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Notes on the biology and ethology of *Luperomorpha xanthodera*, a flea beetle recently introduced into Europe

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Abstract

The life cycle, host plants and damage caused by *Luperomorpha xanthodera* (Fairmaire), a chrysomelid recently introduced to Europe, are described. In Tuscany (Italy) *L. xanthodera* completes 2 generations per year and all stages may overwinter in soil. Adults fly and feed from March-April until autumn. Females oviposit in the soil where larvae complete their development on radicles and pupate. Adults are polyphagous, chiefly anthophagous, causing damage on plants belonging to 23 genera of 19 botanical families.

Key words: Alticinae, biology, ornamental nursery, damage.

Introduction

The presence of a flea beetle previously unknown among European fauna was recently reported in Tuscany (Italy) (Conti and Raspi, 2007). Specimens collected in Italy were initially identified by the Italian chrysomelidologist Maurizio Biondi (University of L'Aquila) as *Luperomorpha nigripennis* Duvivier (Coleoptera Chrysomelidae Alticinae). It attacked numerous cultivated ornamental plants in nurseries of Tuscany, compelling operators in this sector to apply repeated insecticidal treatments for its control (Conti and Raspi, 2007).

Adults of an exotic flea beetle were also detected in Tuscany as early as May 2005 on potted citrus trees (Del Bene *et al.*, 2007) and subsequently identified by the French taxonomist Serge Doguet as *L. nigripennis*. At that time no economic damage was reported as the trophic activity on flowers did not impair fruit-set. The same species was also reported in France in 2005 (Doguet, 2008).

The above reported presence of *L. nigripennis* was not the only case of Alticinae recently and accidentally introduced into Europe. *Luperomorpha xanthodera* (Fairmaire) was recorded on rose and other ornamental flowers in Britain in 2004 (Johnson and Booth, 2004) and it is mentioned in Germany on an Internet website (www.koleopterologie.de) devoted to Coleoptera; in 2008 it was found in The Netherlands for the first time (Beenen *et al*., 2009). *L. xanthodera*, which is widespread in China, bears a strong resemblance to *L. nigripennis*, both with regard to habitus and size, while differing from the latter in the morphology and size of the male genital apparatus (Gressitt and Kimoto, 1963). But the external morphology shows such marked similarity that many specimens originating from China and displayed at the Natural History Museum of London were previously classified as *L. nigripennis* prior to their current recent systematic classification as *L. xanthodera* (Johnson and Booth, 2004).

Like *L. xanthodera*, *L. nigripennis* bears a vague similarity in its aspect to certain species of the genera *Luperus* and *Calomicrus*, which are Galerucinae occurring in the Italian fauna. However, examination of the metafemora unmistakably distinguishes *Luperomorpha* spp. from these European genera.

Despite this, the almost simultaneous detection in Europe of two exotic congeneric species, both originating from Asia and both polyphagous, has led specialists (Doguet, 2008) to speculate that the beetles may effectively represent only one rather than two distinct species, and that new observations may be required to confirm the specific identification recently carried out.

Finally Manfred Doeberl studied some specimens from Tuscany and stated that the previous species *L. nigripennis* is in reality *L. xanthodera.*

It is well known that flea beetles are phytophagous in the larval and adult stage, feeding on roots and stems (larvae), leaves, flowers and pollen (larvae and adults). Among the species present in Europe, the majority have leaf-feeding adults that live on herbaceous plants, ovipositing in the ground, where the larvae live on the exterior of roots or inside roots or stems. By contrast, in species with phyllophagous larvae, eggs are laid on the leaves. Generally one generation per year is completed, with overwintering by the adult (Goidanich, 1952; Doguet, 1994).

