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Is *Harmonia axyridis* a marginal host for the parasitoid wasp *Dinocampus coccinellae*?

Morphological and molecular genetic analyses

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Harmonia axyridis as a model for predator adaptation to chemically defended prey

John J. Sloggett, Kenneth F. Haynes, John J. Obrycki & Andrew J. Davis..... 105-113

Abstract: *Harmonia axyridis* is a stronger intraguild predator of other ladybirds than are many other ladybird species. A correlate of this is that *H. axyridis* is better at resisting the toxic effects of the alkaloids of allospecific ladybird prey. This makes *H. axyridis* an ideal species with which to investigate the adaptations of predators to feeding on potentially toxic chemically defended prey. In this paper we discuss recent studies that, for the first time, have thrown light on the nature of and mechanisms involved in *H. axyridis* alkaloid resistance. We focus on the finding that *H. axyridis* is relatively poorly adapted to prey containing novel alkaloids in areas where it is exotic and on the fate of suitable and unsuitable prey alkaloids after ingestion by the intraguild predator.

Colour pattern polymorphism and chemical defence in *Harmonia axyridis*

John J. Sloggett..... 115-123

Abstract: Chemical defence has long been considered to play some sort of role in relation to colour pattern polymorphism in ladybirds. A recent idea is that intraspecific variation in colour or pattern is an indicator of the strength (i.e. concentration) of defensive chemicals in the individual. This has received support from a recent study showing that in non-melanic *Harmonia axyridis* the proportion of the elytra that is orange is positively correlated with the concentration of the alkaloid harmonine. In this paper I discuss palatability experiments with *H. axyridis* designed to test whether the finding can be extended across colour pattern morphs, specifically whether melanic *H. axyridis* are less well defended than non-melanics. Feeding experiments using spiders (*Araneus diadematus*) and earwigs (*Forficula auricularia*) gave no indication that melanics were less well defended than non-melanics. However, the spiders exhibited a generally high level of acceptance of ladybird prey, making the detection of intraspecific differences in prey palatability unlikely, while data from earwigs is currently of too small a scale to be unequivocal. Further palatability tests are required as well as additional analytical work covering the full range of *H. axyridis* morphs and defensive chemicals.

The establishment and rapid spread of an alien invasive lady beetle:

Harmonia axyridis (Coleoptera: Coccinellidae) in southern Africa, 2001–2009

Riaan Stals..... 125-132

Abstract: That *Harmonia axyridis* (Coleoptera: Coccinellidae), a grievous alien invasive species, has established in southern Africa and is spreading though the region is presently not well known outside South Africa. The first known record for the region is a capture from 2001. Establishment is hypothesised to have taken place in the south-western part of the Western Cape Province. The geographic spread of the insect through southern Africa has been recorded since 2006 and retrospectively, with information largely obtained through citizen science. Until the end of 2009, the beetle has spread widely through the more temperate southern and higher-lying eastern and east-central parts of South Africa, and has also been recorded from Lesotho. In 2009 it has additionally been recorded from localities in the hotter, drier interior of South Africa for the first time. The invader has been found in a large variety of natural and transformed landscapes and habitats. The ecological effects it may exert may ultimately be unknowable because of the absence of baseline information on coccinellid community ecology in southern Africa.

Temperature dependent development of *Harmonia axyridis* Pallas

(Col.: Coccinellidae) on two prey: *Aphis fabae* Scopoli and *Dysaphis crataegi* (Kaltenbach) (Hem.: Aphididae)

George J. Stathas, Dimitris Kontodimas, Filitsa Karamaouna &

Stavros Kampouris 133-136

Abstract: Development of the predator *Harmonia axyridis* was studied at four constant temperatures (15°, 20°, 25° and 30°C) on two prey, *Aphis fabae* and *Dysaphis crataegi*, in laboratory conditions. Total developmental time of the predator at 15°C and 30°C was shorter on

D. crataegi (76.7 and 16.6 days, respectively) than on *A. fabae* (90.2 and 18.3 days respectively) but did not differ significantly between the species at 20°C (36.8-38.9 days) or 25°C (24.0-24.9 days). The thermal constant (K) of development of *H. axyridis* from egg to adult was 258.2 day-degrees above a lower developmental threshold of 11.2°C, on *A. fabae*, and 243.6 day-degrees above a lower developmental threshold of 10.8°C, on *D. crataegi*.

Entomopathogenic fungi found in field populations of the harlequin ladybird,

Harmonia axyridis

Tove Steenberg & Susanne Harding..... 137-141

Abstract: A survey of natural enemies in larvae (including prepupae), pupae and adults of the harlequin ladybird, *Harmonia axyridis*, showed that several species of entomopathogenic fungi could be isolated from samples of the three life stages collected at different times of year. In 2007-2008 *Isaria farinosa* was the most prevalent species in larvae and pupae. In contrast, in the autumn of 2009 *Beauveria bassiana* was the dominant species in larvae, prepupae and pupae. The prevalence of fungus infection varied greatly between locations, life stages and time of year. We also report the finding of the parasitic fungus *Hesperomyces virescens* from an adult *H. axyridis* collected in Germany.

