HOST PLANT USE AMONG CLOSELY RELATED Anaea BUTTERFLY SPECIES (LEPIDOPTERA, NYMPHALIDAE, CHARAXINAE)

QUEIROZ, J. M.

Departamento de Zoologia, Universidade Estadual de Campinas, C.P. 6109, CEP 13083-970, Campinas, SP, Brazil

Correspondence to: Jarbas Marçal Queiroz, Departamento de Ciências Ambientais, IF, Universidade Federal Rural do Rio de Janeiro, Rod. BR 465, km 7, CEP 23850-230, Seropédica, RJ, Brazil, e-mail: jarbas@ufrj.br

Received August 8, 2001 – Accept February 5, 2022 – Distributed November 30, 2002

(With 1 figure)

ABSTRACT

There is a great number of Charaxinae (Lepidoptera: Nymphalidae) species in the tropics whose larvae feed on several plant families. However the genus Anaea is almost always associated with Croton species (Euphorbiaceae). This work describes patterns of host plant use by immature and adult abundance on different vertical strata of sympatric Anaea species in a forest of Southeastern Brazil. Quantitative samples of leaves were taken in April/1999 and May/2000 to collect eggs and larvae of four Anaea species on C. alchorneicarpus, C. floribundus and C. salutaris in a semideciduous forest. Sampled leaves were divided into three classes of plant phenological stage: saplings, shrubs and trees. The results showed that the butterfly species are segregating in host plant use on two scales: host plant species and plant phenological stages. C. alchorneicarpus was used by only one Anaea species, whereas C. floribundus was used by three species and C. salutaris by four Anaea species. There was one Anaea species concentrated on sapling, another on sapling/shrub and two others on shrub/tree leaves. Adults of Anaea were more frequent at canopy traps but there were no differences among species caught in traps at different vertical positions. This work supplements early studies on host plant use among Charaxinae species and it describes how a guild of closely related butterfly species may be organized in a complex tropical habitat.

Key words: Nymphalidae, Charaxinae, Anaea, Memphis, Croton.

RESUMO

Uso de plantas hospedeiras entre espécies proximamente aparentadas de borboletas

Borboletas Anaea (Lepidoptera: Charaxinae) estão freqüentemente associadas a espécies de Croton (Euphorbiaceae). Este trabalho descreve a utilização de plantas hospedeiras por uma guilida de borboletas em uma floresta do Sudeste brasileiro. Folhas de três espécies de Croton foram amostradas em 1999/2000 para a coleta de ovos e larvas de quatro espécies de Anaea. Paralelamente, foram colocadas armadilhas para adultos em duas diferentes posições verticais (1 m e 5 m) para comparação do número de indivíduos capturados entre as espécies. Os resultados demonstraram que a guilida de borboletas segrega na utilização de plantas hospedeiras em duas escalas: espécie hospedeira e estágio fenológico das plantas. Croton alchorneicarpus foi utilizada como hospedeira apenas por A. ryphaea; C. floribundus foi utilizada por três espécies de Anaea; e C. salutaris, por quatro espécies. Anaea otrere foi mais abundante em plantas jovens, A. ryphaea predominou em plantas jovens e arbustos e A. appias e A. arginussa apresentaram maiores densidades em folhas de arbustos e árvores de Croton. Os adultos de Anaea foram capturados com maior freqüência nas armadilhas postas na copa das árvores, todavia não houve diferença significativa entre as espécies. Este trabalho
suplementa os dados sobre utilização de plantas hospedeiras por Charaxinae e descreve como uma guida de borboletas proximamente aparentadas pode estar organizada em um ambiente tropical complexo.

**Palavras-chave:** Nymphalidae, Charaxinae, *Anaea*, *Memphis*, *Croton*.

**INTRODUCTION**

Groups of closely related butterfly species are almost always confined to related larval host plants (Gilbert & Singer, 1975). There is a great number of Charaxinae (Lepidoptera: Nymphalidae) species in the tropics whose larvae feed on several plant families (DeVries, 1987). Ackery (1988) showed that many species feeding on Euphorbiaceae belong to the Anaeini tribe. The genus *Croton*, pantropical in distribution and having more than 800 described species (Webster, 1994), is the main larval foodplant and hosts several species from Anaeini in the genera *Hypna*, *Anaea*, *Polygrapha*, *Fountainea* and *Memphis* (Ackery, 1988).