Only scanty information is available on the biology of *Luperomorpha* spp. in their continent of origin. The most recent reports on *L. nigripennis* in India indicate that adults attack dry seeds of an arboreal leguminous plant, *Leucaena leucocephala* (Lam.) deWit. in both the field and in seed storage areas (Matthew and Sivakumar, 2001). Other species of *Luperomorpha* are known to inflict various types of damage on cultivated plants. For example, in India *Luperomorpha vittata* Duvivier damages the flowers, but not the leaves, of ornamental plants (Lingappa and Siddappaji, 1978), and *Luperomorpha bombayensis* (Jacoby) attacks flowers of eggplant (Santhakumari *et al.*, 1979) and sweet potato (Rajamma, 1982). In Sri Lanka, *Luperomorpha discoidea* (Jacoby) damages the leguminous plant *Psophocarpus tetragonolobus* (L.) DC. (Shanthicharda *et al.*, 2000). In China, *Luperomorpha suturalis* Chen completes two generations a year on a perennial Liliaceae plant, *Allium*

ramosum L., overwintering as a larva or pupa in the ground (Yang *et al.*, 2003).

In Italy, and more specifically in Tuscany, the recently detected *L. xanthodera* appears established. However, its bioecology is so far completely unknown: the damage caused by the adults is not quite cleared and the larval biology is not known. Therefore the aim of this study was to identify its host plants, define the type of damage inflicted and the insect's biological cycle, in order to devise possible containment strategies.

Materials and methods

Observations were conducted in Tuscany (Italy) during the three-year period 2006-2008, in nurseries (ornamental cultivations, both greenhouse-grown and open field plants) and in the laboratory.

Visual samplings and collections were performed in over 20 ornamental nurseries and flower-growing farms of the areas of Pescia and Pistoia, monthly during the winter and bi-weekly during the rest of the year. Plants whose flowers were severely attacked by adults were collected for laboratory observation of the root system.

In 2007 and 2008, 10 yellow sticky traps were installed in a nursery of the Pistoia area. The nursery was 16 ha wide and had a vast range of greenhouse-grown and open-air plant species that were visited by the flea beetle. The traps (15 x 25 cm, Horivert–Koppert) were positioned on citrus, datura, oleander and trachelospermum in the greenhouse, and on spindle tree, hibiscus, lagerstroemia, philadelphus, pyracantha and rose in open air (one for each vegetal species on the upper part of plants). The yellow sticky traps had been shown in preliminary trials

