

Distribution and Host Species Ranges of *Umbonia ataliba* and *Umbonia crassicornis* and the Potential for Interspecific Competition

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ABSTRACT

Umbonia crassicornis and *Umbonia ataliba* (Homoptera: Membracidae) elevational ranges and host tree ranges were studied in Monteverde, Costa Rica. *Umbonia crassicornis* was known to exist at elevations below 1000 m, while *U. ataliba* was known to exist at 1300 -1500 m. The possibility of interspecific competition or possible future competition was investigated in light of recent local and global warming trends and observed population shifts in birds and herps by Pounds et al. (1999). A census of *Umbonia* species and host plants was conducted along an elevational gradient, in addition to an experimental test, which examined *U. crassicornis* survivorship on *U. ataliba* hosts. *Umbonia crassicornis* and *U. ataliba* were not found to coexist at any elevation. However, signature egg and feeding scars were found on *Inga mertoniana*, a plant commonly used by *U. ataliba*, in this case found at elevations likely to be used by *U. crassicornis*. Complete survivorship by *U. crassicornis* on *Acacia angustissima*, a known *U. crassicornis* host, and *Inga mertoniana*, a known *U. ataliba* host, was observed, proving *I. mertoniana* to be an equally suitable *U. crassicornis* host, at higher elevations. Host species *I. mertoniana* was found to exist at all elevations studied, while other known hosts for *U. crassicornis* and *U. ataliba* were limited to lower and higher elevations respectively. If warming trends affect *Umbonia* species ranges, thereby expanding *U. crassicornis* populations to higher elevations, interspecific competition may occur over *I. mertoniana*.

RESUMEN

Las elevaciones conocidas de *Umbonia crassicornis* y *Umbonia ataliba* (Homoptera: Membracidae) y sus árboles huéspedes fueron estudiados en Monteverde, Costa Rica. Se sabe que *U. crassicornis* se encuentra debajo de 1000 m, mientras *U. ataliba* se encuentra entre 1300 - 1500 m. La posibilidad de competencia entre especies distintas o de competencia en el futuro fue investigado tomando en cuenta los cambios de poblaciones vistos en pájaros y lagartijas discutido por Pounds et al. (1999). Un censo de *Umbonia* y sus árboles huéspedes fue levantado sobre una gradiente altitudinal, con una prueba experimental que examinó si *U. crassicornis* podría sobrevivir en las planta huéspedes de *U. ataliba*. Se encontró que *U. crassicornis* y *U. ataliba* no vivieron juntos en ningún elevación. Sin embargo, marcas dejadas después de comer y los huevos encontrados en *Inga mertoniana*, una planta típicamente usado por *U. ataliba*, muestra que en estas elevaciones son actualmente usadas por *U. crassicornis*. *Umbonia crassicornis* sobrevivió en *Acacia angustissima*, un árbol huésped conocido y *Inga mertoniana* un árbol huésped de *U. ataliba*. Este experimento significa que *I. mertoniana* puede ser un arbol huesped de *U. crassicornis* en elevaciones altas. Se discutió que *I. mertoniana* vivió en todas las elevaciones estudiadas. Esto significa que si *U. crassicornis* es afectada por el aumento en la temperatura ambiental y la competencia entre especies distintas es posible para *I. mertoniana*.

INTRODUCTION

The treehoppers of the genus *Umbonia* (Homoptera: Membracidae) are widely distributed throughout the Americas from Southern Florida to Brazil (Wood 1983). Two species, *Umbonia crassicornis* and *Umbonia ataliba*, exist within the Monteverde, Costa Rica area. Although closely related, these species of *Umbonia* exhibit different mating behaviors and population densities (Masters 1997). *Umbonia crassicornis* exhibits patterns of outbreeding and maintains a large population along the Río Guacimal below 1000 m. In contrast, *U. ataliba* characteristically inbreeds and maintains a smaller population on the upper banks of the Río Guacimal at approximately 1300-1500 m in elevation (Masters 2000). Both species occupy riparian corridors; however within this area *U. crassicornis* has a greater affinity for disturbed or open areas, while *U. ataliba* prefers closed canopy forest (Masters 1997).

