

***Asianidia* Zachvatkin (Hemiptera, Cicadellidae) associated with the laurisilva forest of Madeira island: species phenology and host-plant preferences**

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Abstract: Five *Asianidia* Zachvatkin species (Hemiptera, Cicadellidae) - *A. albula*, *A. decolor*, *A. insulana*, *A. chrysanthemii* and *A. melliferae* - were found in a survey of the leafhoppers associated with a patch of the laurel forest in Madeira island. A total of 513 specimens were collected as a result of a two-year study. *Asianidia decolor* was the most abundant species (47%), followed by *A. albula* (36%) and *A. insulana* (16%). *A. chrysanthemii* and *A. melliferae* were scarcely found. These leafhoppers proved to be active mostly during spring and summer, but *A. albula* and *A. decolor* also showed a peak of abundance during November. The *Asianidia* species showed considerable variation in host-plant preferences, being some of them monophagous (*A. chrysanthemii* and *A. melliferae*), while others are oligophagous or even have a wide range of host-plants (*A. albula*, *A. decolor* and *A. insulana*). During this study new associations were found between these leafhoppers and plants of the Madeiran laurisilva. The host-plant spectra of the closely related *Asianidia albula* and *A. decolor* showed considerable overlap. On the contrary, *A. insulana*, a species of a different lineage, had different host-plants. It is possible that differences in the preference for host-plants might have played a key role in the diversification of *Asianidia* in the Madeiran laurisilva.

Zusammenfassung: Im Rahmen einer Untersuchung zur Zikadenfauna von Lorbeerwäldern auf Madeira wurden fünf Arten der Gattung *Asianidia* Zachvatkin nachgewiesen: *A. albula*, *A. decolor*, *A. insulana*, *A. chrysanthemii* und *A. melliferae*. In Summe wurden 513 Individuen gesammelt. Die Häufigste Art war *Asianidia decolor* (47%), gefolgt von *A. albula* (36%) und *A. insulana* (16%). *A. chrysanthemii* und *A. melliferae* wurden nur in geringer Zahl gefangen. Die Hauptaktivität der Arten ist im Frühjahr und Sommer, *A. albula* und *A. decolor* zeigten ein weiteres Abundanzmaximum im November. *Asianidia chrysanthemii* und *A. melliferae* sind monophag, die anderen drei Arten oligo- bis polyphag.

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Im Rahmen dieser Studie konnten neue Nährpflanzenassoziationen zwischen *Asianidia*-Arten und Pflanzenarten der Lorbeerwälder Madeiras gefunden werden. Die Nährpflanzenspektren der nahe verwandten Arten *A. albula* und *A. decolor* zeigten große Ähnlichkeiten, während die systematisch weiter entfernte Art *A. insulana* andere Nährpflanzen nützt. Möglicherweise spielte die unterschiedliche Nahrungspräferenz eine entscheidende Rolle in Artbildungsprozessen der Gattung *Asianidia* auf Madeira.

Key words: Leafhoppers, *Asianidia*, laurisilva, host-plants, Madeira

1. Introduction

The genus *Asianidia* Zachvatkin is represented in Madeira by nine species, six of which are strictly endemic to this archipelago – *A. albula*, *A. atlantica*, *A. chinai*, *A. insulana*, *A. madeirensis* and *A. melliferae* (Quartau, 2007, 2008; Aguin-Pombo & Freitas, 2008). A similar situation exists in the Canary Islands, where 14 endemic species of *Asianidia* have been recorded (Lindberg, 1954; Oromí *et al.*, 2004). According to Quartau (1996), the high number of endemic *Asianidia* in Madeira, and in Macaronesia in general, may offer a good example of the adaptive radiation process by host-shift. For most phytophagous insects, plants provide not only a food source but also frequently the bulk of their environment, such as for concealment, substrate-borne communication during courtship, mating and oviposition (Claridge *et al.*, 1997). So, differences in the preferences for the host-plants for feeding and/or ovipositing might have increasingly driven the establishment of patterns of specialization among some insect populations. Colonizing a new host and specializing in its resources could originate host races and eventually lead to speciation, particularly if the insects mate assortatively on their host (e.g., Bush & Butlin, 2004; Matsubayashi *et al.*, 2010; Nyman, 2010). In fact, given enough time, these populations may diverge slowly by the adaptation to different host-species, thus becoming independent and distinct species through a sympatric process (Bernays & Chapman, 1994; Bush, 1994; Bush & Butlin, 2004). As such, host-plant differentiation would be a major factor in the initial origin of the new closely related species. Bush and Butlin (*op.cit.*), for instance, pointed out that sympatric divergence due to host-shift could be the major source of diversity in many phytophagous and parasitoid insects, groups that are particularly speciose.

