Biology and laboratory culturing of the root-feeding flea beetle, *Longitarsus columbicus columbicus* Harold, 1876 (Chrysomelidae: Alticinae): a potential natural enemy of *Lantana camara* L. (Verbenaceae) in South Africa

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Abstract


The introduced ornamental plant, *Lantana camara* L. (Verbenaceae), is one of South Africa’s worst invasive weeds. It has been the target of a biological control programme here for the past four decades. Although several natural enemies have been established, the level of control is considered unsatisfactory, and a number of new potential biocontrol agents are being evaluated. The flea beetle *Longitarsus columbicus columbicus* Harold is considered to be highly destructive, attacking the roots of *Lantana*, a niche largely ignored by biocontrollers in the past. Little is known about this potential natural enemy, and attributes of its life history and mode of feeding are discussed. Adults feed on the leaves and deposit eggs in the leaf litter near the soil surface. The larvae burrow into the soil, where they feed externally on the secondary rootlets. Development takes about 60 days during the summer, with the potential of 2-3 generations per annum in the field in South Africa. Rearing techniques are described, notably the use of a modified cage, and the results are compared with the alternative of rearing cultures in petri dishes. Implications for the host-specificity screening of *L. columbicus* and other *Longitarsus* and root-feeding flea beetle species under laboratory conditions are discussed.

Additional key words: External root-feeder, laboratory culture, classical biological control.
Root-feeding flea beetles, in particular species of *Longitarsus*, may be able to supplement damage inflicted by the suite of agents already established on lantana.

Field surveys in the countries of origin of the Lantana complex have revealed several flea beetle species associated with the plants (Winder and Harley 1983; Palmer and Pullen 1995). The intensity of adult feeding damage noted in the field during exploratory surveys in USA (Florida), Mexico, Jamaica, Trinidad and Venezuela, has encouraged interest in the potential of various root-feeding flea beetles, including species in the genus *Longitarsus*, as biocontrol agents. Although a few *Longitarsus* species are considered to be polyphagous, most are oligophagous and several have been used as biocontrol agents. Examples include *L. jacobaeae* (Waterhouse) and *L. flavicornis* (Stephens) on *Senecio jacobaeae* L. (Compositae) (Frick 1970; Frick and Johnson 1973), *L. albinaeus* (Foudras) on *Heliotropium europaeum* L. (Boraginaceae) (Delfosse and Cullen 1981; Huber 1981) and *L. aeneus* Kutschera and L. echii Koch on *Echium plantagineum* L. (Boraginaceae) (Wapshere 1982). Other *Longitarsus* species are under consideration as biocontrol agents, including *L. horni* Jacoby on *Chromolaena odorata* (Zachariades et al. 1999), and *L. quadriguttatus* Pont. on *Cynoglossum officinale* L. (Boraginaceae) (Jordan 1997). In addition, the host records of other species, such as *L. columbus* H arold, which has only been recorded from *Longitarsus* spp. in Venezuela (Bechyné 1997), indicate the potential of these species as biocontrol agents.

Little is known about the life history and host-range of *L. columbus* H arold, besides its association with the Lantana complex. This paper investigates the biology and laboratory culturing of this flea beetle, as the first step towards evaluating its potential for release as a natural enemy against *L. camara* in South Africa.

**Materials and Methods**

A laboratory culture was started with some 55 adults that were collected north of M aracay, along the road to Choroni (lat ° 34°45"N, long ° 34°67"W) in Venezuela, and imported into South Africa in October 1998. Field collections were made with a cupped beating tray, during the late afternoon. Identiﬁcations were conﬁrmed by Prof. Vilma Savini, and voucher specimens of the beetles are deposited at the Museo del Instituto de Zología A gricola (M IZA ), M aracay, Venezuela. *Longitarsus columbus* belongs to the tribe *Longitarsini*, and has also been collected from five other sites in Venezuela and one in Colombia (Bechyné 1997). The closely related *L. columbus centroamericanus* Bechyné has been collected in Guatemala, El Salvador and Nicaragua (Bechyné 1997).