Both *Umbonia* species feed on phloem of young branches of genera within the tribe Ingaeae (Mimosaceae), with few exceptions (e.g. *Acacia*). *Umbonia crassicornis* is known to feed on the species *Acacia centralis*, *Acacia angustifolia*, *Calliandra bijuca*, and *Enterolobium cyclocarpum*, whereas *U. ataliba* is known to use host plants such as *Zygia palmanum*, *Inga punctata* and *Inga sierrae* (Masters 2000). The specific ranges of these host plants were largely unexamined to date, thus, it is unknown whether *Umbonia* ranges are limited by host plants or other factors.

Interspecific competition occurs when individuals of one species suffer a reduction in fecundity, survivorship or growth as a result of resource exploitation or interference by individuals of another species (Began et al. 1990). For competition to occur, these species must occur at the same place and at the same time. Thus far, studies on *U. crassicornis* and *U. ataliba* have only looked at host species use at the core of *Umbonia* population areas, not in areas where *U. crassicornis* and *U. ataliba* may co-exist. The potential for contemporary and future range overlap is unknown for *U. crassicornis* and *U. ataliba*, since there exists no systematic study of host plant use and ranges.

Climate changes more rapidly with elevation (about 1 °C per 160 m) than it does with latitude (about 1 °C per 150 km), so, rapid changes in montane communities are expected as climate changes (Grabherr 1994 in McCarthy 2001). Climatic stress is known to have caused extinctions in amphibians and upslope shifts in the range of bird species, potentially creating competition for resources where there once was none (McCarthy 2001, Pounds et al. 1999). Although many other factors are known to influence the geographic range of any given species, recent global climate changes have warranted a closer look at the dynamics of insect populations, such as *Umbonia* species in Monteverde.

This study investigated the possibility of *U. crassicornis* and *U. ataliba* range overlap and the potential for interspecific competition in *U. ataliba* hosts. It was thought that *U. ataliba* populations would be small and located at the highest elevations of the gradient, while *U. crassicornis* would be more widespread, pushing into areas and using host species used by *U. ataliba*.

METHODS

Part I - Distribution of *Umbonia* spp. and Their Hosts at Different Elevations

A census of *Umbonia* species was conducted along an elevational gradient consisting of four plots along the Río Guacimal and its tributaries, from 870 - 1580 m on the Pacific slope of the Cordillera de Tilarán in November of 2001. A search for *Umbonia crassicornis* and *U. ataliba* was conducted at all sites to define their ranges and identify any range overlap. Known host tree species were searched in addition to other Mimosoids which could also be used as hosts. The Río Guacimal was chosen for its bordering riparian forest, continuous over a broad elevational gradient where both species were thought to exist (Masters 1997).

The four plots were each 900 m² and of differing shapes because of topographical limitations. Plots were located at the Mata Farm from 870 - 880 m, Bajo del Tigre from 1100-1180 m, La Lecheria from 1360 - 1365 m, and El Estación from 1560 - 1570 m. Each plot was searched for 3.5 person hours or until all potential host plants were searched. Within each plot, the following seven host plants were searched for; *Acacia centralis*, *Acacia angustifolia*, *Calliandra bijuca*, *Enterolobium cyclocarpum*, *Zygia palmanum*, *Inga punctata* and *Inga brenesii*. The presence of these, in addition to other potential Mimosoid hosts were recorded to identify the ranges of each host species.

