

Morphological and ecological differences between two endemic species of *Asianidia* Zachvatkin (*A. insulana* and *A. madeirensis*) (Hemiptera: Cicadellidae) from Madeira: species boundaries and conservation status

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Abstract: *A. insulana* (Lindberg, 1961) and *A. madeirensis* (China, 1938) are two endemic and closely related species of the *Asianidia perspicillata* complex present in Madeira. They are relatively easy to distinguish on the basis of the aedeagus shape, body size and colour pattern, yet nymph morphology, distribution, plant associations and habitats were poorly known. The present study is a general overview of the morphology and ecology of this pair of species. New information on intra- and inter-specific variation, together with new distributional and ecological data are presented as a result of a thorough field-work from sea level up to the mountains and involving all main vegetation zones in the island. Moreover, their eventual origin through adaptive radiation by host-plant shift together with some conservation considerations are discussed.

Zusammenfassung: *A. insulana* (Lindberg, 1961) und *A. madeirensis* (China, 1938) sind zwei endemische und nah verwandte Arten des *Asianidia perspicillata*-Komplexes von Madeira. Sie sind relativ einfach an der unterschiedlichen Form der Aedeagusbasis, der Körpergröße und -färbung zu unterscheiden. Die Morphologie der Nymphen sowie die Verbreitung, Nahrungspflanzen- und Habitatbindung waren bisher wenig bekannt. Der Beitrag gibt einen allgemeinen Überblick zu Morphologie und Ökologie dieses Artenpaars. Auf der Basis umfangreicher Feldarbeiten, die vom Meeresniveau bis in die Gipfelregionen alle Hauptvegetationszonen der Insel einschlossen, werden neue Informationen zur intra- und interspezifischen Variation sowie mit neuen Daten zu Verbreitung und Ökologie präsentiert. Außerdem werden Aspekte der Artentstehung durch adaptive Radiation und Nahrungspflanzenwechsel sowie zum Artenschutz diskutiert.

Keywords: *Asianidia*, taxonomy, ecology, Madeira, Auchenorrhyncha, adaptive radiation

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1. Introduction

Three main species groups within leafhoppers of the genus *Asianidia* Zachvatkin are recognized in the Macaronesian area: *apiculata*, *atlantica* and *perspicillata* (Lindberg, 1954, 1961; Quartau, 1996). In the Canaries there are 17 species, 14 of which are endemics, while in the Madeira archipelago nine species occur, six of which are also endemics (Quartau, 1996, 2007, 2008; Quartau & Remane, 2006; Aguin-Pombo & Freitas, 2008). The single species present in the Azores, *A. chrysanthemii* (Lindberg, 1954), is believed to have been introduced in this archipelago through its host-plant (*Argyranthemum pinnatifidum*), an ornamental in gardens, as suggested by Quartau (1996).

The *perspicillata* complex is characterized by the dark pigmentation on the head, pronotum and forewings and the characteristic structure of the aedeagus. It includes *A. perspicillata* (Horváth, 1909), an endemic species to the Canaries, and three endemics to Madeira Island: *A. chinai* (Lindberg, 1961), *A. insulana* (Lindberg, 1961) and *A. madeirensis* (China, 1938).

A. chinai, the largest of the group, is a rare species and, as found by Quartau *et al.*, (2004), has got a striking colour polymorphism and is strictly associated with also a rare endemic plant (*Isoplexis sceptrum*).

The two remaining species - *A. insulana* and *A. madeirensis* - are relatively easy to distinguish on the basis of the aedeagus shape, body size and colour pattern. However, distribution, food plant associations and habitats were poorly known. The present paper gives detailed information on adult morphology of these two closely related species, together with new distributional and ecological data. This information will enable the Madeiran authorities to adopt effective conservation measures in the future.

2. Material and methods

Field sampling: Specimens were collected from the vegetation either through a sweeping net or a pooter mainly from February to June in 2002. Sampling was made from sea level up to the mountains. All main vegetation zones (*e.g.*, Jardim & Francisco, 2000) were prospected: highland vegetation (>1200m), laurel forest or *laurisilva* (470-1000m), cultivated land (25-575m), abandoned agricultural fields (30-725m), spontaneous vegetation near water channels (55-320m) and exotic deciduous forest (240-950m). About 50 localities (Plate 4) and 24 plant species from 14 different families were prospected (Table 1). Host-plants were identified according to *Flora of Madeira* (Press & Short, 1994).

Rearing conditions: Species identity was established by rearing adults from isolated nymphs sampled on *Geranium palmatum* in the same area (Queimadas). Several instar nymphs were reared under the same laboratory conditions from February to April 2002. Specimens were kept on plastic cups with fresh leaves of *G. palmatum* replaced every two days. Mean temperature of laboratory was 20°C to 21°C in the three months varying the lowest and highest temperature from 17.8°C to 18.8°C and 20.8°C to 21.4°C, respectively. Mean humidity for each month varied between 65 to 66%, with minimum humidity between 49 to 55% and maximum between 76 to 83%.

3. Results

Asianidia insulana (Lindberg, 1961)

(Plate 1, A-C, F-H; Plate 2, A-D)

Erythronera insulana Lindberg, 1961; Lindberg, 1961: p. 71, illustrated erroneously aedeagus in Fig. 9b.