During culturing in quarantine (Pretoria, South Africa) field-collected adults were split into two groups. Twenty adults were exposed to shoot tip cuttings in 15 cm petri dishes, and the remaining 35 adults were exposed to whole plants placed in rearing cages (Figure 1). Each cage comprises a mild steel frame with psylla screen gauze (C limatex cc, South A frica) and is fitted over a plastic trough with drainage. In these cages, three small rooted lantana plants were transplanted into the plastic troughs 2 weeks prior to exposure to promote new root growth. Adults were removed after two weeks and placed into additional cages with fresh plants. Cages were maintained under controlled glasshouse conditions and watered (from above) so as to maintain fairly damp soil conditions. Temperatures ranged from 30°C to 20°C in a day/night cycle, under a natural summer photoperiod of about 14 hours. Emerging first generation adults were recorded and collected weekly, and exposed to similar rearing conditions.

Petri dish rearing trials were conducted under laboratory conditions, in a controlled temperature room at temperatures ranging from 29°C to 22°C in a day/night cycle. Experiments were conducted on laboratory benches under artificial light banks on a 13 hour photophase. A dults were exposed to fresh cuttings every two days. The number of eggs, size of egg clusters, oviposition site, and mode of feeding was recorded. These trials were repeated using newly emerged adults from the first laboratory generation when the preoviposition period was also measured. Eggs were maintained under moist conditions and the duration of embryonic development recorded. Measurements were made with the use of an ocular micrometer mounted on a Wild microscope. Illustrations by the author were made with the use of a camera lucida.

Eight dominant *L. camara* varieties from the M pamulanga, N orthern and K waZulu-N atal Provinces of South A frica were used to rear the beetles in both petri dishes and cages. In the cages, different varieties were used to compare relative susceptibility for feeding and development, which was subjectively rated by the amount of shot hole damage to the leaves, and the number of progeny emerging from rearing cages respectively.
Results

Biology

Adults of *Longitarsus columbicus columbicus* (Figure 2a) are small (about 2 mm in length) and have a dark copper-brown colour. Adults feed on the leaves causing small shot holes, leaving the upper epidermal layer intact. Field-collected adults survived for two months under laboratory conditions, and remained fertile during this period. Adults emerging from the laboratory cultures survived for up to three months, and displayed a preoviposition period of about 2 weeks.

A dult feeding damage in the field was severe, and was similar to damage observed for other unidentified species of flea beetles (including prob. *Longitarsus* spp.) in Florida and Trinidad in April 1996, Mexico in October 1998, and Jamaica in July 1999. Adults are active and jump readily, and peak activity appears to occur during the cooler hours of the late afternoon, or under cloudy conditions. Adults shelter in the lower parts of the lantana plants, and amongst the surrounding vegetation during the hotter periods of the day.
Figure 3. (a) First, and (b) second generations of Longitarsus columbicus columbicus, maintained in gauze cages, kept in quarantine glasshouses during summer conditions. (c) Third generation L. columbicus columbicus, kept in a glasshouse (F2a & F3a), and laboratory (F2b & F3b) during winter conditions. P1 – field-collected adults; F1, F2 & F3 – First, second and third generation adults; arrows indicate length of adult exposure.
The intensity of adult feeding damage, and the number of progeny emerging in the first and second generations were noted to be similar on the eight lantana varieties that were exposed in both petri dish and cage experiments. The varieties of L. camara used, including orange, pink and white flowering forms, differed in morphological features like leaf hairiness and toughness, factors which seemingly had no noticeable effect on rearing success.