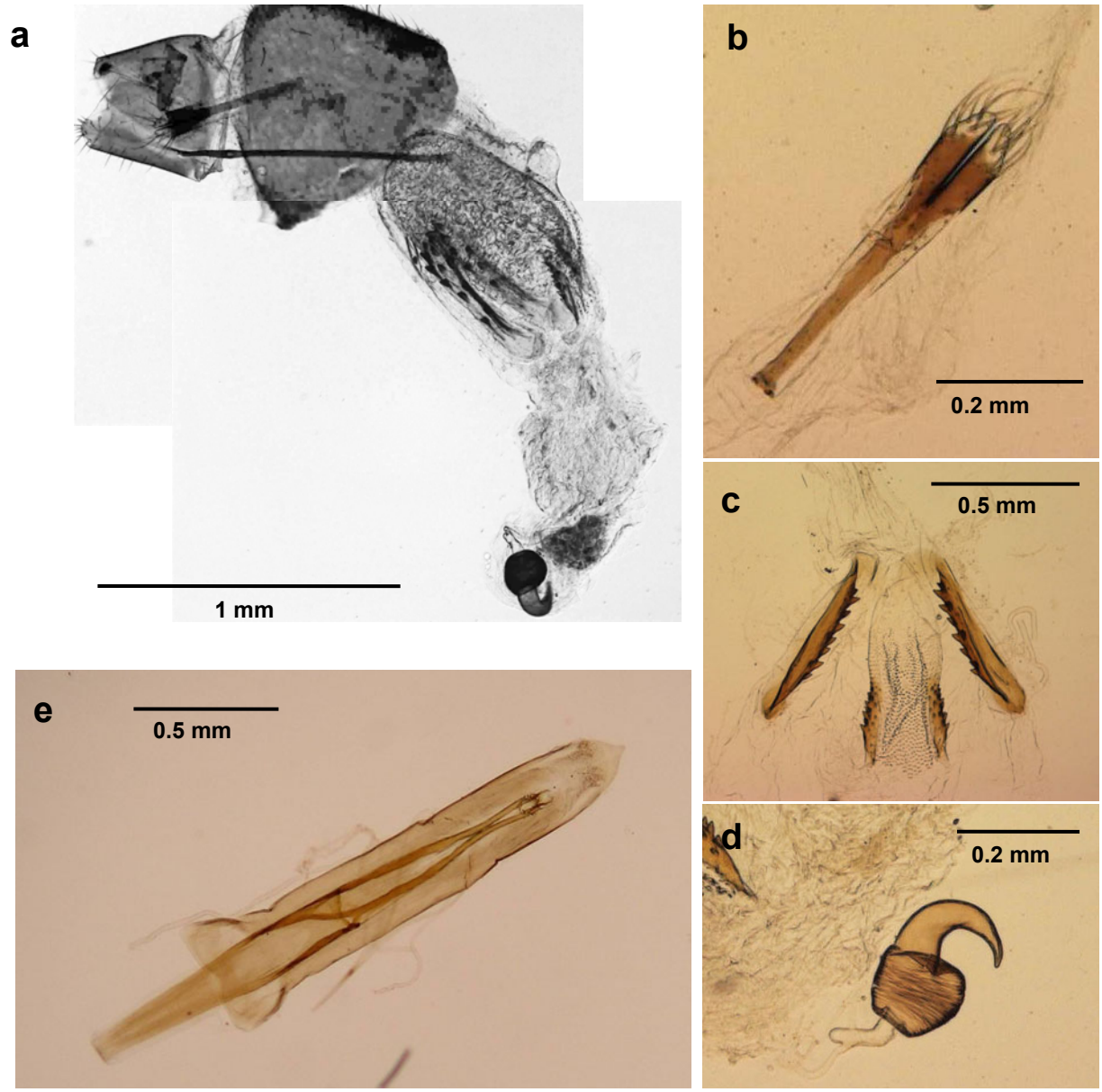

Figure 1. Microscope preparations of *L. xanthodera*. ♀: a) general view of genital organs, b) coxites, c) bursa copulatrix toothed rods, d) spermatheca; ♂: e) median lobe of aedeagus.
(In colour at www.bulletinofinsectology.org)

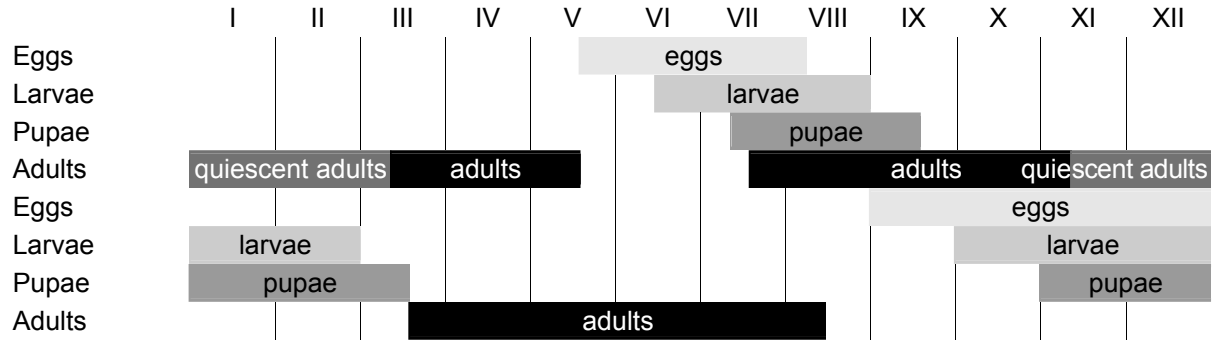

Figure 2. Life cycle of *L. xanthodera* in ornamental nurseries of Tuscany. Roman numbers indicate month.

to be attractive to adults of *L. xanthodera*. Monitoring was conducted throughout the year, and the traps were replaced every 15 days.