The harlequin ladybird (*Harmonia axyridis*) in Denmark: spread, phenology, colour forms and natural enemies in the early phase of establishment

Tove Steenberg & Susanne Harding..... 143-147

Abstract: *Harmonia axyridis* arrived in Denmark in 2006, was established by 2007 and now has spread to the southern and eastern part of the country. The rate of spread in Denmark has been surprisingly low, and except for a few strongholds with large populations *H. axyridis* has mainly been recorded as single specimens. Studies of the phenology of *H. axyridis* in Denmark indicate bivoltinism and show that it is currently not well adapted to Danish conditions. The frequency of occurrence of four colour forms has not changed within the first two years after its establishment in Denmark. At present, f. *succinea* is the dominant colour form (~94%) and the nominate colour form f. *axyridis* is rare (0.6% prevalence). Among the native natural enemies interacting with *H. axyridis* are phorid flies (*Phalacrotophora* sp.), entomopathogenic fungi and the hymenopteran parasitoid *Dinocampus coccinellae*.

Is *Harmonia axyridis* really eating *Adalia bipunctata* in the wild?

Alison Thomas, Styliana Philippou, Remy Ware, Heather Kitson & Peter Brown.. 149-153

Abstract: Preliminary work was conducted to identify a PCR based method for detection of *Adalia bipunctata* in the predatory ladybird *Harmonia axyridis*. A primer pair (Ab35) was identified which amplified well a microsatellite marker in the genome of *A. bipunctata* but not that of *H. axyridis*. Controlled laboratory studies were conducted when *H. axyridis* fourth instar larvae were fed on *A. bipunctata* eggs or first instar larvae. A single first instar larva or seven to ten eggs could be detected two hours post-feeding, suggesting that if a field collected *H. axyridis* larva had consumed an *A. bipunctata* larva or a number of eggs within two hours before collection, this intraguild predation could be detected. Of 112 field collected *H. axyridis* larvae tested, one revealed the presence of *A. bipunctata*.

Investigating global invasion routes of the harlequin ladybird (*Harmonia axyridis*) using mtDNA

Cathleen E. Thomas, Eric Lombaert, Remy Ware, Arnaud Estoup &

Lori Lawson Handley..... 155-157

Abstract: Although species invasions have important ecological and economical consequences, there is still much we do not understand about why only certain species become successful invaders, and what impacts they have on other species. Molecular techniques can be used to gain vital information on invasion dynamics, so as part of an ongoing study, we have used mitochondrial DNA sequence data to investigate the global invasion of *Harmonia axyridis*, and

particularly the characteristics of the founding population(s). This will also complement data currently being gathered on microsatellite genotype and endosymbiont presence to provide a powerful dataset for understanding the invasion history of this species, and, more broadly, to attempt to determine what factors might make an invasive species successful.

Occurrence of the harlequin ladybird *Harmonia axyridis* (Pallas, 1773)

(Coleoptera: Coccinellidae) in Bulgaria

Rumen Tomov, Katya Trencheva, Georgi Trenchev & Marc Kenis 159-164

Abstract: Surveys were carried out in Bulgaria in 2009 to monitor the presence of the invasive harlequin ladybird, *Harmonia axyridis* (Pallas, 1773) (Coleoptera: Coccinellidae). Ladybirds were collected by beating the branches of trees and shrubs and sweeping grasslands throughout the country. The species was found in 17 localities in Bulgaria: Ardino, Belogradchik, Bladoevgrad, Botevgrad, Dupnitsa, Elin Pelin, Gabrovo, Kresna defile, Montana, Pravets, Smolyan, Sofia, Varna, Veliko Turnovo, Velingrad, Vidin and Vratsa,. Except for the natural location Kresna defile, *H. axyridis* occurred mainly in urbanised landscapes. The species was more often found in Western part of the country. The species was found exclusively on broadleaved trees heavily infested by aphids: *Acer pseudoplatanus* L., *Cornus sanguinea* L., *Fraxinus excelsior* L., *Paliurus spina-christi* Mill., *Populus nigra* L., *Quercus rubra* L., *Quercus cerris* L., *Tilia cordata* Mill. and *Tilia tomentosa* Moench. The pathway of introduction of the ladybird in Bulgaria is not clearly known. Although releases of *H. axyridis* were carried out in Bulgaria and Greece in the 1990s, the present invasion is most probably due to populations coming from the West. The invasion of *H. axyridis* in Bulgaria is still at an early stage and despite the first observation of the species in 2008, it seems that it started to spread in summer 2009 from populations of Sofia. The infestation by *Eucallipterus tiliae* (L.) on *Tilia cordata* Mill. clearly facilitated the natural spread of *H. axyridis* in Bulgaria.