Asianidia insulana Dworakowska, 1970: 698, combination in *Asianidia*; Quartau, 1996: p. 223 illustrated head and scutellum of holotype in Fig. 6, aedeagus in Fig. 5 and correctly assigned aedeagus depicted in Lindberg (1961) to *A. insulana*.

Adults

Overall length 3.0-3.2 mm ♂♂ (n = 20), 3.1-3.4mm ♀♀ (n = 20). Very slender and delicate species. Head slightly narrower than pronotum with anterior margin concave; vertex longer at midline than near eyes. Lateral margins of pronotum divergent; anterior margin rounded; posterior margin nearly straight.

Colouration (Plate 1, A-C, H): Vertex yellowish with a continuous black pigmented median strip from the apex of the head to the apical cell of forewing widening across pronotum and medial third of forewings. Vertex with a black triangular spot from the anterior margin of head up to near crown apex touching basally or medially the internal margin of eyes; black pigmentation occupies about ¾ of pronotum and completely the scutellum; forewings black pigmented on clavus except on the basal half along ¼ of the outer margin; apical cell fully pigmented and medial third of cubital cell. Forewings veins yellowish and hind wings transparent. Frontoclypeus and thorax ventrally yellowish. Abdomen pale yellowish ventrally and dorsally with dark horizontal bands on each tergite. Legs yellowish with dark tarsi.

Intraspecific variation: Intraspecific variation on the extension of black pigmentation in head and thorax was common. Very few specimens from the Laurel forest had little or no pigmentation on the vertex. Specimens with a triangular black spot on the crown showed three main types of black spots: (i) similar to an inverted cognac glass, observed in 35.1% of the specimens and holotype as illustrated by Quartau (1996); (ii) with three vertices apically more or less rounded and more extended colouration on pronotum, present in 61.6% of the specimens; (iii) similar to a triangle curved apically and found in 3.3% of the specimens. Vertex can also be entirely black. This variation was not associated with sex and did not seem to follow any special pattern regarding the site or vegetation.

Male genitalia (Plate 1, F-G; Plate 2, A-D): Subgenital plates with kidney shape, twice wider ventrally than in its narrower part; dispersed small setae apically; the outer margin with three long macrosetae almost near central area. One of the specimens studied had four macrosetae instead of the usual three. Styles resemble an axe laterally; the centre of the style is wider, giving a sea horse shape laterally; apex curved about 1.2 x larger than its bases and round apically (Plate 1, F). Aedeagus shaft tubular, forming basally a chamber and apically acute or roundish with two pairs of apical processes (Plate 2, A-D): a small pair of straight divergent small horn-like appendages and a second pair of curved long arm appendages slightly wider in the middle, 2.5 x longer than previous ones, ending near aedeagus shaft, sometimes touching it. There is some variation in the shape of aedeagus apically, the length of apical appendages, the curvature of the bigger ones and their position relative to the aedeagus shaft. Lindberg (1961) mistook the drawing of the

aedeagus of this species with that of *A. madeirensis* which was corrected by Quartau (1996).