During the last decades some studies have shown that species once thought to be polyphagous are instead genetically differentiated groups of specialized populations. Some of these groups are differentiated populations still capable of interbreeding, while others are sympatric species adapted to different host plants or complexes of sibling species (Thompson, 1994).

In what concerns the *Asianidia* species, these exhibit a considerable diversity in their host specificity. As typical typhlocybines they feed not by sucking sap, like most other leafhoppers, but mostly by emptying the leaf mesophyll cells of their contents, so that a whitish stippling can be visible on the leaves as a result of their feeding activity (e.g., DeLong, 1971). Some species have been found on several host-plant species (even from different families), while others are extremely specific in host utilization, having been observed exclusively in one plant species, such as *A. chinai* and *A. melliferae*, in relation to *Isoplexis sceptrum* and *Euphorbia mellifera*, respectively (Quartau, 1996). Nevertheless, no definite conclusions can be drawn regarding the ecological niches for each of the Madeiran *Asianidia* species, since for most of these leafhoppers the range of the host-

plants for feeding and ovipositing, for instance, is far from being properly known. Host preferences are difficult to determine since most habitats where *Asianidia* occur can include a mixture of a high number of vascular plants, namely a great diversity of herbaceous species. Moreover, it is well known that leafhoppers are also able of performing vertical migrations from the herbaceous vegetation up to the plant canopy (Nickel *et al.*, 2002), thus making difficult the complete inventory of their hosts. The recent data by Quartau (1996, 2007 and 2008) and Quartau & Remane (1996) on the Madeiran leafhoppers served as the principal stimulus for this work where we present the results of a preliminary survey of the *Asianidia* species carried out in a patch of the Madeiran laurel forest. The following is an analysis of the diversity of the *Asianidia* species found and their seasonal variation in abundance during a two-year period, as well as of the associations between these leafhoppers and their host-plants.

2. Material and Methods

The study was carried out at Chão da Ribeira (32°47'N, 17°06'W) which is located in the northern part of Madeira island, near Seixal (Fig. 1). Selected plant species of the upland laurisilva were sampled by standardized sweeping with entomological nets. Sweep netting was followed since besides being an easy and quick method of sampling terrestrial insects, it had proven in previous studies to be quite effective for surveying *Asianidia* (e.g., Quartau, 1996; Quartau & Remane, 1996; Quartau *et al.*, 2004). The number of sweeps varied between five and 20, according to the morphological and phenological characteristics of the individual plant. Sampling took place from May 1997 until June 1999 and was performed monthly, whenever the weather conditions allowed it (during December 1997 sampling was not possible). The data collected during this two-year period were pooled to identify the patterns of seasonal abundance for the three most common *Asianidia* species: *A. albula*, *A. decolor* and *A. insulana*.