Part II - Experimental Test of Host Plant Use

The capacity of *U. crassicornis* to use the known host plants of *U. ataliba* is important to evaluate the likelihood of interspecific competition, particularly if *U. crassicornis* can colonize higher elevations. Ninety-five *U. crassicornis* adults were removed from *Acacia angustissima* trees at 815 m and 840 m and moved to experimental host plants at 1520 m. Twenty *U. crassicornis* adults were relocated to non-host mimosoids, known *U. ataliba* hosts: *Zygia palmanum*, *Inga mortoniana* and *Cojoba costaricensis*. Fifteen additional *U. crassicornis* adults were moved to *Acacia angustissima* in addition to *Psidium guajava*, a non-host, non-mimosoid species, acting as a positive and negative control respectively. The positive control was the *A. angustissima*, a known host plant species at lower elevations, where survival was expected; the negative control being *P. guajava*, a non-host plant, non-mimosoid where survival was not expected. The experiment lasted 21 days.

Groups of five *U. crassicornis* were placed in fine mesh bags around a branch tip. One bag per branch tip, with four bags on each tree, the exception being *A. angustissima*, which only had three bags. Groups were distributed over multiple branches to minimize variation in branch quality, thus countering the effects of a bad branch or species loss due to any other factor besides feeding capacity. Each group was observed every one to two days for evidence of mortality as well as indications of feeding. The number of days each individual survived was quantified.

RESULTS

Part I - Distribution of *Umbonia* spp. and Their Hosts at Different Elevations

Of the four sites censused, *Umbonia* species were only found at two sites, with *U. crassicornis* and *U. ataliba* being only found at one site each with no range overlap. The frequency distribution of *U. crassicornis* over life stages appeared even (Figure 1). At the lowest elevation site (870 - 880 m) two trees were found with *U. crassicornis*. On one tree, a single female with eggs; while the other tree had three single females with eggs, three adult groups and three nymph groups. *Umbonia ataliba* was observed at the 1360 - 1365 m site. The frequency of observed females with eggs was two, as were adult groups and nymphs groups. Each of the *U. ataliba* groups were found on separate trees as opposed to *U. crassicornis*, where nine groups were found on a single tree.

Of the two trees found *U. crassicornis*, both tree species were *A. angustissima*. Of the six trees found with *U. ataliba*, three were *Z. palmanum*, while the remaining three were; *I. mortoniana*, *I. punctata*, and *I. Sierrae*. No tree host species was used by both *Umbonia* species (Figure 2). *Inga mortoniana* was the only tree host found at every elevation surveyed, with an estimated range of 850 - 1580 m. Most species had smaller ranges: *Albizia adinocephala*, *Lysiloma divericanum*, *Acacia angustissima*, *Inga marginata*, *Calliandra bijuca*, *Zygia palmana*, *Inga micheliana* only being found at one elevation each (Figure 3).

Part II - Experimental Test of Host Plant Use

Only *A. angustissima* and *Inga mortoniana* had complete *U. crassicornis* survivorship, meaning that 100% of transferred insects survived. *Zygia palmana*, *C. costaricensis*, and *P. guajava* all experienced lower mean survivorship (Figure 4). A significant difference was found between survivorship on host plants (ANOVA, $F = 8.096$, $p < 0.0001$, $DF = 4$). Using a Post-hoc Fisher's PLSD, significant differences were found between survivorship on *P. guajava* and all other hosts tested (all $p \leq 0.008$). Significant differences were also found between *C. costaricensis* and both *A. angustissima* and *I. mortoniana* ($p = 0.0393$ and $p = 0.0262$ respectively). Overall, survival was increasing from the lowest *P. guajava*, to *C. costaricensis*, to *Z. palmanum*, with *I. mortoniana* and *A. angustissima* having the highest survivorship.