Material studied. ADULTS. CALHETA: Calheta, 01.v.2002, on *Geranium purpureum*, 6♂♂, 7♀♀; Paúl do Mar – Serrado Novo, 03.v.2002, on *Geranium* sp., 1♂; Prazeres, 01.v.2002, on *G. purpureum*, 14♂♂, 16♀♀. CÂMARA DE LOBOS: Curral das Freiras, 05.v.2002, on *Geranium palmatum*, 1♂, 17♀; 05.v.2002, on *G. purpureum*, 2♂♂, 6♀♀, Eira do Serrado, viii.1997, on *Castanea sativa*, 1♂, 1♀; Quinta Grande – Cabo Girão, 30.iv.2002, on *Geranium* sp., 8♂♂, 5♀♀. FUNCHAL: Boa Nova, 22.ii.2002, on *G. purpureum*, 27♂♂, 31♀♀; Monte, 07.vii.2001, on *Geranium purpureum*, 2♀♀; 16.iv.2002, on *G. palmatum*, 4♂♂, 4♀♀; on *G. purpureum*, 15♂♂, 27♀♀; on *Geranium dissectum*, 1♂. MACHICO: Lombada – Machico, on *Tetragonia tetragonoides*, 1♀; Machico, 03.ii.2002, on *Pteridium aquilinum*, 1♀; 17.ii.2002, on *Phyllis nobla*, 1♂; 24.ii.2002, on *Solanum tuberosum*, 1♂; Porto da Cruz – Maiata, 29.iv.2002, on *Geranium robertianum*, 2♂♂, 1♀♀; 29.iv.2002, on *G. purpureum*, 1♂, 5♀♀. PORTO MONIZ: Achadas da Cruz, 01.v.2002, on *Geranium palmatum*, 8♂♂, 39♀♀; 01.v.2002, on *G. purpureum*, 4♀♀; Chão da Ribeira, 28.vii.1997, on ferns, 1♀; 04.viii.1998, 1♀; 13.iv.1998, on *Erigeron karvinskianus*, 1♀; 14.iv.1998, on *G. palmatum*, 1♂, 2♀♀; 14.iv.1998, on *Rubia peregrina*, 4♀♀; 15.v.1998, on *Ageratina adenophora*, 2♀♀, on *G. palmatum*, 7♀♀; 30.vii.1998, on *Cedronella canariensis*, 1♀; Fonte do Bispo – Paul da Serra, 23.iv.2002, on *Vaccinium padifolium*, 1♂, on *G. purpureum*; 23.iv.2002, 1♀; Porto Moniz, 24.iii.2002, on *G. purpureum*, 2♂♂, 1♀♀; Rabaçal, 8.xi.1996, on herbaceous, 1♂, 02.v.2002, on *G. palmatum*, 1♂; Santa – Feira do Gado, 23.iv.20002, on *G. purpureum*, 3♂♂, 11♀♀. RIBEIRA BRAVA: Encumeada, 30.v.2001, on *G. purpureum*, 1♂, 1♀; Ribeira Brava – Boa Morte, 30.iv.2002, on *G. purpureum*, 1♂, 2♀♀. SANTA CRUZ: Pico da Silva – Abrigo do Pastor, 15.v.2002, on *G. purpureum*, 3♀♀; Curral – Montado do Pereiro, 18.v.2002, on *E. karvinskianus*, 1♂, 1♀; 18.v.2002, on *Acacia mearnsii*, 1♂, 1♀; 18.v.2002, on *Hordeum murinum*, 2♀♀; on *G. purpureum*, 4♀♀; 27.v.2002, on *G. purpureum*, 5♀♀; Estrada do Nicho – Poiso, on *Castanea sativa*, 1♀♀; on *Argyranthemum pinnatifidum*, 1♀; Camacha, 02.v.2002, on *G. purpureum*, 6♂♂, 19♀♀; Caniço de Cima, 24.xii.1997, on *Geranium molle*, 1♀; 28.xii.1997, 4♀♀; 09.iv.2001, 2♂♂, 2♀♀; 20.i.2002, 22♂♂, 9♀♀; Ribeiro Serrão, 17.v.2002, on *Origanum vulgare*, 1♀; on *Geranium dissectum*, 3♂♂, 5♀♀; Santo da Serra – Quinta, 02.v.2002, on *E. karvinskianus*, 1♂; 02.v.2002, on *G. purpureum*, 5♂♂, 12♀♀; 02.v.2002, on *G. palmatum*, 3♀♀. SANTANA: Arco de São Jorge, 03.v.2002, on *G. purpureum*, 2♂♂, 3♀♀; Faial, 03.v.2002, on *G. purpureum*, 3♂♂, 5♀♀; Pico das Pedras, 03.v.2002, on *G. palmatum*, 1♂, 1♀; Queimadas, 04.iii.2000, on *Geranium* sp., 4♀; 08.x.2001, on *Blechnum spicant*, 1♂, 2♀♀; 22.x.2001, on *G. palmatum*, 1♀; 13.i.2002, on *E. karvinskianus*, 3♀♀; Santana, 03.v.2002, on *G. purpureum*, 1♀; Ribeiro Frio, 05.x.1996, on *Gramineas*, 3♂♂, 2♀♀; 24.x.2001, on *E. karvinskianus*, 1♂, 2♀♀; 16.v.2002, on *G. robertianum*, 13♀♀; 16.v.2002, on *G. purpureum*, 4♂♂, 29♀♀; 24.v.2002, on *G. purpureum*, 1♀; 24.v.2002, on *G. purpureum*, 1♂, 5♀♀; 24.v.2002, on *G. molle*, 1♂, 5♀♀; 24.v.2002, on *Geranium maderens*, 2♂♂, 26♀♀; 23.vi.2002, 4♀♀; 24.v.2002, on *G. purpureum*, 9♂♂, 20♀♀; 24.v.2002, on *Geranium molle*, 11♀♀; 25.v.2002, on *G. palmatum*, 27♀♀; 31.v.2002, 1♀; 23.vi.2002, 2♀♀; São Jorge, 03.v.2002, on *G. purpureum*, 4♂♂; 03.v.2002, on *G. palmatum*, 3♂♂; São Jorge – Cabanas, 03.v.2002, on *G. purpureum*, 5♂♂, 3♀♀; 03.v.2002, on *G. palmatum*, 1♀; Pico do Gato, 03.iv.2002, on *G. purpureum*, 2♀♀. SÃO VICENTE: Boaventura, 03.v.2002, on *G. purpureum*, 1♀; Lombo do Urzal, 16.vii.2002, on *Ranunculus* sp., 1♂, 1♀; Chão dos Louros, 24.iii.2002, on *G. purpureum*, 5♂♂, 19♀♀; 24.iii.02, on *Blechnum spicant*, 2♂♂; 24.iii.02, on *E. karvinskianus* 1♀; Ponta

do Pargo, 01.v.2002, on *Trifolium repens*, 1♂, 3♀♀; 01.v.2002, on *G. purpureum*, 1♀; 14.ii.2002, on several plants, 3♀♀; São Vicente, 24.iii.2002, on *G. purpureum*, 7♀♀. NYMPHS. FUNCHAL: Boa Nova, 22.ii.2002, on *Geranium purpureum*, 1 nymph; Laboratory, 11.ii.2002, on *Geranium palmatum*, 14 nymphs (obtained from adults collected in Queimadas, Santana, at 13.i.2002, on the same host and reared in the laboratory); SANTA CRUZ: Caniço de Cima, 20.i.2002, on *G. purpureum*, 5 nymphs; SANTANA: Queimadas, 13.i.2002, on *Erigeron karvinskianus*, 1 nymph.