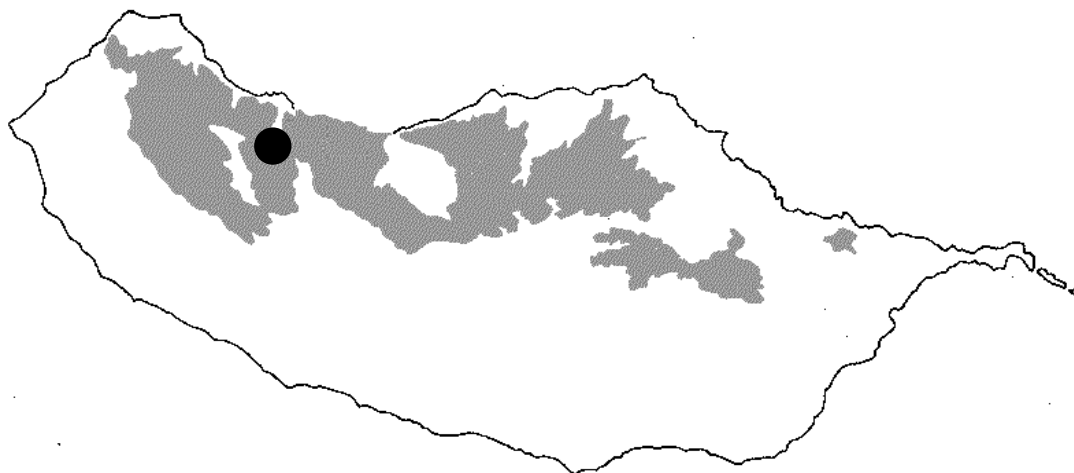


Fig. 1: Surveying site in Madeira island (dark circle) and Madeiran laurisilva (shaded area).

The sampling was undertaken on the most characteristic and/or endemic plant species (Neves *et al.*, 1996; Borges *et al.*, 2008) of the three main vegetation layers: (a) arboreal layer - *Ocotea foetens*, *Laurus novocanariensis*, *Salix canariensis*, *Clethra arborea* and *Euphorbia mellifera*; (b) arbustive layer - *Phyllis nobla*, *Teucrium betonicum*, *Argyranthemum pinnatifidum*, *Erica platycodon*, *Rubia agostinhoi*, *Bystropogon maderensis* and *Heberdenia excelsa*; and (c) herbaceous layer - *Teline madeirensis*, *Festuca donax*, *Geranium palmatum*, *Cedronella canariensis*, *Oenanthe divaricata* and *Erigeron karvinskianus*.

Further plant species, not referred to above, have also been sampled during this period, but no specimens of *Asianidia* were obtained from them.

The present study follows the species interpretation within *Asianidia* of Lindberg (1954, 1961), Quartau (1996) and Quartau & Remane (1996).

The Index of Levins (LO) was applied to the data on insect-plant associations for selected *Asianidia* species in order to evaluate the degree of overlap of their plant preferences (Levins, 1968; Ludwig & Reynolds, 1988).

$$LO_{1,2} = \frac{\sum [(p_{1,j})(p_{2,j})]}{\sum (p^2_{1,j})}$$

3. Results

During this study five *Asianidia* species were found, namely *A. albula*, *A. decolor*, *A. insulana*, *A. chrysanthemii* and *A. melliferae*. More than five hundred specimens were captured as a result of the two-year sampling period (Table I). *Asianidia decolor* was the most abundant species (47%), followed by *A. albula* (36%) and *A. insulana* (16%). Only three specimens of *A. chrysanthemii* were sampled during the surveying period. All were found on *Argyranthemum pinnatifidum*, which is in accordance with previous findings indicating that *A. pinnatifidum* is the host-plant of this leafhopper both for feeding and ovipositing (Quartau, 1996). On the other hand, *Asianidia melliferae* was recorded only once and the very one specimen collected was found on *Euphorbia mellifera*, which is also in accordance with previous ecological data for this species (Quartau, 1996).

A. albula appeared to be the most generalist species. It was collected on 13 different plant species and was present in all three vegetation layers (Table I). Besides occurring predominantly in the herbaceous layer, this species presented a strong association with *Cedronella canariensis* (Fig. 2).

On the other hand, *A. decolor* and *A. insulana* appeared to be oligophagous species since they were found on several plant species (Table 1), being the former present in great numbers in the canopy of *Salix canariensis* (Fig. 3). *A. insulana* appeared to be especially associated with *Rubia agostinhoi* (Fig. 4).

In order to quantify the degree of host plant overlap between the most common species of *Asianidia*, Levins index of overlap (Lo) was calculated for the following pairs of species: *A. albula* - *A. decolor* and *A. albula* - *A. insulana*. This procedure was not applied to *A. decolor* and *A. insulana* because they did not share any host-plants (Fig. 5). The results of this analysis indicated that there is a considerable overlap between *A. albula* and *A. decolor* (Lo (alb-dec) = 0.971, Lo (dec-alb) = 0.217). On the contrary, the overlap between *A. albula* and *A. insulana* was very small (Lo (alb-ins) = 0.001, Lo (ins-alb) = 0.005).

Table 1: Number of specimens of the three most abundant *Asianidia* species (*A. albula*, *A. decolor* and *A. insulana*) collected on selected plant species of the Madeiran laurisilva.