The use of generic names in Charaxinae varies considerably among authors and I will follow Comstock’s (1961) nomenclature, which considered *Memphis* Hübner as a subgenus of *Anaea* Hübner (see Caldas, 1994). The genus *Anaea* includes most Neotropical Charaxinae (e.g., DeVries, 1987, 1988). Biological studies for several *Anaea* species can be found in Muyshondt (1974, 1975a,b) and Caldas (1991, 1994). Up to twelve *Anaea* (Memphis) species have been recorded feeding on *Croton* (see Ackery, 1988), but in Brazil only *A. ryphaea* Cramer has been studied more extensively (see Caldas, 1991, 1994, 1995).

Tropical adult butterflies may exhibit stratified distributions between canopy and understory (DeVries, 1988; DeVries et al., 1997, 1999; Beccaloni, 1997). In some cases, larvae of butterfly species may be more abundant on saplings than on adults of the same host plant species (see Karban, 1987). Several others immatures of herbivore species have shown vertical stratification on their host plants (e.g., Brown et al., 1997 and included references). In Ithomiinae the flight height of adults may be correlated to the occurrence of their larval host-plants (Beccaloni, 1997). Charaxinae species have often been trapped in the forest canopy (DeVries, 1988; DeVries et al., 1997, 1999) but stratification of immatures was not investigated. This work describes patterns of host plant use by immatures of sympatric *Anaea* species that feed on *Croton* and compares the abundance of adults between understory and canopy strata in a forest of Southeastern Brazil.

**METHODS**

Three *Croton* species are commonly found along trails in the semideciduous forest of the Serra do Japi Reserve (23°16’S, 47°00’W) near Jundiaí, São Paulo, Brazil, immediately after Japi. The place is a continuous forest of 300 km² with an average canopy height ranging between 5 and 15 m above the ground. *Croton floribundus* Spreng is the most widespread and abundant species and *C. salutaris* Baill is the rarest species and occurs in discrete patches. A third species, *C. alchorneicarpus* Croizat, may be very abundant on some trails but is rare on others.

Eggs of *Anaea* species (1.0 mm diameter) are frequently laid singly on the underside of leaves. Although they are very similar in appearance, there are some variations of color among species. Larvae from the first and second instar are quite similar to the naked eye, but from the third instar onward different species can be easily identified in the field. First to third instar larvae of *Anaea* species construct frass chains, adding feces with silk to the leaf vein, on the tip of which they rest. Fourth and fifth instar larvae may roll the leaf to form a tubular shelter, holding it closed with silk, and hide inside when not feeding (see Muyshondt, 1974, 1975a,b, and Caldas, 1994, for descriptions of immatures).

I used a stratified sample of leaves in April/1999 and May/2000 to collect eggs and larvae of *Anaea* on the three *Croton* species in Japi. I took the samples at four different sites in the forest. These sites were as far as 4 km from each other.
In 1999 I sampled leaves up to 3 m height and in 2000 I divided the samples into three classes: leaves sampled on saplings (less than 1 m height), on shrubs (from 1-3 m) and on trees (from 3-5 m). Eggs and first instar larvae obtained in quantitative samples were reared in the laboratory using closed plastic dishes containing foodplant leaves and identified to species after reading to the third instar. Larvae species from the third instar onward were identified in the field. At the end of June 2000 I used paired traps with rotting banana bait (see trap design in DeVries, 1987) to sample adults of *Anaea* at two heights. One trap of each pair was placed at 5 m from forest floor in the forest canopy and the other immediately below it, 1 m from ground level. I positioned traps to receive direct sunlight between 10:00 to 14:00 h (the sample time). All butterflies caught in traps after the 4 hour period were identified and set free. Total sample effort was 92 hours of trapping for each height in a total of seven days from two to four different sites in the forest.