Asianidia madeirensis (China, 1938)

(Plate 1, D-E, I; Plate 2, E-G)

Erythroneura madeirensis China, 1938: pp. 48-49; Lindberg, 1961: p. 71, illustrated erroneously aedeagus in Fig. 9a

Asianidia madeirensis Dworakowska, 1970: p. 698 combination in *Asianidia*; Quartau, 1996: p. 223, illustrated head and scutellum in Fig 7, aedeagus in Fig. 8 and correctly assigned aedeagus depicted in Lindberg (1961) to *A. madeirensis*.

Adults

Body length 3.0-3.3 mm ♂♂ (n = 20), 3.0-3.3mm ♀♀ (n = 20). Colouration and shape similar to *A. insulana*, except for the extension of the dark longitudinal band.

Colouration (Plate 1, D-E, I) : Vertex yellowish with a triangular dark spot medially much thinner than in *A. insulana*, occupying about half of the surface, extending from the anterior margin of the head up to the crown apex, but never touching the internal margin of eyes; black pigmentation in pronotum much thinner than in *A. insulana* occupying about 2/3 of its surface; scutellum practically all black or except in lateral margins. Black pigmentation of forewings not reaching medially the margin of clavus; darkening of apical half of cubital cell not reaching apical cell. Veins, frontoclypeus and both thorax and abdomen ventrally, as well as legs as in *A. insulana*.

Intraspecific variation: Two extreme types of variation on the extension of black pigmentation in vertex with all intermediate forms were found: (i) an elongated and narrow triangle dark band in 39% of the specimens (Plate 1, D); and (ii) a triangular larger black spot with a constriction apically in 60.9% of the specimens (Plate 1, E). Some males and females showed asymmetrical margins in this large dark spot.

Male genitalia (Plate 2, E-G) : Subgenital plates and styles similar to those of *A. insulana*. Aedeagus shaft of a long straight tubular shape with a basal chamber and apically roundish and with four apical processes joined basally: a small pair of curved divergent small horn-like appendages facing upwards, and a second pair of long arm appendages wider in the middle, strongly curved and about 5x longer than previous ones and with tips ending near aedeagus shaft, but never touching it (Plate 2, E-G). The distance between the tips of the long arm appendages and the aedeagus shaft, as well as their curvature varied among specimens.

Material studied. ADULTS. FUNCHAL: Laboratory rearings. PORTO MONIZ: Chão da Ribeira, 30.vii.1997, on ferns, 2 ♂♂; 30.vii.1997, 1♂; 29.viii.1997, 2♂♂; 30.ix.1998, 1♂; 21.v.2002, on several plants, 2♀♀. SANTANA: Arco de São Jorge, 03.v.2002, on *Geranium purpureum*, 1♂; Queimadas, 22.x.2001, on *Geranium palmatum*, 10♂♂; 13.i.2002, 1♂, 1♀; 27.ii.2002, 7♀♀; 16.i.2002, 1♂; 17.i.2002, 1♀; 31.i.2002, 1♀; 16.ii.2002, 1♀; 02.iii.2002, 1♀; 23.iii.2002, 1♂; 26.iii.2002, 1♀; 29.iii.2002, 1♂, 1♀; 01.iv.2002, 1♂; 02.iv.2002, 1♀; 05.iv.2002, 2♂; 08.iv.2002, 1♂; 10.iv.2002, 1♂, 1♀; 15.iv.2002, 1♀; 23.iv.2002, 1♀;

02.v.2002, 1♂; 05.v.2002, 1♂; 06.v.2002, 4♂♂, 1♀; 21.v.2002, 2♂♂, 4♀♀ on *Erigeron karvinskianus*, 7♂♂, 1♀; Santana, 03.v.2002, on *G. purpureum*, 1♀; Ribeiro Frio, 24.x.2001, on *E. karvinskianus*, 1♂; 24.x.2001, on *Clethra arborea*, 1♂; 24.v.2002, on *Arrhenaterum bulbosum*, 2♂♂; 24.v.2002, on *Geranium molle*, 1♂; 16.v.2002, on *G. purpureum*, 1♂; 24.v.2002, on *G. purpureum*, 1♂; 24.v.2002, on *G. purpureum*, 12♂♂, 5♀♀; 31.v.2002, on *G. palmatum*, 1♂; 23.vi.2002, 1♂, 1♀; 23.vi.2002, on *Origanum vulgare*, 1♀. SANTA CRUZ: Abrigo – Meia Serra, 15.v.2002, on *G. purpureum*, 1♀. NYMPHS. FUNCHAL: Penteadá, 11.ii.2002, on *Geranium palmatum*, 6 nymphs (obtained from adults collected in Queimadas, Santana, at 13.i.2002, on the same host and reared in the laboratory); SANTANA: Queimadas, 13.i.2002, on *Erigeron karvinskianus*, 1 nymph; on *G. palmatum*, 31 nymphs.

Key to species of the *A. perspicillata* complex in Madeira

A- Head, pronotum and scutellum yellowish with no dark patterning. Forewings with yellow veins and in both sexes either uniformly opaque yellowish (non-melanic morphs) or with a dark pattern on the clavus and the apical part of the cubital cell (melanic morphs). Aedeagus typical of the *perspicillata* group. Overall length of male 4.1-4.3 mm (mean 4.2 mm), of female 4.2-4.6 mm (mean 4.4 mm).