Layer	Plant species	<i>A. albula</i>	<i>A. decolor</i>	<i>A. insulana</i>
Arboreal	<i>Clethra arborea</i>	1	0	0
	<i>Euphorbia mellifera</i>	0	0	1
	<i>Laurus novocanariensis</i>	1	4	0
	<i>Ocotea foetens</i>	5	0	1
	<i>Salix canariensis</i>	43	223	0
Arbustive	<i>Bystropogon maderensis</i>	10	0	0
	<i>Erica platycodon</i>	1	0	0
	<i>Heberdenia excelsa</i>	9	0	0
	<i>Phyllis nobla</i>	2	0	0
	<i>Rubia agostinhoi</i>	0	0	52
Herbaceous	<i>Teucrium betonicum</i>	4	0	0
	<i>Cedronella canariensis</i>	97	15	0
	<i>Erigeron karvinskianus</i>	0	0	13
	<i>Festuca donax</i>	1	0	6
	<i>Geranium palmatum</i>	1	0	10
	<i>Oenanthe divaricata</i>	8	0	0
	<i>Teline madeirensis</i>	0	1	0
Total relative abundance		183	243	83
Total host species		13	4	6

The three most common *Asianidia* species were more abundant in spring and summer as expected (Table 2). However, for *A. albula* and *A. decolor* a peak of abundance was also recorded in November. No specimens (both nymphs and adults) were found during the winter months.

Table 2: Seasonal variation of the abundance of three *Asianidia* species in Madeiran laurisilva. (white: no specimens; light grey: ≤ 5 specimens, dark grey: ≤ 25 specimens, black: > 25 specimens).

Species names	Months											
	J	F	M	A	M	J	J	A	S	O	N	D
<i>A. albula</i>				■	■	■	■	■	■		■	
<i>A. decolor</i>					■	■	■			■	■	■
<i>A. insulana</i>					■		■	■	■			