In the laboratory, different types of rearing systems were set up, starting from adults of *L. xanthodera* collected in the nurseries during the various periods of the year: a) 30 adults on potted citrus, hibiscus, viburnum and spindle tree plantlets, maintained in 4 entomological cages (cylinders of Plexiglas - h 150 cm x diameter 50 cm - with a net on the top); b) 20 adults in 8 Plexiglas cylinders (h 30 cm x diameter 15 cm) in a thermostatic chamber with 12:12 D:L photoperiod and 10-20 °C thermoperiod. According to season, the cylinders contained fresh cut flowers (oleander, viburnum, rose) or newly-produced leaves (viburnum, rose, citrus, eleagnus, eucalyptus, spindle tree, or strawberry tree) and on the bottom soil with growing iris and strawberry rhizomes; c) 6 adults x 14 Petri dishes with soil and fresh flowers were maintained under the same conditions. Observations were carried out examining both the above-ground and below-ground part of the plants weekly (a, b) and every two days (c).

Additionally, in the laboratory 10% of the adults collected in all samplings were utilized for dissection of the reproductive apparatus; the specimens were then prepared for optical microscope examination of the male and female genital armour and of egg maturity.

Results and discussion

Biological observations

Optical microscope observation of the genital armour of both sexes (figure 1), with particular attention to characters of taxonomic interest (median lobe of aedeagus, spermatheca, toothed rods of the *bursa copulatrix*, *spiculum ventrale* and coxites), suggested that the individuals sampled belonged to one species.

Overall, observations performed in the field and in the laboratory indicated that in Italy, in the areas where *L. xanthodera* has been detected, the species completes 2 generations a year (figure 2). It overwinters in soil in all post-embryonic stages, with larvae overwintering in the upper 10 cm of soil among roots, while pupae and adults overwinter at shallower depths. Resumption of activity by overwintering adults, as well as activity by newly emerged individuals, begins in late March-early April. The adults (figure 3a) swarm to the first flowers available (greenhouse citrus flowers), feeding voraciously to mature the gonads. They then move to inflorescences of other plants as these become available (tables 1 and 2, figure 4). Adults are highly active above all during the sunniest time of day, when mating was also observed. Mating and oviposition continues for a number of weeks; consequently, different stages of development can be found simultaneously on infested plants (adults on above-ground parts, larvae and pupae among roots). Scalar maturation of adults takes place up to July, simulating several generations. Sex ratio determined on adults sampled in nurseries is 1 male/2 females. In the laboratory conditions, adults were very long-lived (up to 8 months on oleander, viburnum or rose flowers).

The eggs are 0.7 mm long and 0.4 mm wide (figure 3b), making them difficult to collect from container-grown plants. Therefore oviposition was monitored only in the laboratory. Oviposition of the first cycle occurred from May to August and extended on average for 40 days after mating (up to 53 days). It was noted that eggs are laid on the surface or in the upper layers of soil, either in isolation or in small groups. The surface of the chorion is strongly reticulated (figure 5a), and the eggs are at first transparent, later becoming yellowish.

The larvae are eruciform and endowed with a pygopod at the 10th urite. In the laboratory, first instar larvae (length 1.3 mm - width 0.2 mm; figure 5b) were seen feeding on lateral radicles of iris and spindle tree from mid June. Second and third instar larvae (figure 3c) were observed inside the hairy roots of container-grown spindle tree plants. After reaching maturity the larvae pupate in soil; the anoic pupa (length 3 mm) lies free, close to roots at depths of a few cm (figure 3d).

During the hottest months, when flowers are less abundant, adults are less active. From the end of July, the newly emerged adults begin to appear, giving rise to a second generation (figure 2). Mating was observed up to the beginning of autumn, and in October 60% of the dissected females had mature eggs. In the laboratory, oviposition continued up to December. In the nursery, activity of adults stopped in mid-November, both in the greenhouse and the open air, with adults overwintering in the soil. Second generation larvae and pupae were detected in soil from October to February, and from November to March, respectively.