A rare and monophagous species, found by Quartau et al. (2004) only associated with *Isoplexis sceptrum* mostly in Ribeiro Frio and Queimadas

..... ***A. chinai* (Lindberg, 1961)**

- Head, pronotum and scutellum yellowish with a continuous dark longitudinal band.....**B**

B – Vertex with an extensive black triangular spot medially occupying about half of the surface touching basally or medially the internal margin of eyes; scutellum and ¾ of pronotum black pigmented; forewings black pigmented on clavus except on the basal half along ¼ of the outer margin, apical half of cubital cell and apical cell black (Plate 1, A-C, H). Aedeagus apically acute or roundish with a small pair of straight divergent small horn-like appendages facing upwards; basally a second pair of curved long arm appendages facing downwards and ending near aedeagus shaft about 2.5x longer than previous ones (Plate 2, A-D).

A common species found all over the Island, except on xerophytic zones. Mainly associated with Geranium purpureum, an introduced plant***A. insulana* (Lindberg, 1961)**

- Vertex yellowish with a triangular dark spot occupying about half of the surface but never touching the internal margin of eyes; 2/3 pronotum black pigmented; scutellum black but sometimes yellowish on its margins; forewings black pigmented on clavus but not reaching medially the margin of clavus; apical half of cubital cell and apical cells black (Plate 1, D-E, I). Aedeagus shaft apically largely roundish, with a pair of long arm appendages widely curved outwards ending near aedeagus shaft, and with a small pair of curved divergent small horn-like appendages about 5 x smaller than previous ones (Plate 2, E-G).

Mostly common in laurel forest. Mainly associated with Geranium palmatum, an endemic plant to Madeira Island.....***A. madeirensis* (China, 1938)**

Habitats and Host-plants

Habitats

Both species differ in their distribution, abundance and number of habitats in which they occur. *A. insulana* is more widely distributed being present on nearly every selected sampling site throughout Madeira Island from coastal areas up to 1200m (Fig. 1). This species was sampled in 65% of the studied localities, while *A. madeirensis* was found only in 12 % of the localities below 1000m. *A. insulana* was present in a larger number of habitats including highland vegetation (>1200m), laurel forest (470-1000m), cultivated land (25-575m), abandoned agricultural field (30-725m), spontaneous vegetation near water channels (55-320m) and exotic deciduous forest (240-950m). Yet, this species seem to be more abundant at higher altitudes on shady places, near paths and water channels known as “levadas”, especially in the laurel forest than in lower altitudes by the sea. In contrast *A. madeirensis* shows a more restricted distribution and smaller number of habitats, being found only in laurel forest, in exotic deciduous forest and spontaneous vegetation near water channels. Specimens of this latter species were found on just a few scattered localities in the North and central parts of the island where laurel woods are best conserved (Plate 3). No specimens of these two species were found to occur in the dry eastern part of the island (Caniçal), characterised by higher temperatures and lower relative humidity and where no known host-plants seem to occur.

Host-plant associations

Adults of both species were found associated with a larger number of plants than nymphs. However, *A. insulana* appear to use a larger number of food plants than *A. madeirensis*. Adults of both species, in addition to the six plant species recorded in the literature (Lindberg, 1954, 1961; Quartau, 1996), were found in 19 plant species. *A. madeirensis* was sampled on eight species from five different plant families while *A. insulana* was collected on 24 plant species of 15 different plant families (Table 1). Many plant associations were represented by a few individuals that could represent accidental occurrences of these highly mobile insects. Thus, excluding as food plants those with less than five individuals, the numbers were much reduced: *A. insulana* had eight food plants of three plant genera in three different plant families while *A. madeirensis* had three plant species of two genera in two plant families (Table 1). Such host-plant associations do not seem to change according to habitats and/or localities. In fact *A. insulana* was found on *Geranium* spp. all over the island in different localities, habitats or altitudes.

However, the actual number of plants used for ovipositing by both species seems to be much smaller than the number of food plants. Also host-plants on which both adults and nymphs feed were only two species of *Geranium*: *G. palmatum* and *G. purpureum* in *A. insulana* and *G. palmatum* in *A. madeirensis*. Of all the plant species prospected, 90% and 92% of the individuals of *A. insulana* and *A. madeirensis*, respectively, were found on species of *Geranium* spp. Although nymphs were found only in two species of *Geranium*, taking into account that these are difficult to be observed in the field, it is possible that the six *Geranium* species on which adults occur are true host-plants. This could be supported by the larger number of adults found on plants of these species. But both species seem to include *Erigeron karrivskianus* in their host-plant range, an exotic Asteraceae native to Mexico, which is now widely distributed in Madeira.