Suitability of diverse prey species for development of *Harmonia axyridis* and the effect of container size

Dita Ungerová, Plamen Kalushko & Oldřich Nedvěd 165-174

Abstract: Larval development time and fresh body mass of newly emerged adults are widely used quantitative parameters characterizing food suitability. These parameters were measured in the ladybird *Harmonia axyridis* with nine different aphid species. We calculated suitability parameter $SL = m/t$ (mass divided by developmental time), and ranked the aphid species studied accordingly: *Aphis philadelphi* (2.6), *Aphis fabae* on *Rumex* (2.5), *Aphis spiraephaga* (2.0), *Acyrtosiphon pisum* (1.8), *Rhopalosiphum padi* (1.7), *Acyrtosiphon ignotum* (1.6), *Dysaphis plantaginea* (1.5), *Hyadaphis tataricae* (1.4), *Aphis sambuci* 2009 (1.3), *Aphis sambuci* 2008 (1.1). Conspecific eggs were moderately suitable (1.7). When larvae were reared together in 0.5l glass jars, the developmental parameters were better than when reared individually in 7 or 15cm Petri dishes in combination with most aphid species. Sexual differences in fresh mass (females being 1.1 to 1.2 times heavier) but not in developmental time were found. Some prey species which are well suitable for large larvae were found not so good for young ladybird larvae due to the large body size of these aphids.

Adaptation of native parasitoids to a novel host: the invasive coccinellid

Harmonia axyridis

Remy Ware, Laura-Jane Michie, Tomoki Otani, Emma Rhule & Richard Hall 175-182

Abstract: In its introduced range, the invasive coccinellid *Harmonia axyridis* (Coleoptera: Coccinellidae) threatens many non-pest insects through competition and predation, and this raises the need for appropriate control measures to be investigated. One strategy could be to consider the introduction of natural enemies (predators, parasites and pathogens) that regulate *H. axyridis* populations in its native range. Indeed, escape from natural enemies is likely to have contributed to its invasive success (the so-called ‘enemy release hypothesis’). However, re-uniting *H. axyridis* with its own enemies requires rigorous and time-consuming risk assessment to ensure there are no

unwanted side effects on native species. Moreover, the introduction of alien enemies may be unnecessary if the organisms that attack native ladybirds in Britain also attack harlequins. Here we present field data which indicates that two species of parasitoid wasp: *Dinocampus coccinellae* (Hymenoptera: Braconidae) and *Oomyzus scaposus* (Hymenoptera: Chalcidoidea); and two species of parasitoid fly: *Phalacrotophora fasciata* and *Phalacrotophora berlinensis* (Diptera: Phoridae) may be adapting to *H. axyridis* in Britain as a novel and abundant host. This may provide some level of natural population control.

A feel for the organism: Ladybirding with Mike Majerus

Remy Ware 183-184
No abstract

Intraguild predation of non-coccinellid aphid natural enemies by *Harmonia axyridis*: prey range and factors influencing intraguild predation

Patricia M. Wells, Jason Baverstock, Michael E. N. Majerus, Frank M. Jiggins, Helen E. Roy & Judith K. Pell 185-192

Abstract: Although *Harmonia axyridis* has been recorded as an intraguild predator of various aphidophagous coccinellids, little is known about its interactions with other aphid natural enemies. We assessed the intraguild interactions between *H. axyridis* and four non coccinellid aphid natural enemies (two species of parasitoid plus two larval stages of lacewing). Petri dish trials showed that *H. axyridis* is an intraguild predator of 2nd instar lacewing (*Chrysoperla carnea*) larvae but not 3rd instar larvae. Predation of *Aphidius ervi* and *Praon volucre* parasitoid pupae was only observed occasionally. Experiments at a larger spatial scale and in more complex environments are needed to determine whether these interactions are ecologically important. The effect of alternative prey density and alternative prey species was assessed on whole plants in insectary cages. The density of alternative prey (pea aphid) did not affect predation of 2nd instar *C. carnea* by *H. axyridis* on bean plants. In contrast, aphid species may have an effect on aphid predation and intraguild predation.

PCR-based gut content analysis in *Harmonia axyridis*

Renate Zindel, Angelos Katsanis, Marc Kenis & Alexandre Aebi 193-194
Abstract only

Is *Harmonia axyridis* a potential biocontrol agent in Christmas tree plantations?

Susanne Harding, Tove Steenberg 195-201

Abstract: Nordmann fir (*Abies nordmanniana*) Christmas trees are a high value crop and quality demands are high. The adelgid *Dreyfusia nordmanniana* is the key pest in the production of Christmas trees, feeding on current-year foliage and causing needle distortion. Laboratory assays were carried out to evaluate the potential of *Harmonia axyridis* as a biocontrol agent in Christmas tree plantations. Differences appeared in the predation efficiency of larvae and adults as well as in the suitability as prey of different adelgid generations and developmental stages. *Harmonia axyridis* preferred and performed better on aphids belonging to Aphidoidea than on an adelgid diet. Our laboratory results indicate that *H. axyridis* may not be a highly effective biocontrol agent against *D. nordmanniana*. However, *H. axyridis* may assist in the natural regulation of the increasingly common lachnid *Cinara confinis* in Christmas tree plantations.