Discussion

Previous attempts to culture an unidentified Longitarsus species on lantana from Mexico, during the winter period, have proved unsuccessful (Baars and Nesser 1999). In this study, a culture of L. columbicus columbicus was successfully manipulated to maintain egg laying and immature development under artificial light and temperature regimes. Cultures reared in cages as described in this paper, were maintained under natural winter photo periods in glasshouses. The delayed emergence of the F1 progeny of L. columbicus columbicus exposed to natural winter conditions, suggest a significantly slow developmental rate or a state of diapause was induced. An immature stage probably enters a state of oligopause, as described by Mansingh (1971), which may be induced by a gradual change in photoperiod and/or plant physiology. Presumably, field populations enter a similar state to overcome the drier conditions and plant dormancy in Venezuela.

Laboratory cultures of L. columbicus columbicus are best maintained under the caged conditions described above. Under these conditions, adults should be exposed to the plants for short periods (about 2 weeks) to reduce the egg load per cage. Plants with larvae should be carefully watered to maintain intermediate soil moisture levels, in order to promote secondary root development and reduce larval mortality. Although laboratory rearing techniques are largely successful, mass-collection of insects in the country of origin for use in host-specificity tests may provide an efficient alternative. This method has been used for other Longitarsus species (Wapshere 1982; Jordon 1997), especially univoltine species, which take too long to culture.

The external mode of larval feeding appears to expose the immature stages of L. columbicus columbicus to high rates of mortality during excessive soil desiccation, and also probably excessive soil saturation. Areas infested with L. camara in South Africa are generally subject to summer rainfall and dry winters. During winters the topsoil dries excessively forcing the lantana plants into a state of dormancy. As a result natural enemies attacking this niche have to be adapted to cope with these extreme winter conditions. For biocontrol
agents to successfully suppress lantana in the drier areas of South Africa, insect populations must survive the winter period in sufficient numbers to maintain levels of damage on plants during the spring regrowth, as was the case for L. albineus on H. europaean (Huber 1981). By means of diapause the pupae of L. columbicus may thus provide a resistant life stage, which is able to cope with the unfavourable winter conditions. Wapshere (1983) discussed the effectiveness of biotypes of L. jacobaeae, originating from different geographical regions in Europe, as biocontrol agents in Australia, highlighting the importance of environmental synchrony.

Adults of root-feeding Longitarsus spp. that have been employed as biocontrol agents either feed externally, like L. aeneus on Echium plantagineum (Wapshere 1982) and L. albineus on H. europaean (Delfosse and Cullen 1981; Huber 1981), or internally in the root crown, like L. echii on Echium plantagineum (Wapshere 1982), and L. jacobaeae on S. jacobaeae (Frick and Johnson 1973). Through resource partitioning, Wapshere (1982) argued that the combined impact of the two Longitarsus species on Echium plantagineum improved the prospects for control. Similarly the biocontrol programme against L. camara in South Africa may benefit if priority be given to determine whether there are Longitarsus species, or other root-feeding flea beetles, which feed internally to avoid dry soil conditions. Surveys for other root-feeding agents have so far been conducted in Mexico and Jamaica, in 1998 and 1999 respectively (Baars unpbl.). The Mexican survey, conducted in the northern coastal areas of the Yucatan, Tabasco and Veracruz provinces, resulted in the collection of an unidentified flea beetle (Accession number: AcSN 2431, National Collection of Insects, ARC-Plant Protection Research Institute, Pretoria, South Africa) that has a similar life cycle to L. camara with a specialized guild that has not been represented in the biocontrol programme against Lantana camara in South Africa.

Conclusions
Field and laboratory observations indicate that L. columbicus columbiae is a potentially damaging natural enemy that warrants more intensive host-specificity evaluation in South Africa. Longitarsus columbiae and other root-feeding flea beetles constitute a specialized guild that has not been represented in the biocontrol programme against Lantana camara worldwide. The seasonal synchrony between L. camara and Longitarsus species will be an important factor influencing establishment and population increases in South Africa. With reference to the dry winter conditions, further exploration for other internal root-feeding flea beetle species remains a priority.

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References


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