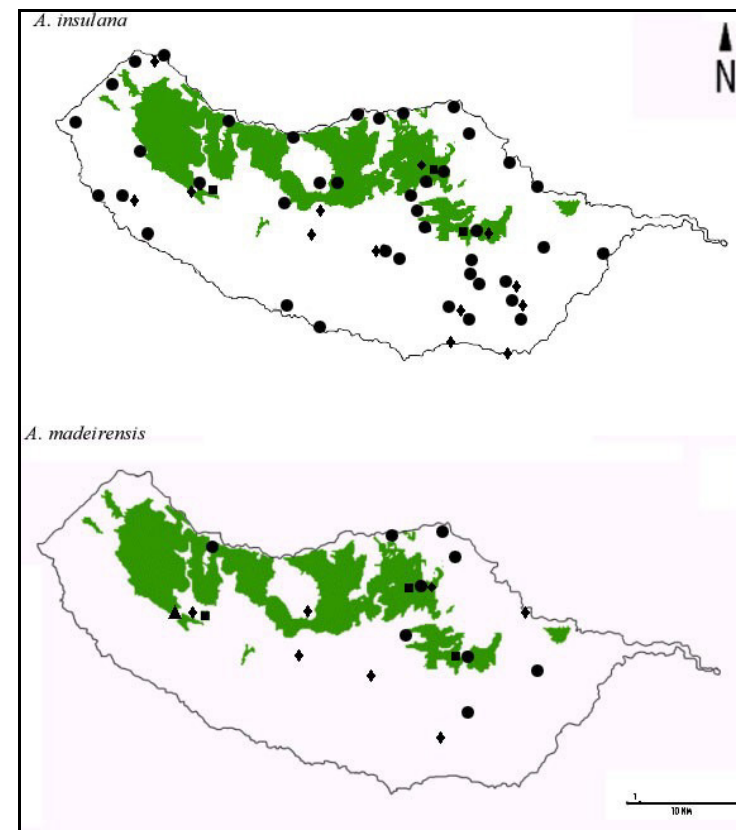


Fig. 1: Site records of *Asianidia insulana* and *A. madeirensis* in Madeira Island. In black spots (●) are samples of this work, while those marked with (◆) are from Lindberg (1961), with (■) from Quartau (1996) and with (▲) from China (1938). Laurel forest is represented in green.

Both species are associated with endemic plants but the degree of specificity seems to be greater in *A. madeirensis* than in *A. insulana*. *A. madeirensis* is mostly related to an endemic plant, *Geranium palmatum*, while *A. insulana* is to *G. purpureum*. Only 21 % of all adults of *A. insulana* were collected on endemic plants in contrast to 57.4% of *A. madeirensis*. These results are similar if we consider the number of specimens sampled on the endemic plant, *G. palmatum*, in which *A. insulana* has only 13.6 % of adults, while *A. madeirensis* has a total of 56.4%. Despite these differences, host-plant range and host specificity, especially in what concerns oviposition, are yet poorly known and should be further investigated. In fact, regardless the plant species on which they were collected, nymphs of both species often coexist in the same locality, on the same plant and even in the same date. In addition, adults of both species were found all over the year, although are less common in summer and more common from October to May.

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Table 1: Host-plants with families and number of sampling sites where *A. insulana* and *A. madeirensis* were collected. Six last columns with total number of specimens studied, including those collected and the nymphs (nym.) reared in the laboratory.

Family	Plant species	N Plant Sites	<i>A. insulana</i>			<i>A. madeirensis</i>		
			♂♂	♀♀	nym.	♂♂	♀♀	nym.
Geraniaceae	<i>Geranium purpureum</i>	23	999	1185	6	115	27	
	<i>Geranium molle</i>	2	22	117		22		
	<i>Geranium dissectum</i>	1	33	55				
	<i>Geranium palmatum</i>	8	77	556	14	219	224	
	<i>Geranium robertianum</i>	2	72	14				
	<i>Geranium maderense</i>	1	72	330				
Blechnaceae	<i>Blechnum spicant</i>	2	23	22				
Rubiaceae	<i>Phyllis nobla</i>	2	21	22				
Clethraceae	<i>Clethra arborea</i>	1				21		
Asteraceae	<i>Argyranthemum pinnatifidum</i>	1		21				
	<i>Ageratina adenophora</i>	1		23				
	<i>Erigeron karvinskianus</i>	5	23	27	1	28	21	
Fabaceae	<i>Acacia mearnsii</i>	1	21	21				
	<i>Trifolium repens</i>	1	21	23				
Fagaceae	<i>Castanea sativa</i>	2	21	22				
Ericaceae	<i>Vaccinium padifolium</i>	1	21					
Dennstaedtiaceae	<i>Pteridium aquilinum</i>	1		21				
Tetragoniaceae	<i>Tetragonia tetragonoides</i>	1		21				
Solanaceae	<i>Solanum tuberosum</i>	1	21					
Lamiaceae	<i>Prunella vulgaris</i>	1				21	23	
	<i>Origanum vulgare</i>	1		21			21	
Ranunculaceae	<i>Ranunculus</i> sp.	1	21	21				
Poaceae	<i>Arrhenaterum elatius bulbosum</i>	1				22		
	<i>Hordeum murinum</i>	1		22				

4. Discussion

A. insulana and *A. madeirensis* are two closely but clearly independent species. In spite of showing some intraspecific variation in the colour pattern and in the aedeagus shape, these are the best characters for separating this pair of species. The comparatively greater variation in colouration found in *A. insulana* may be related to the larger number of specimens studied. In contrast to previous drawings (Lindberg, 1961, Quartau, 1996),

some specimens of *A. insulana* showed yellowish colouration in the basal angles of scutellum. Colour pattern variation is also present in *A. chinai*, in which Quartau *et al.* (2004) found colour polymorphism in both males and females.

