

Confinement stimulates trivial flight in *Coccinella septempunctata*
(Coleoptera: Coccinellidae)

OLDŘICH NEDVĚD^{1,2} and Ivo HODEK¹

¹Institute of Entomology, Academy of Sciences and ²Faculty of Biological Sciences,
University of South Bohemia, Branišovská 31, 370 05 České Budějovice, Czech Republic

Flight activity, *Coccinella septempunctata*

Abstract. Coccinellids (ladybird beetles) are usually kept in small containers before or during flight tests. We have recorded in mature reproductive adults of *Coccinella septempunctata* that confinement can increase both the tendency to fly (take-off) and the performance (duration) of trivial flight. This possibility should be taken into consideration in the interpretation of flight tests.

Introduction

Seasonal changes in vagility of coccinellids have a great impact on the use of these species in biological or integrated control. This use, together with demands of basic research, stimulates experimental studies to monitor the flight tendency and duration during particular periods of the year and so determine the effects of age, reproduction, prey availability and physical factors on these two parameters.

When the flight behaviour of coccinellids is monitored the collected animals are kept in a limited space, impeding their inherent tendency to disperse when they forage for prey or leave their dormancy sites. We suspected that confinement may modify flight characteristics. Our preliminary tests indicate such modification which may lead to imprecise interpretation of flight tests.

Methods

Flight activity of overwintered ovipositing adults of *Coccinella septempunctata* foraging for aphids on shrubs (*Philadelphus*, *Spiraea* series A, B) and herbs (*Tripleurospermum* series C) was tested in late spring. In additional control groups (n = 42 on 9 June, n = 18 on 20 June) flight activity was measured on the day of collection (day 0). In series A and B (n = 12 in each series) the activity of experimental specimens was measured on days 0, 1, 2, 3, and 4. In series C (n = 12), flight activity was measured on days 0 and 3. The series C represented a sort of control for the potential objection that A and B animals might have been stimulated by daily “forced” flight. Between measurements the beetles were kept outdoors, each specimen isolated in a Petri dish (90 mm diameter), provided with water, and half of the beetles in each sample also with aphids (*Aphis philadelphi*, *Brachycaudus* sp.). Temperature was recorded inside the cage where the Petri dishes were kept.

The flight activity was measured as propensity or tendency to fly (take-off), and duration of the flight. Measurements were performed in a controlled environment chamber at 32–33°C. The surface was illuminated by eight 15 W fluorescent tubes from 50 cm height. The measurements took place between 10 a.m. – 4 p.m., after 1/2 hour acclimation in the chamber.

Take-off was measured as the time elapsed from releasing the ladybird onto a small Petri dish (50 mm dia) to its attempt to fly (ranging from 1 s to 60 s if no flight occurred, see Okuda & Hodek, 1989). The time was then recalculated as number of potential take-offs per minute (60/TO-1). Ten trials for each specimen were averaged.

Flight performance was measured as duration of tethered flight using the technique of Dingle (1966) modified by Rankin & Rankin (1980b); the ladybird was attached by wax on its pronotum to a pin head. Flight was initiated by moving the insect rapidly through the air and maintained by a low air current. This

method is different from that of non-stimulated flight used by Solbreck (1974). Durations of ten trials for each specimen were pooled.

Because the values of both parameters were highly variable and the distribution strongly skewed, non-parametric statistics (based on ranks) were used for analysis. However, trends for either means or medians or ranks were similar.

Results

When the feeding and reproducing animals were tested on the day of sampling (day 0) their flight performance was very low in all cases during late May and in June; the average accumulated duration of flight remained as low as 50 s in late May and early June, and slightly higher (70–90 s) on June 20 and 26 (Fig. 1). There was no significant difference between confined starved and fed beetles (Mann-Whitney tests: series A: $U = 491$, $p = 0.54$; B: $U = 459$, $p = 0.89$; C: $U = 101$, $p = 0.09$); therefore both subsamples were pooled. In contrast to the insects just after collection, ladybirds kept for several days in Petri dishes increased their duration of tethered flight, particularly in the instance of sample B (almost 1,000 s). In series A and B, the duration decreased on the fourth day, although it still remained quite high (more than 600 s in B) in comparison to insects on the day of sampling (Fig. 1). In series C (beetles left three days "at rest"), the increase in flight duration was very similar to series A, where flight was tested every day.

The incidence of take-offs increased after confinement, most steeply in A, the second day after confinement from 2 to 16 min^{-1} . A similar steep increase was registered in series C: from 4 to 14 min^{-1} . When duration was compared between days 0 vs. 3 in each series and take-off between days 0 vs. 1 in A and B and 0 vs. 3 in C by Wilcoxon paired test, four of six comparisons indicated significant increase of flight characteristics (duration: $Z = 1.69, 2.35, 2.40$, $p = 0.091, 0.019, 0.016$ in A, B, C, take-off: $Z = 2.75, 1.11, 2.43$, $p = 0.006, 0.266, 0.015$).