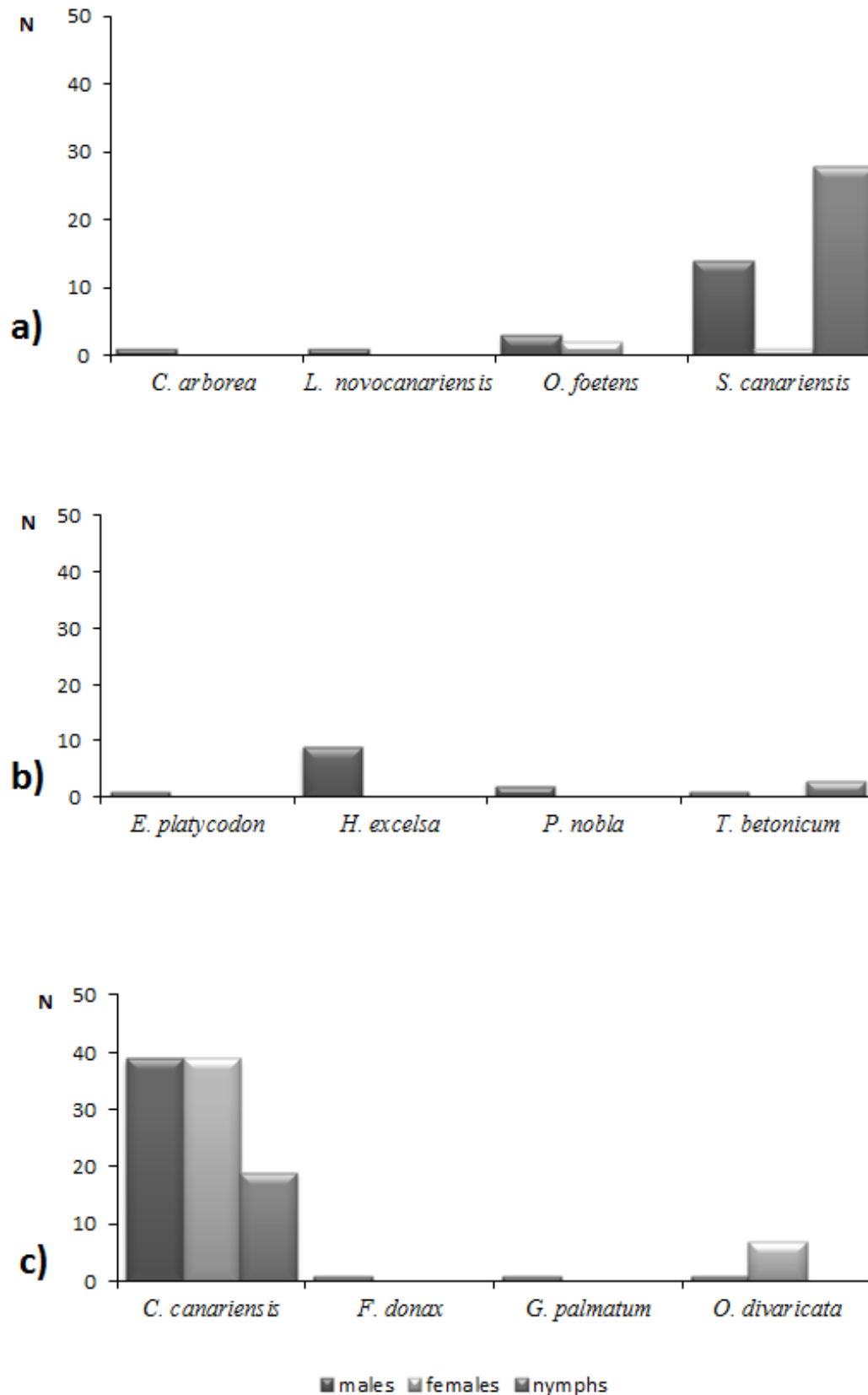


Fig. 2: Number of *A. albula* specimens collected on different plant species of the arboreal (a), arbustive (b) and herbaceous layers (c) of the Madeiran laurisilva.

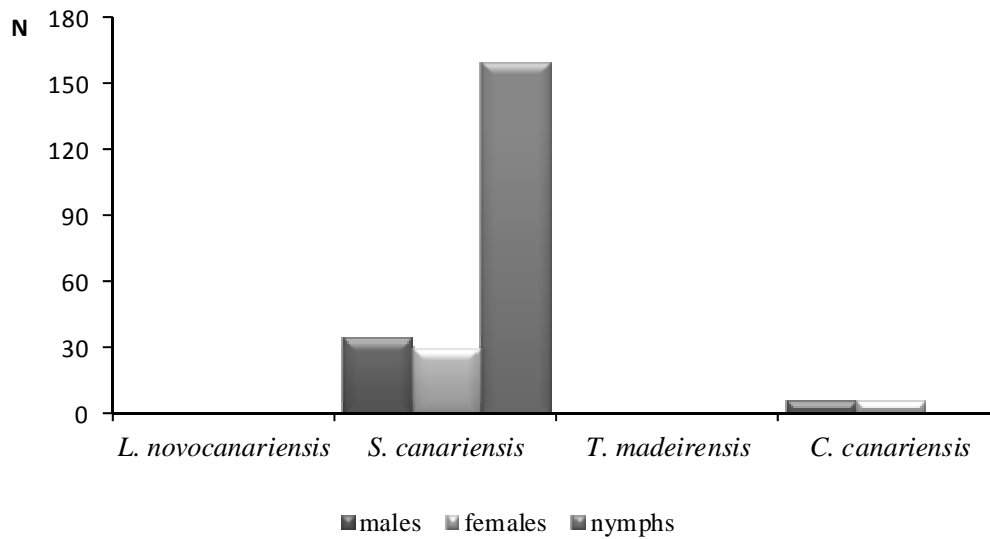


Fig. 3: Number of *A. decolor* specimens collected on plant species of the arboreal (*Laurus novocanariensis*, *Salix canariensis*) and herbaceous layers (*Teline madeirensis*, *Cedronella canariensis*) of the Madeiran laurisilva.