A. insulana and *A. madeirensis* can be considered polyphagous or oligophagous with preference for plants of the genus *Geranium*. But differences in the number of specimens found among species of this plant suggest that they show different degrees of host preferences. As referred to before, *A. madeirensis* is mostly related to an endemic plant, *Geranium palmatum*, while *A. insulana* is to *G. purpureum*. The fact that nymphs of both species were found on *Erigeron karvinskianus*, an introduced plant, suggests that these leafhoppers have potential for expanding their host-plant range. However, it is not clear why both species differ greatly in distribution, abundance and the number of habitats in which they were found. Availability of food plants does not seem to be the cause for these differences, since the two most important plants, *G. purpureum* and *G. palmatum* are largely distributed in the island. *A. madeirensis* is also absent in many localities where these two plants were present. The fact that both adults and nymphs of *A. madeirensis* and *A. insulana* are frequently found coexisting in the same habitat at the same time and on the same plant seems to indicate that there is no temporal and ecological segregation.

As referred to before, *A. madeirensis* is mostly restricted to laurel forest in the north and centre of the island which suggests that differences in distribution must be related with other causes other than the associated plants, probably environmental factors such as humidity. But availability of plants for oviposition may be also important. Since both species seemed to use less plants for ovipositing than for feeding, it is likely that competition for oviposition sites might occur whenever they coexist.

In phytophagous insects the degree of host-plant specificity can play an important role on species diversification on islands, particular those with a narrow range of host-plants (e.g., Schluter, 2000; Percy, 2003; Losos & Ricklefs, 2009). Colonizing a new host and specializing in its resources could originate host-races and eventually lead to new species (e.g., Bush & Butlin, 2004; Percy, 2003; Nyman, 2009). Remane (1984) in his brief, yet inspiring summary, referred that in the Erythroneurini of Macaronesia adaptation of the head structure and size of legs to the different hairy covering of the leaves of the host-plants might have been one of the important steps in the colonization and specialization to new plants. In fact, *Asianidia* leafhoppers seem to be a suitable group to investigate the process of island radiation, since their species might have been originated in Madeira (and the Canaries) by progressive adaptation to different host-species through host-shift (Remane, 1984; Quartau, 1996).

Further work, namely molecular phylogenies together with research on acoustic isolating mechanisms, systems which are used by leafhoppers on mate recognition and courtship, might shed some light on this interesting example of radiation.

Finally, as *A. madeirensis* is of much more restricted distribution than *A. insulana*, being sometimes even absent when its principal host-plant is present, it might be or become endangered in the future. This suggests that specific preventive measures for its conservation, like population monitoring, are desirable even though the laurel forest is currently under Government protection.

5. Acknowledgements

We dedicate this work to Professor Reinhard Remane to whom we ought many exciting entomological discussions. We hope that his enthusiasm, curiosity and knowledge will also inspire the younger generations. This work is based on a graduation thesis of the first author at Faculty of Science of Lisbon in 2002, and was carried out at the University of Madeira. Thanks are given to the Natural Park of Madeira, for sampling facilities in protected areas, to Dr. Susana Fontinha and Ms. Amélia, of the Madeira Botanical Gardens, for their help in the plant identification and for allowing the consultation of the Herbarium and to Mr. Genage André, of Faculty of Science of Lisbon, for his continued support.

6. Summary

A. insulana (Lindberg, 1961) and *A. madeirensis* (China, 1938) are two endemic and closely related species of the *Asianidia perspicillata* complex present in Madeira. They are relatively easy to distinguish mostly on the basis of the male genitalia and adult colouration, yet distribution, plant associations and habitats were poorly known.

The present study is a general overview of the morphology and ecology of this pair of species. New information on intra- and inter-specific variation, together with new distributional and ecological data are presented as a result of a thorough field-work from sea level up to the mountains and involving all main vegetation zones in the island.

Adults of both species were found associated with a larger number of plants than nymphs, namely endemic plants, but the degree of specificity seemed to be greater in *A. madeirensis* than in *A. insulana*. They both showed preference for plants of the genus *Geranium*, being *A. madeirensis* mostly associated with an endemic plant, *G. palmatum*, while *A. insulana* is to *G. purpureum*.

A key to species of the *A. perspicillata* group present in Madeira is also given. Moreover, as first advanced by Remane and later by Quartau, *Asianidia* leafhoppers seem to be a suitable group to investigate the process of island radiation, since their species might have been originated by progressive adaptation to different plants through host-shift.

Finally, as *A. madeirensis* is of much more restricted distribution than *A. insulana*, being sometimes even absent when its principal host-plant is present, some conservation measures are also suggested.