Increases in take-offs were recorded at average daily temperatures higher than 20°C. Increases in flight duration, on the other hand, were greatest at much lower temperatures in early June (daily means around 15°C).

Mean daily temperature during outdoor storage (given in Fig. 1) was different for each series and no clear influence on flight performance was revealed.

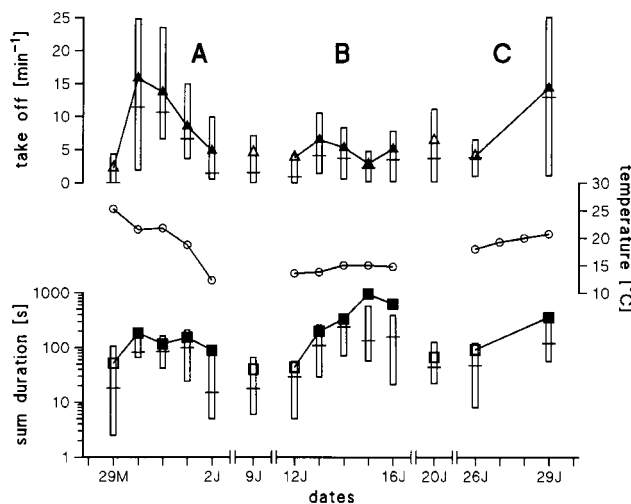


Fig. 1. Flight characteristics in foraging adults of *Coccinella septempunctata* in spring (series A, B, C, and controls). Flight duration (■, below), flight tendency (take-off, ▲, above) and environmental temperature (daily means, ○, middle). Open symbols represent means on day of collection, solid symbols are means after confinement in Petri dishes. Bars represent lower and upper quartiles, dashes represent medians.

TABLE 1. Storage of several coccinellid species during flight tests.

Species	Long storage at low temperature	Short storage at laboratory temperature	Space	Reference
<i>Coleomegilla maculata</i>	no	2–25 days 15, 19, 23, 27, 31°C, 1 h acclim. at 25°C	60–70 beetles in a plastic box 120 × 85 × 60 mm	Solbreck, 1974
<i>Hippodamia convergens</i>	7°C, dark	> 1 day, 24°C often 3 days	"small containers"	Rankin & Rankin, 1980a,b
<i>Hippodamia convergens</i>	3°C, 10L:14D, 4–6 months	0, 3, 6 days	Petri dishes 100 mm diam.	Davis & Kirkland, 1982
<i>Hippodamia convergens</i>	10°C, dark (Dec.–Feb.)	before the 1st flight 2 days, 24.5/21°C 4 days during the exp. period	not given	Růžicka & Hagen, 1985
<i>Coccinella septempunctata</i> <i>Semiadalia undecimnotata</i>	no	< 1 day	plastic bottles 500 ml	Okuda, 1984; Okuda & Hodek, 1989
<i>Coccinella septempunctata</i>	no	5–24 h, > 48 h, 26°C	plastic bottles (volume not given)	Honěk, 1990

Discussion

The experiments were undertaken during the period of coccinellid trivial flight. *Coccinella septempunctata* adults left their overwintering sites in late April – early May, about one month before the experiment. The tests were performed on insects foraging for prey, having full guts and, in the case of females, mature ovaries. Evidently they had fed enough before collection so that three days of starvation did not affect their flight ability, as documented by the absence of significant differences between insects fed during confinement and those that were starved.

As absence of prey was not the stimulating factor, the tendency to disperse eggs to a larger area may explain the observed flight behaviour. It is well known that, at adequate temperatures, coccinellids have a tendency to fly away even from favourable habitats with enough prey (e.g. De Bach & Hagen, 1964; Kieckhefer & Olson, 1974; Ives, 1981). The duration of visits of overwintered *Coccinella trifasciata* and *C. californica* to oat and alfalfa fields was measured in Vancouver, Canada; the mean visit lasted only 1–2 days or less and was predominantly affected by temperature (Ives, 1981). Some recent papers report the presence of conspecific eggs or larvae as an inhibitory factor for oviposition (Hemptinne & Dixon, 1991; Růžicka, 1994). In our experiments the eggs were removed daily, and some females oviposited repeatedly.

Coccinella septempunctata in Central Europe usually feeds on aphids on their primary host-plants, shrubs, in May and early June, but moves later to aphid secondary hosts, herbaceous plants including agricultural crops. Thus a relatively high flight capacity could be retained even after migration from overwintering sites. The higher values of flight duration in series B perhaps reflect this period of movement from primary to secondary host plants, i.e. from shrubs to fields.