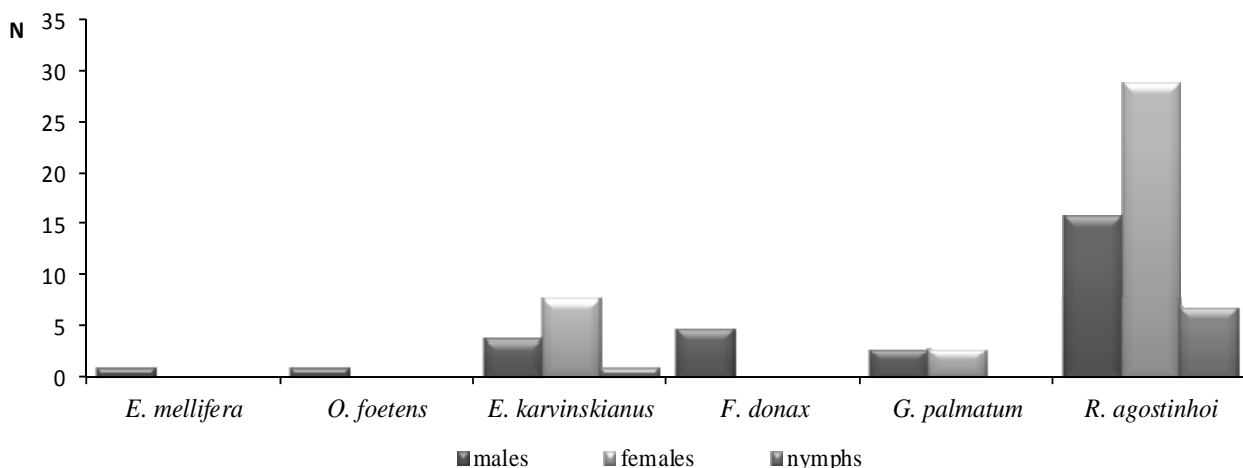


Fig. 4: Number of *A. insulana* specimens collected on plant species of the arboreal (*Euphorbia mellifera*, *Ocotea foetens*) and herbaceous layers (*Erigeron karvinskianus*, *Festuca donax*, *Geranium palmatum*, *Rubia agostinhoi*) of the Madeiran laurisilva.

4. Discussion

The present investigation revealed new plant associations within leafhoppers of the genus *Asianidia* in the Madeiran laurisilva (cf. Quartau, 1996). For the three most abundant *Asianidia* species it was possible to improve our knowledge on the range of their host-plants. *A. albula* was recorded for the first time on plants of the genera *Clethra*, *Laurus*, *Ocotea*, *Bystropogon*, *Erica*, *Heberdenia*, *Phyllis*, *Teucrium*, *Festuca*, *Geranium* and *Oenanthe*. On the other hand, *A. decolor* was found for the first time on *Laurus* and *Teline*. Moreover, *A. insulana* was collected for the first time on plants of the genera *Euphorbia*, *Ocotea*, *Rubia*, *Erigeron* and *Festuca*.

