1,5–2 секунди кожен, що чергуються з переміщенням личинки на наступну ділянку внутрішньої поверхні мумії; у зоні між червцем та грудьми попелиці, а також за наявності розривів у шкірці хазяїна плетіння триває у цих місцях довше — 30–50 секунд. Потрібні подальші дослідження для уточнення деталей процесу плетіння кокона.

К л ю ч о в і с л о в а: *Trioxys curvicaudus*, личинка, поведінка, плетіння кокона, Aphidiinae, Braconidae.

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ПОВЕДЕНИЕ ВО ВРЕМЯ ПЛЕТЕНИЯ КОКОНА *TRIOXYS CURVICAUDUS* МАСКАУЕР, 1967 (HYMENOPTERA, BRACONIDAE: APHIDIINAE)

Даны первые результаты по изучению поведения во время плетения кокона паразитоидом тлей *Trioxys curvicaudus* Маскауер, 1967. Зараженные тли-хозяева *Eucalipiterus tiliae* (Linnaeus, 1758) были собраны в мае 2012 на *Tilia cordata* Miller. Личинка последнего возраста *T. curvicaudus* внутри шкурки тли до образования мумии была помещена в чашку Петри, где начала плести кокон. Поведение

ние во время плетения кокона было записано на видео, продолжительность всех действий измерена с помощью секундомера. В процессе плетения кокона личинкой *T. curvicaudus* последнего возраста выделено 3 этапа: 1) прикрепление шкурки тли-хозяина к субстрату; 2) плетение внешнего слоя кокона; 3) плетение внутренних слоев кокона. В поведении личинки последнего возраста во время плетения кокона внутри шкурки тли выделено 2 фазы: активную фазу и фазу покоя. Активная фаза включает в себя 3–6 циклов плетения по 1,5–2 секунды каждый, чередующиеся с перемещением личинки на следующий участок внутренней поверхности мумии; в зоне между брюшком и грудью тли, а также при наличии разрывов в шкурке хозяина плетение проходит в этих местах дольше — 30–50 секунд. Требуются дальнейшие исследования для уточнения деталей процесса плетения кокона.

К л ю ч е в ы е с л о в а: *Trioxys curvicaudus*, личинка, поведение, плетение кокона, Aphidiinae, Braconidae.