In view of the well known vagility of ladybirds our findings on the effect of confinement are not particularly surprising. Nonetheless, this phenomenon apparently has not been taken into consideration in most studies of flight behaviour in Coccinellidae (Table 1). Although in most earlier studies activity was measured within a period of three days or longer, in most cases no changes in flight behaviour with time were reported (Rankin & Rankin, 1980a,b; Davis & Kirkland 1982; Honěk, 1990). For adults of *Hippodamia convergens* collected in their overwintering sites just before spring dispersal, Růžicka & Hagen (1985) found a decrease in flight performance during a four-day period. These insects certainly had depleted fuel reserves after about 9–10 months of dormancy (Hagen, 1962; Hodek & Čerkašov, 1963) and

were then starved during the experiment. The physiological condition of these coccinellids, differing substantially from our feeding and reproducing adults, explains the opposite tendency in the change of flight duration with time.

In *Coleomegilla maculata*, however, Solbreck (1974) recorded an increase in flight duration with time, although the adults were also collected in overwintering sites, just before spring dispersion, and starved during the experiments. The response was reported as "spring rematuration" of flight behaviour. This interpretation is quite probable for coccinellids sampled several weeks before their dispersal (mid-late April), e.g. in late March. However, the steep increase in flight duration within 4–5 days even in samples collected on April 18 and 26 (when the maturation of flight should have been completed) could have been affected by the confinement of tens of beetles in a limited space, at 23°C (Tab. 1).

By this preliminary note we intend to attract attention to the recorded effect of confinement which might cause flight behaviour observed in the laboratory to be misinterpreted.

ACKNOWLEDGEMENT. The study of flight behaviour in coccinellids was funded by the grant GA AV ČR A607103.

References

- DAVIS J.R. & KIRKLAND R.L. 1982: Physiological and environmental factors related to the dispersal flight of the convergent ladybird beetle, *Hippodamia convergens* (Guérin-Meneville). *J. Kans. Entomol. Soc.* **55**: 187–196.
- DE BACH P. & HAGEN K.S. 1964: Manipulations of entomophagous species. In De Bach P. (ed.): *Biological Control of Insect Pest and Weeds*. Chapman & Hall, London, pp. 429–458.
- DINGLE H. 1966: Some factors affecting flight activity in individual milkweed bugs (*Oncopeltus*). *J. Exp. Biol.* **77**: 335–343.
- HAGEN K.S. 1962: Biology and ecology of predaceous Coccinellidae. *Annu. Rev. Entomol.* **7**: 289–326.
- HEMPTEINNE J.-L. & DIXON A.F.G. 1991: Why ladybirds have generally been so ineffective in biological control? In Polgár L., Chambers R.J., Dixon A.F.G. & Hodek I.: *Behaviour and Impact of Aphidophaga*. SPB Acad. Publ., The Hague, pp. 149–157.
- HODEK I. & ČERKASOV J. 1963: Imaginal dormancy in *Semiadalia undecimnotata* Schneid. (Coccinellidae, Col.). II. Changes in water, fat and glycogen content. *Věst. Čs. Spol. Zool.* **27**: 289–318.
- HONĚK A. 1990: Seasonal changes in flight activity of *Coccinella septempunctata* L. (Coleoptera, Coccinellidae). *Acta Entomol. Bohemoslov.* **87**: 336–341.
- IVES P.M. 1981: Estimation of coccinellid numbers and movement in the field. *Can. Entomol.* **113**: 981–997.
- KIECKHEFER R.W. & OLSON G.A. 1974: Dispersal of marked adult coccinellids from crops in South Dakota. *J. Econ. Entomol.* **67**: 52–54.
- OKUDA T. 1984: *Anatomical and Ecophysiological Study of Coccinella septempunctata L. and Semiadalia undecimnotata Schneid. in Relation to Diapause*. Ph.D. thesis, Institut of Entomology, Prague.
- OKUDA T. & HODEK I. 1989: Flight tendency of 2 coccinellids, *Semiadalia undecimnotata* and *Coccinella septempunctata*, in relation to diapause. In Tonner M., Soldán T. & Bennetová B. (eds): *Regulation of Insect Reproduction IV*. Academia, Prague, pp. 385–400.
- RANKIN S.M. & RANKIN M.A. 1980a: Some factors affecting presumed migratory flight activity of the convergent ladybird beetle *Hippodamia convergens* (Coccinellidae: Coleoptera). *Biol. Bull.* **158**: 356–369.
- RANKIN S.M. & RANKIN M.A. 1980b: The hormonal control of migratory flight behavior in the convergent ladybird beetle, *Hippodamia convergens*. *Physiol. Entomol.* **5**: 175–182.
- RŮŽIČKA Z. 1994: Oviposition-detering pheromone in *Chrysopa oculata* (Neuroptera: Chrysopidae). *Eur. J. Entomol.* **91**: 361–370.
- RŮŽIČKA Z. & HAGEN K.S. 1985: Impact of parasitism on migratory flight performance in females of *Hippodamia convergens* (Col., Coccinellidae). *Acta Entomol. Bohemoslov.* **82**: 401–406.
- SOLBRECK C. 1974: Maturation of post-hibernation flight behaviour in the coccinellid *Coleomegilla maculata* (DeGeer). *Oecologia (Berlin)* **17**: 265–275.

Received July 20, 1995; accepted August 11, 1995