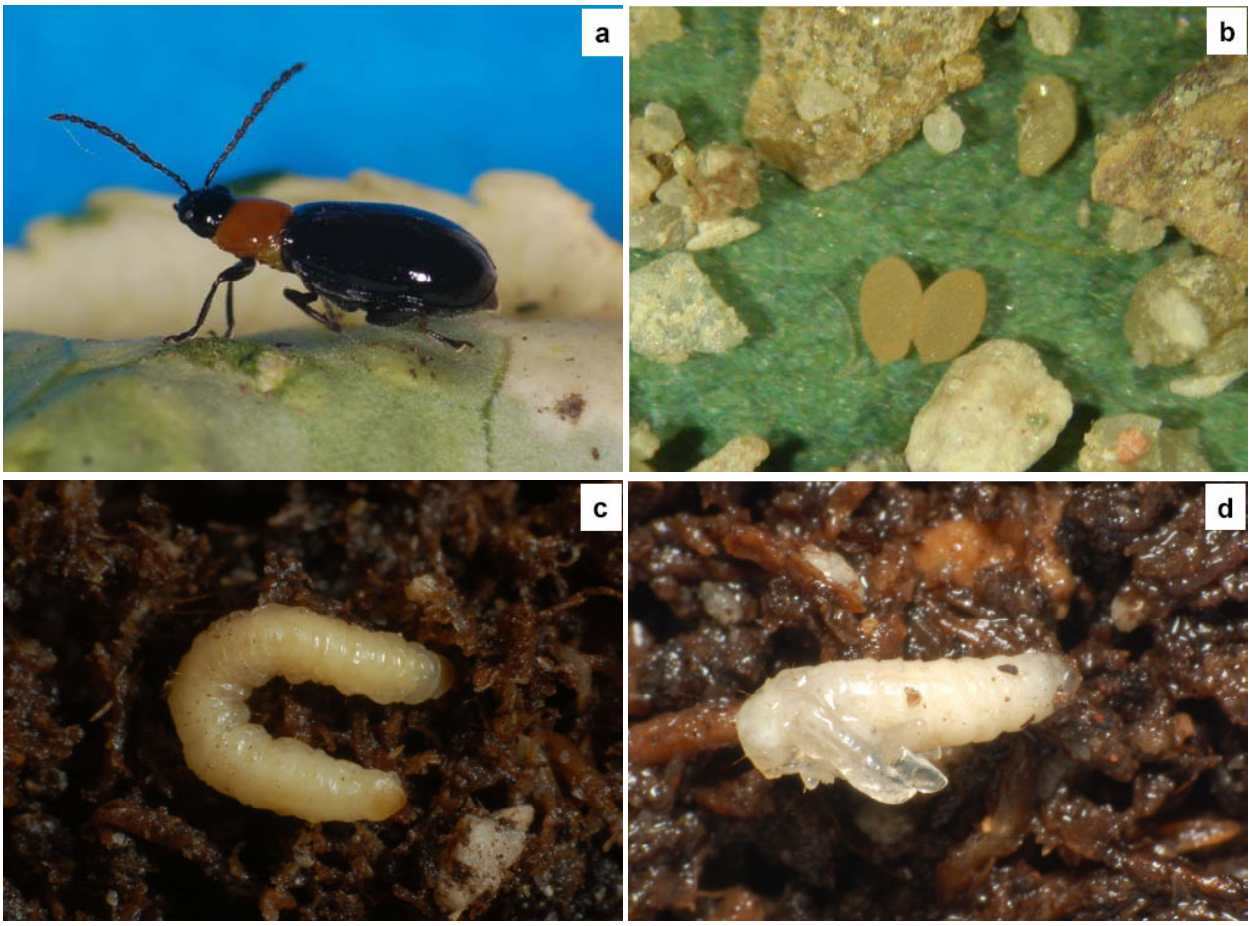

Figure 3. *L. xanthodera*: a) adult, b) eggs, c) larva, d) pupa.
(In colour at www.bulletinofinsectology.org)

Table 1. Plants whose flowers were damaged by *L. xanthodera* adults in the nursery.