DISCUSSION

Umbonia crassicornis and *Umbonia ataliba* were not found to co-exist at any elevations studied. At the lowest elevation site (870 - 880 m), *U. crassicornis* was found with groups of individuals at various life and reproductive stages. Reproducing groups were also found for *U. ataliba* at the 1360 - 1365 m site. Other groups of both *U. crassicornis* and *U. ataliba* were also observed in non-study sites, at elevations of 815 m and 1520 m respectively. Neither species was found between 880 - 1360 m, the area of potential overlap. Therefore direct evidence of current range overlap and competition remains nonexistent. The 1100 - 1180 m site was a prime candidate for overlap, containing both forest types and plants species suitable for either *Umbonia* species. In general, insect populations are known to fluctuate annually making the likelihood of finding

insects such as *Umbonia* variable. This in addition to the plot shape of this site, a 2 x 450 m plot, essentially transecting a ridge-top, may have decreased viewable hosts. A previous study had estimated densities at 4 - 14 and 27 - 207 females per hectare for *U. ataliba* and *U. crassicornis* respectively (Masters 1997). Such variable densities posed a challenge for creating plots that would accurately depict populations and ranges.

The fact that direct evidence of overlap was not found in this study is inconclusive, since scarring was found on hosts of both species at two elevations, 870 -880 m and 1100 - 1180 m, possibly indicating range overlap. Although the scarring was distinctively *Umbonia* created, is the same for both species. This finding, in addition to a better understanding of host plant ranges and feeding potentials, makes the future population dynamics of *Umbonia* species very interesting as global climate continues to change.

The data suggest that *U. crassicornis* survivorship at higher elevations is not limited by climate, but it may be limited by hosts. Known *U. crassicornis* hosts were only found at elevations from 850 - 1145 m. In contrast, known hosts for *U. ataliba* were found at every elevation, mainly, *I. mortoniana*, whose range extended down to 850 m. *Umbonia ataliba* however, was not found to have a corresponding range. At the two lowest elevational sites *I. mortoniana* was found with egg and feeding scars. The scars may have been created by *U. crassicornis*. *Umbonia crassicornis* survived as well on *I. mortoniana* as it did on *A. angustissima* (a known host), in spite of the fact that it was previously not known to use *I. mortoniana*.

Interestingly, both *I. mortoniana* trees with scars were found under a closed canopy, habitat favored not by *U. crassicornis* but by *U. ataliba*. It is possible that *U. crassicornis* occasionally uses *I. mortoniana* in contemporary situations. Possible explanations for these observations are many. One is that host plants in shaded areas may occasionally be used by *U. crassicornis* simply because of the constant experimentation for new, better ways to live, a shadow of the fundamental mechanism that drives evolution. Another explanation for these observations may be a new drive for *U. crassicornis* to explore new habitats as a result of climate change. These findings are very significant for the future ecology of these two organisms because if climate changes result in population range changes for insects, in the same way as has been suggested for birds, lizards and anurans by Pounds et al. (1999), *U. ataliba* populations may be driven to interspecific competition with *U. crassicornis* for host plants.

The potential for interspecific competition must be weighed by the limitations of this study; the host plant experiment only lasted twenty-one days. And although this time frame was a good indicator of survivorship potentials, it was not representative of a full year. Further studies ought to investigate the potential for full life and reproductive cycles at high elevations. Studies of this sort in addition to a more detailed investigation of the 880 - 1360 m region are necessary to create a more complete picture of *Umbonia* interactions.

Umbonia spp. may be vulnerable to ongoing climate change in Monteverde. Global warming and possibly lowland deforestation have apparently contributed to warmer, drier conditions in Monteverde, and consequently, the upslope colonization of species (Pounds et al. 1999; Lawton et al. 2001). Changing climate may provide favorable conditions for *U. crassicornis* to establish new breeding populations at higher elevations. This is especially likely considering that the results here show that suitable host trees exist. The use of *I. mortoniana* by *U. crassicornis* should be the focus of future studies.