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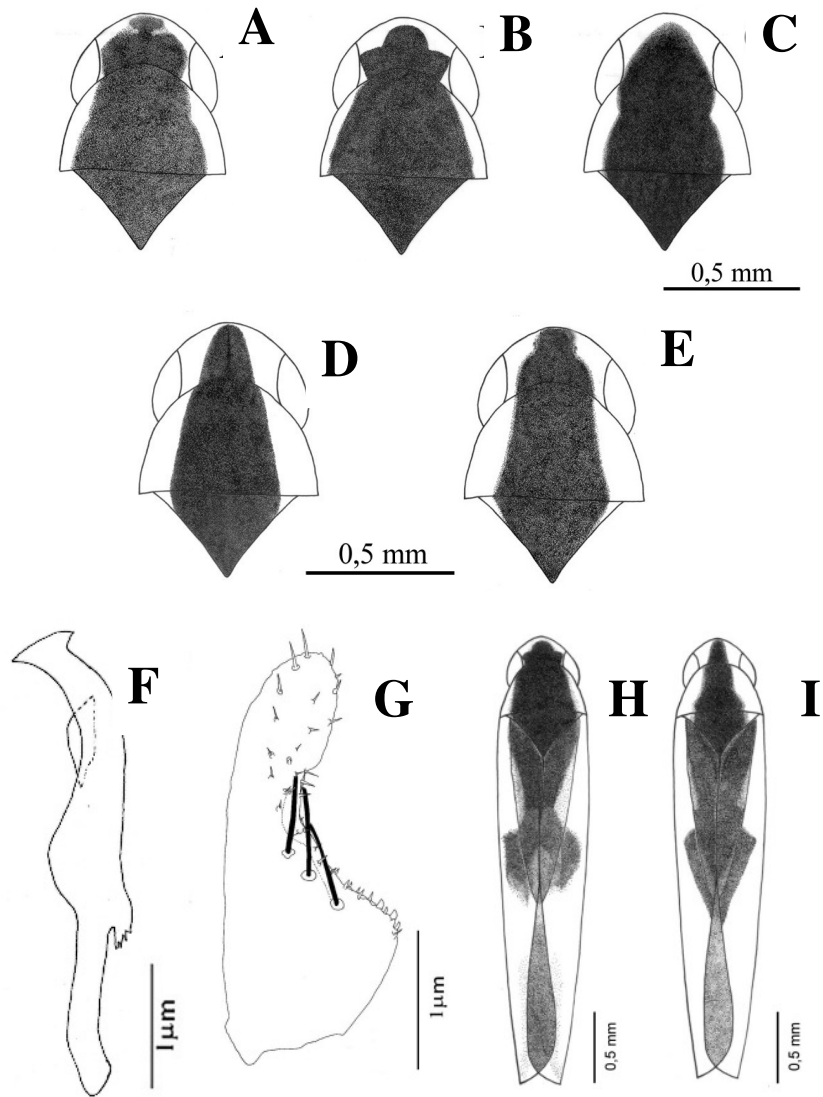


Plate 1: Vertex, pronotum and scutellum, dorsal view (A-E). *Asianidia insulana*: A male from Boa Nova, Funchal, on *Geranium purpureum*; B male from São Jorge, Santana, on *G. palmatum*; C male from Camacha, Santa Cruz, on *G. purpureum*. *Asianidia madeirensis*: D male from Queimadas, on *G. palmatum*; E female from Queimadas, Santana, on *G. palmatum*. *Asianidia insulana*: Style in lateral view (F); genital plate in ventral view (G). Adults in dorsal view of *Asianidia insulana* (H) and *Asianidia madeirensis* (I).

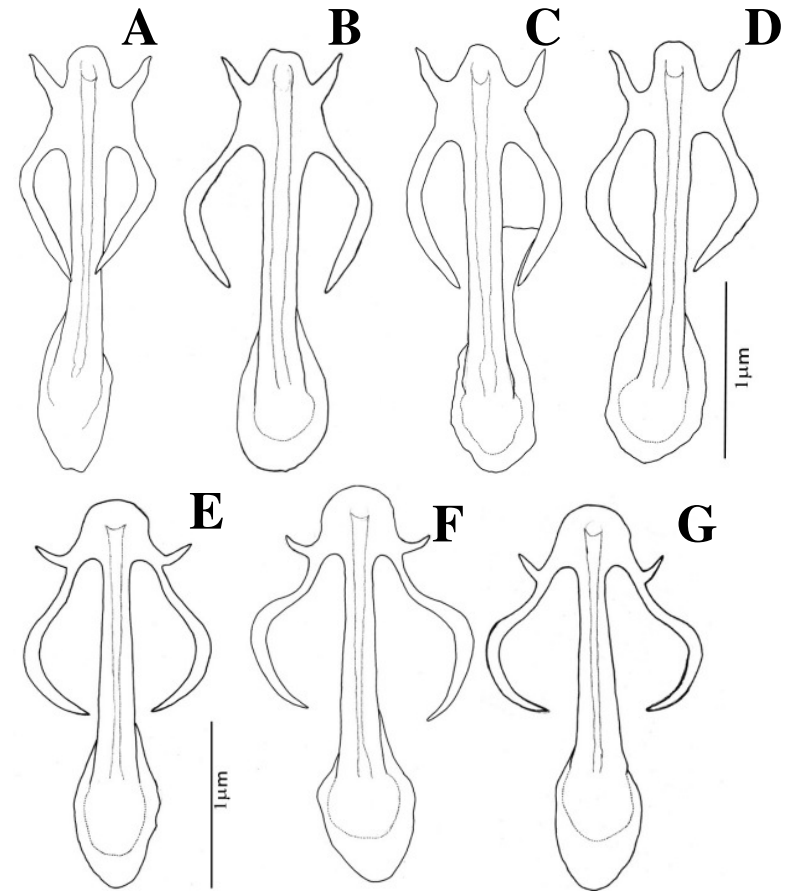


Plate 2: Aedeagus in postero-dorsal view: A-D *Asianidia insulana*; E-G *Asianidia madeirensis*.