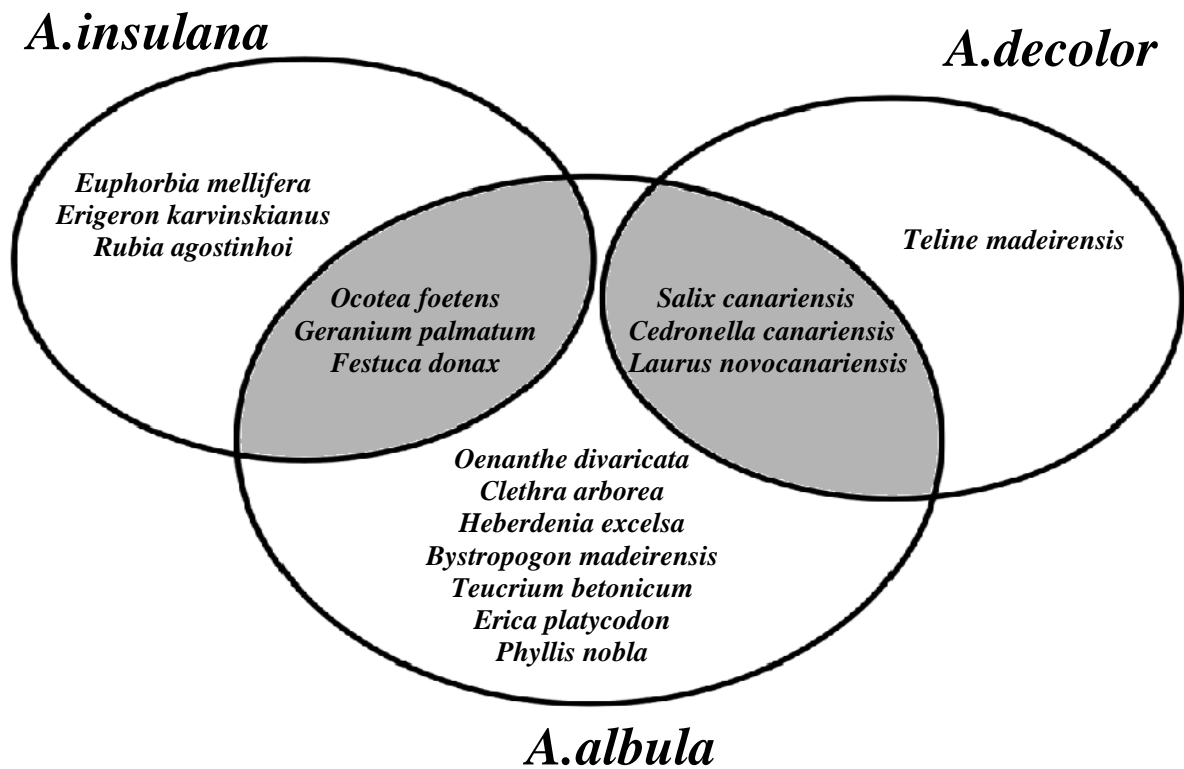


Fig. 5 – Host-plant species' overlap between the three most abundant *Asianidia* species (*A. albula*, *A. decolor* and *A. insulana*) of the Madeiran laurisilva.

However, it is important to correctly discriminate between true insect-plant associations and casual occurrences. The presence of nymphs on a particular plant species is usually a clear indication of a true association since these immature forms have developed from eggs oviposited on it, have limited mobility and usually feed on the same plants used by adults. On the other hand, the record of a few adult specimens on a particular plant species is not indicative of a true insect-plant association since such occurrences can be incidental. A closer inspection of our results (cf. Table I) seems to suggest that the occurrence of *A. albula* on plants of the genera *Clethra*, *Laurus*, *Erica*, *Phyllis*, *Festuca* and *Geranium* is probably accidental and not an indication of a real association. The same reasoning can be applied to *A. decolor* in what concerns its association with *Teline*, and *A. insulana* in relation to *Euphorbia* and *Ocotea* species.

Adults and nymphs of all three *Asianidia* species were common on their host-plants during spring and summer. Both *A. albula* and *A. decolor* showed another peak of abundance in November, suggesting that these two species may be bivoltine. The absence of specimens during winter makes us suppose that in these species overwintering occurs mostly in the egg stage.

The analysis of the trophic spectra of the three most abundant *Asianidia* species show some overlap on their host-plant species. *A. insulana* and *A. decolor* do not share host-plant species, but both of these species exhibit some degree of overlap with *A. albula* (Fig. 5). The high degree of overlap found between *A. albula* and *A. decolor* contrasts with the one found between *A. albula* and *A. insulana* (a Lo of about 0.97 as against 0.22, respectively). This finding is possibly a reflection of the phylogenetical proximity between the former pair of species (Lindberg, 1954, 1961; Quartau, 1996). *A. decolor* and *A. albula* both belong to the *apiculata* species group and it is possible that one species has derived from the other

by the colonization of different hosts. Besides being morphologically similar, these species still maintain similar trophic spectra probably as a result of biological constraints determined by their close gene pools. Although plausible, this hypothesis needs support from accurate molecular phylogenies. On the other hand, *A. insulana* has distinct host-plants from those recorded for *A. albula* and *A. decolor*. *A. insulana* belongs to a different species group – the *perspicillata* complex – and is also morphologically different, presenting distinctive dark patterning on the head, thorax and elytra (Quartau, 1996) which may confer some ecological advantage (e.g., predator avoidance).

In conclusion we would like to emphasize the need for further studies on the interactions between these *Asianidia* species and their host-plants, namely their possible origin through radiation in Madeira (and the Canaries) by progressive adaptation to different host-species. On the other hand, the biosystematic affinities within *Asianidia* are still poorly understood and the taxonomic status of particular populations is still unclear. As such, further investigations should be carried out with a view to identify and describe the entire diversity of host-plants, as well as the outlines of the life histories of these species, namely the number of generations per year and the stage in which they overwinter.

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