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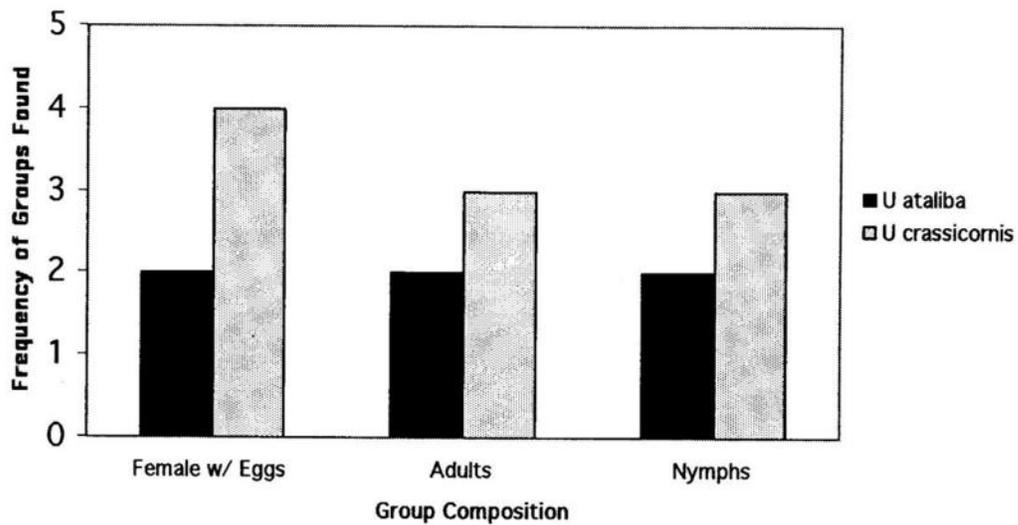


Figure 1: Frequency of Groups for *U. ataliba* and *U. crassicornis* at 1360 m and 870 m respectively.

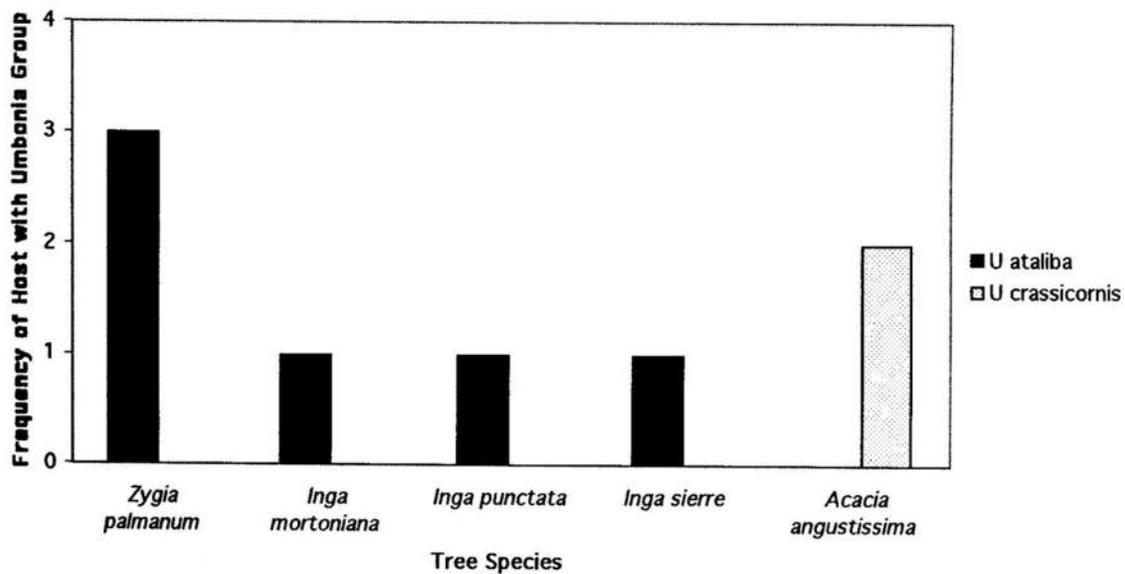


Figure 2: Frequency of observed occupied hosts for *U. ataliba* and *U. crassicornis*