Family	Species
Apocinaceae	*Nerium oleander* L.*, *Trachelospermum jasminoides* Lem.
Buddleiaceae	*Buddleia* spp.
Caprifoliaceae	*Viburnum* spp., *Weigelia florida* DC.
Celastraceae	*Euonymus japonicus* Thunb.*
Hypericaceae	*Hypericum* spp.
Leguminosae	*Genista* spp.
Liliaceae	*Yucca gloriosa* L.
Lythraceae	*Lagerstroemia indica* L.
Malvaceae	*Hibiscus syriacus* L.*
Myrtaceae	*Eugenia myrtifolia* New Port
Nyctaginaceae	*Bougainvillea glabra* Choisy
Oleaceae	*Ligustrum* spp.
Pittosporaceae	*Pittosporum tobira* Thunb.*
Rosaceae	*Pyracantha* spp.*, *Rosa* spp.*
Rubiaceae	*Gardenia grandiflora* Lour.
Rutaceae	*Citrus* spp.*
Ranuncolaceae	*Clematis* spp.
Saxifragaceae	*Hydrangea* spp., *Philadelphus coronarius* L.
Solanaceae	*Datura arborea* L.*

* indicates a number ≥ 5 adults/inflorescence.

Table 2. Periods of capture of *L. xanthodera* adults by means of yellow sticky traps on the different plant species grown in the nursery in 2007. Values indicate the maximum number/trap detected for each species. Roman numbers indicate month.

Plant	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Greenhouse												
Citrus				53								
Datura					41							
Nerium					50							
Trachelospermum					45							
Open air												
Euonymus							48					
Hibiscus								29				
Lagerstroemia										24		
Philadelphus					11							
Pyracantha					88							
Rosa								27				

Figure 4. Adults of *L. xanthodera* and damage on: a) datura; b) oleander; c) citrus; d) rose.
(In colour at www.bulletinofinsectology.org)

Host plants and damage

In the ornamental nurseries the trophic activity of adults of *L. xanthodera* was recorded on the flowers of plants listed in table 1. These plants belong to 23 genera of 19 botanical families, and the preferred flowers are those with most intense scent or richest in pollen. The plants found to be most attractive included pyracantha, spindle tree, hibiscus and rose grown in the open air, and greenhouse-grown citrus, oleander, trachelospermum and datura (table 2, figures 4a, 4b and 4d).

Feeding damage affects the petals and may be inflicted on the margin or the surface, at first on one sur-