**RESULTS**

In all, over 16831 *Croton* leaves were inspected in two years of sampling. Leaves from *C. floribundus* accounted for 55%; from *C. alchorneicarpus* for 25% and from *C. salutaris* for 20% of samples. The quantitative sample showed that *C. alchorneicarpus* was used only by *A. ryphea* in Japi. Indeed I have never seen other *Anaea* species using *C. alchorneicarpus* but another Charaxinae, *Hypna clytemnestra* Butler, was sporadically recorded. *Croton floribundus* was used by all *Anaea* species except *A. arginussa* (Geyer). *Croton salutaris* hosts *A. otrere* (Hübner), *A. appias* (Hübner), *A. ryphea* and mainly *A. arginussa*. *Anaea otrere* and *A. appias* were predominantly found on *C. floribundus*. *Anaea arginussa* only occurred on leaves of *C. salutaris* and *A. ryphea* was most frequently seen in *C. alchorneicarpus* leaves (Table 1).

Densities of immatures *A. appias* and *A. otrere* were very similar in 2000. Although both species use *C. floribundus* as their main larval foodplant, *A. otrere* was predominantly found on saplings whereas *A. appias* was concentrated on leaves of shrubs and, in a lesser degree, in trees. Moreover, *Anaea otrere* was also abundant on sapling leaves of *C. salutaris*. On the other hand, *A. arginussa*, that shared *C. salutaris* leaves with *A. otrere*, was predominantly found on shrub and tree leaves. *Anaea ryphea* was more abundant in shrubs, mainly *C. alchorneicarpus*. Although *A. ryphea* occurred on leaves of trees, the densities on those leaves in relation to shrub leaves were much lower in comparison with *A. appias* and *A. arginussa*. Therefore *A. appias* and *A. arginussa* occurred more frequently than *A. ryphea* in trees (Fig. 1).

**TABLE 1**

<table>
<thead>
<tr>
<th></th>
<th><em>C. floribundus</em></th>
<th><em>C. alchorneicarpus</em></th>
<th><em>C. salutaris</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. otrere</em></td>
<td>75 (94%)</td>
<td>81 (74%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td><em>A. appias</em></td>
<td>0</td>
<td>104 (93%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td><em>A. ryphea</em></td>
<td>6 (14%)</td>
<td>20 (28%)</td>
<td>36 (82%)</td>
</tr>
<tr>
<td><em>A. arginussa</em></td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>
Fig. 1 — Densities of immatures *Anaea* species among plant phenological stages. Data for eggs and larvae were lumped together. Densities for *A. otrere* and *A. appias* were calculated considering the number of sampled leaves of *C. floribundus* and *C. salutaris*. Densities for *A. arginussa* were calculated considering only sampled leaves of *C. salutaris* and densities for *A. ryphea* were calculated considering sampled leaves of all *Croton* species. These calculations were based on natural occurrence data of *Anaea* species among host plant species in 1999 and 2000 samples (see Table 1). Number of sampled leaves for each phenological stage in 2000 were: Saplings (2297), Shrubs (5546) and Trees (4065).
These results suggest that a butterfly guild composed of closely related species is segregating in host plant use at least on two scales: host plant species and plant phenological stages (see Table 1 and Fig. 1).

The number of Anaea adults trapped in seven days was 187; there were 3.5 times more adults captured at the 5 m positions than at the 1 m traps. Anaea arginussa and A. appias were trapped 4.5 more times in 5 m than at 1 m traps, whereas A. ryphea was only 2 times more frequent at canopy traps. Anaea otrere was equally frequent in either vertical strata but only 4 adults were trapped during the sampling. Even with the differences cited above, the number of captured individuals among Anaea species was not significantly different between understory and canopy traps (Table 2).

**DISCUSSION**

Although Charaxinae butterflies use several host plant families (e.g., DeVries, 1987; Ackery, 1988), Anaea butterflies are frequently associated with Croton species (e.g., Ackery, 1988). The data reported here suggest that these butterflies are segregating in host plant use in two scales in Serra do Japi Reserve. The guild of Anaea butterflies occurred at different degrees of densities among Croton species and phenological stages. Females butterfly usually lay their eggs on habitats where juvenile growth and survival are best (Rausher, 1979; Freitas & Oliveira, 1996). The co-occurrence of butterfly species on the same foodplant may affect the number of eggs laid and larval survivorship (Yamamoto, 1981). Thus if competition among Anaea species is important in structuring the community on Croton, then segregated use of larval foodplant may be advantageous.