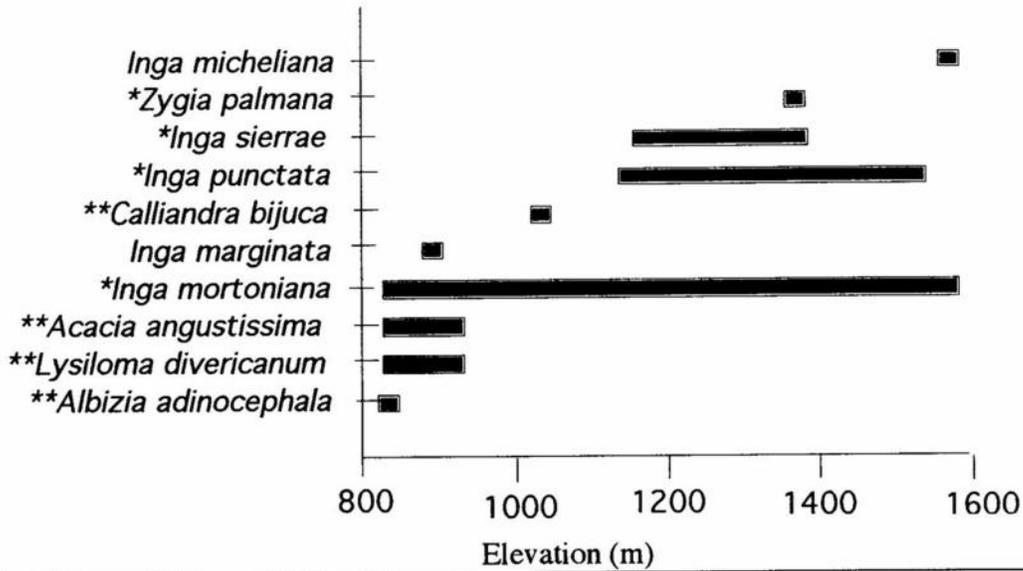


Figure 3: Observed Host Tree Species Elevational Ranges as Derived from Study Sites. *Known *U. ataliba* host, **known *U. crassicornis* host (Masters 1997, Wood 1983).

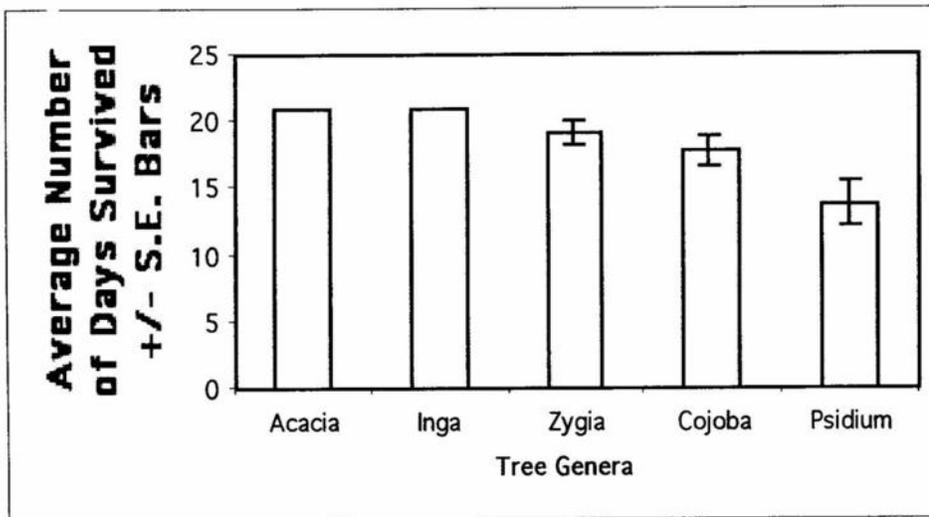


Figure 4: Mean Number of Days Survived by *U. crassicornis* on a know host (*Acacia*), Three Mimosoid Hosts of *U. ataliba* (*Inga*, *Zygia* & *Cojoba*), and on a Non-Mimosiod, Non-Host (*Psidium*).