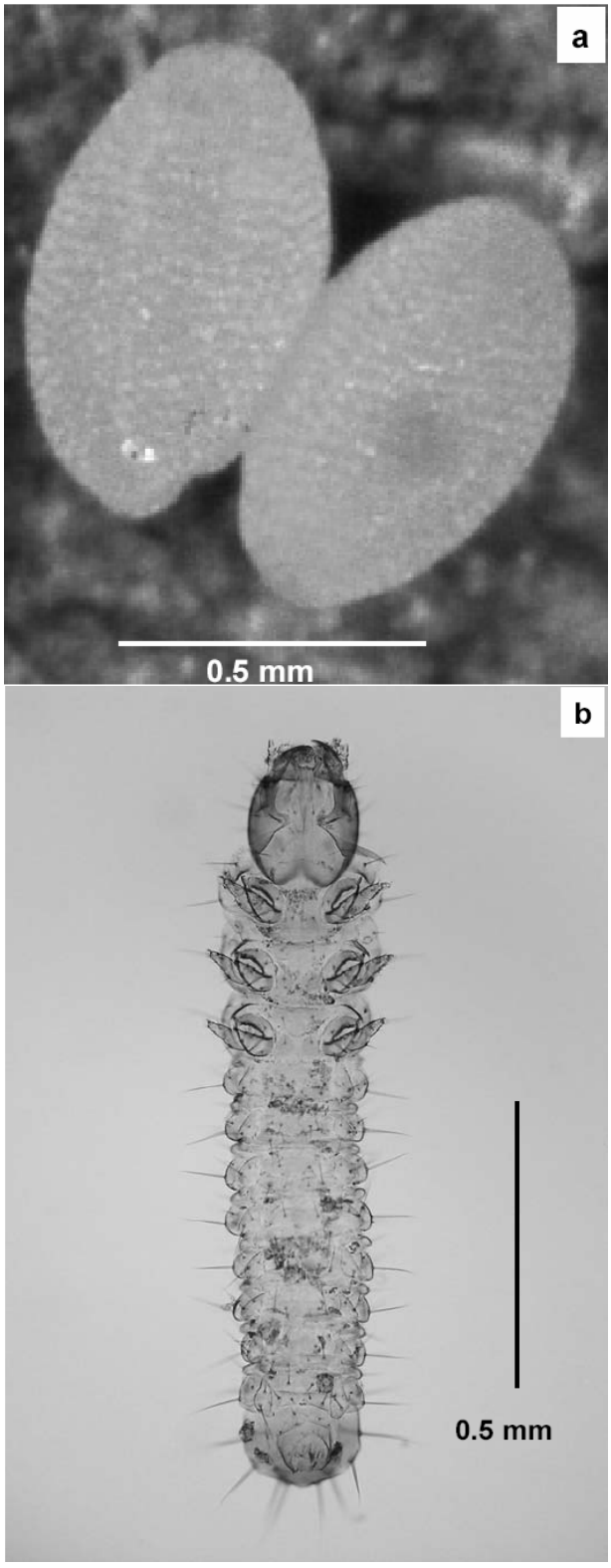

Figure 5. *L. xanthodera*: a) eggs, b) first instar larva mounted on glass slide.

face only, a hole then being chewed through to the underside. Destruction of the petals may be extensive, but for the ornamental nursery sector this aesthetic damage does not produce significant economic loss in marketing the plants, as the most important commercial consideration for ornamentals is the age and size of the plants rather than the presence of flowers. The ovarium is not damaged; consequently, in ornamental species grown for the beauty of their fruits such as certain types of citrus plants, fruit-set takes place normally and no adverse economic repercussions are experienced.

In ornamental plant nurseries, during periods characterized by absence of flowers, adults were detected on leaves and leaf damage attributable to the Alticin was observed. This phenomenon was confirmed in the laboratory, where slight damage was observed only on tender spindle tree and citrus leaves (figure 4c) when adults were provided with leaves of different species.

In the nursery monitored by sticky traps, during the two-year period 2007-2008 flights and trophic activity of adults were recorded from March-April in the greenhouse (above all on citrus, i.e. on the plants richest in flowers during this period) and from May in the open air (table 2, figure 6). Greatest numbers of flights were recorded in the month of May 2007, with captures/trap peaking at 88 individuals on pyracantha in the open air. A decline in number of captures was noted in June, both in the greenhouse and the open air, coinciding with a reduction in available flowers. In July, an increase in flights was recorded, and in 2007 the number of trapped adults remained appreciable up to October, ceasing around mid-November. By contrast, in 2008 no evidence of adult flight and trophic activity was recorded after September either in the greenhouse or in the open air. Overall, during 2008 the flea beetle population density was lower than in the preceding year (figure 6).

Only in five out of the over twenty ornamental nurseries sampled was the presence of *L. xanthodera* detected. No adult or damage attributable to the flea beetles was observed in adjacent cultivations of flowering plants during the three years of investigation. This was probably due to the routine insecticide treatments necessary to meet the extremely low economic thresholds required for cut flower production, whereas similar drastic treatments are not adopted in ornamental plant nurseries. For example, it was noted that rose flowers were severely damaged (figure 3d) only in rose-plant growing nurseries, while in nearby rose cut-flower cultivations where treatments were applied according to a pre-established calendar, no adult was detected.

With regard to pre-imaginal stages, it is likely that the rhizophagous larvae are polyphagous, but in the laboratory only the rearings on iris and spindle tree radicles were successful. In the nursery, none of the numerous host plants of adults showed signs of damage to the root system, even when numerous larvae were detected among the roots, as in the case of spindle tree.

Conclusions

This study allowed definition of some aspects of the ethology and life cycle of a flea beetle species recently introduced into Italy, previously unknown in Europe. Based on our three-year observations, we determined that *L. xanthodera* is a species with polyphagous and predominantly anthophagous adults and rhizophagous larvae.