In Santa Genebra Reserve (hereafter St. Genebra), a forest fragment in Campinas, SP, 50 km far from Japi, only A. ryphea had been recorded using Croton (Caldas, 1991). In this fragment A. ryphea is found on C. floribundus and C. priscus Croizat saplings and shrubs (Caldas, 1994). Although adults of A. arginussa, A. appias and A. otrere have been recorded in the area (K.S. Brown, pers. com.) caterpillars were rarely seen on Croton leaves (A. Gomes-Filho and myself, pers. obs.). Caldas (1991) recorded only one other Charaxinae, Hypna clytemnestra, using Croton in St. Genebra. She suggested that H. clytemnestra could be considered a potential competitor when it co-occurs with A. ryphea, however observations on asymmetric competition between these two species indicated a low-intensity interaction, because the H. clytemnestra population was never higher than 10% of the A. ryphea population (Caldas, 1991). However, I suggest that in Japi A. otrere is a strong candidate to be a competitor of A. ryphea because it frequently occurs in a high density on C. floribundus leaves.

### TABLE 2

<table>
<thead>
<tr>
<th>Anaea species</th>
<th>1 m</th>
<th>5 m</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. appias</td>
<td>24</td>
<td>106</td>
<td>130</td>
</tr>
<tr>
<td>A. arginussa</td>
<td>3</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>A. otrere</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>A. ryphea</td>
<td>13</td>
<td>24</td>
<td>37</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>42</td>
<td>145</td>
<td>187</td>
</tr>
</tbody>
</table>

Number of individuals of Anaea species and position of paired traps. Total of baiting was 92 hours in seven days of sampling for each height (between 10:00-14:00 h). There were no significant statistical differences among Anaea species in the number of individuals captured by the two vertical trap positions (G test; $G = 5.9286; p > 0.05$, d.f. = 3).
The community of immature Anaea species on Croton leaves in Japi is much more diverse than in St. Genebra forest fragment. While in Sta. Genebra C. floribundus leaves are dominated by A. ryphea (Caldas, 1991), it seems that A. ryphea is displaced to use C. alchorneicarpus as its main larval foodplant in Japi. Croton floribundus saplings were the main foodplant for A. ottere, but leaves were frequently used by two other species in Japi. I suggest that A. ottere could be considered a specialist in saplings, due to the observed high densities on the two host plant species at those phenological stages. Unfortunately, the number of adults of A. ottere captured in the traps was too low to verify if adults were also stratifying vertically. In the field, I saw adults of A. ottere flying very close to the ground level apparently in oviposition behavior. An additional sampling effort should be conducted in the future to collect more adults of A. ottere in different vertical positions.

Anaea appias and A. arginussa that shared the same distribution pattern among plant phenological stages segregated in use of host species. These two species may be considered in a continuous pattern of host plant use as canopy species. Indeed the adults from these species were twice as frequent as A. ryphea in canopy traps. Moreover and interestingly they have a particular way to make a leaf funnel, different from the other two Anaea species. The funnel position of A. appias and A. arginussa is perpendicular to the leaf plane whereas in the other two species the funnel is at the same level of leaves. I suggest that the particular behavior of rolling leaves may be used as one of the taxonomic characters to separate Anaea species. It remains to be investigated if these different behaviors of making leaf refuges have any ecological role.

This study supplements Muyshondt's early works (1974, 1975a,b) and more recently Caldas' (1991, 1992, 1994) towards a better understanding of host use in Charaxinae and encourages other investigations of Anaea community structure in places like the Amazon Basin and Central America where there is a great diversity of these butterflies and Croton species. As DeVries et al. (1999) points out, the documentation of diverse insect communities in space (as done here) and time (as done there) can reveal ecological patterns relevant to elucidate the evolution of community structure in complex tropical habitats. The system presented here deserves more attention. Future experimenatal studies with potted plants should be conducted to separate the effects of leaf quality among host plant phenological stages and the vertical positions of leaves per se, as well as tests of oviposition and host preference among Anaea species to help in explaining the observed segregation patterns.

Acknowledgments — I thank Inês Cordeiro (Instituto Botânico de São Paulo) for identifying Croton species. André Freitas and Keith Brown Jr. (Universidade Estadual de Campinas) helped with Anaea identification. Traps for adult sampling were kindly provided by Arlindo Gomes-Filho. The manuscript was improved by the comments of André Freitas, Flavia Medeiros, Keith Brown Jr. and Matthew Orr. This research was supported by the Brazilian Federal Government through a fellowship from CAPES.

REFERENCES


HOST-PLANT USE AMONG BUTTERFLY SPECIES