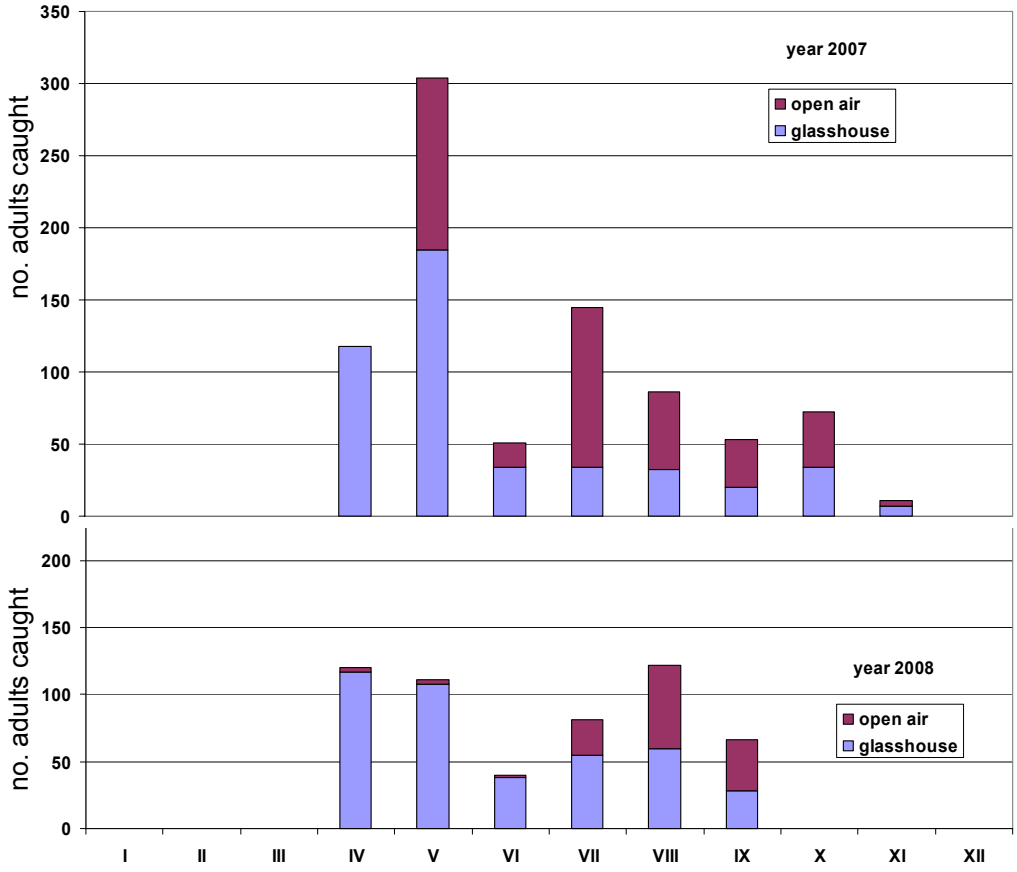

Figure 6. Captures of adults of *L. xanthodera* by yellow sticky traps (total number out of 10 traps) in a nursery of the Pistoia area in the years 2007 and 2008. Roman numbers indicate month.

In the case of development of large populations, *L. xanthodera* could represent a danger for ornamental crops. However, its trophic activity on flowers affects only the petals, and does not impair fruit-set. Thus it has no adverse effect on the economic value of plants such as citrus which are grown for the beauty of their fruits. Furthermore, trophic activity by larvae, which are probably polyphagous on secondary roots, does not appear to compromise normal development of the root system.

In Tuscany, this species is so far limited to the same nurseries where it was originally detected and no increase in population density was noted. But sale and exchange of plants among nurseries, which is fairly frequent in the ornamentals sector, could favour the spread of harmful organisms. The fact that *L. xanthodera* pre-imaginal stages are difficult to detect, as they live in soil, facilitates their spread. Therefore, in order to prevent the beetle from expanding over a large area, insecticide treatment against adults can be considered justified.

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