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ABSTRACT

In Monteverde the practice of using non-native garden ornamentals is widespread. This practice could be economically and ecologically costly in the future if these non-native species escape gardens. Because many non-native invasive fruits are dispersed by birds, this study assesses non-native and native fruit species and tropical birds as non-native and native fruit dispersers. To determine whether fruits from an introduced species or a native species were preferred by dispersers and more frequently visited by birds, fruits from, *Rubus rosifolius*, a common roadside non native, and *Acnistus arborescens* a common native garden ornamental were monitored for presence or absence and levels and proportion of ripeness, and number of bird visits. Fruit observations show that the introduced fruits took longer to ripen than the native fruits, they provided a smaller proportion of ripe fruits, but they were taken sooner than the native fruits. Bird visit observations show a significantly higher number of bird visits to the native *A. arborescens* than the introduced *R. rosifolius*. This difference can be explained by mammal dispersal agents and depredation by insects. Potential invasive species in Monteverde should be monitored for a better understanding of invasion mechanisms.

RESUMEN

En Monteverde la practica de usar las plantas exóticas como tipo ornamental en la jardinería es muy común. Esta practica podría ser economicamente y ecologicamente costoso en el futuro si se escapan estas plantas exóticas de los jardínes. Dado que muchos de los frutos de invasoras exoticas están dispersados por aves, este estudio investiga especies de frutos nativos y frutos exóticos e aves tropicales como dispersadores de frutos nativos y frutos exóticos. Para determinar si dispersadores prefieren frutos de un especie introducido o un especie nativo y cual especie visitan mas los dispersadores, frutos de *Rubus rosifolius*, una planta exotica que se encuentra creciendo al la orilla de las calles, e *Acnistus arborescens*, una planta nativa con uso frequente en la jardinería como tipo ornamental, fueron monitoreados por la presencia, absencia, niveles y proporciones de madurez, y numeros de visitas por aves. Obsevaciones de los frutos muestran que los frutos introducidos duraran mas para madurar que las los frutos nativos, brindan una proporcion de frutos más pequeña, pero fueron recolectados más rapido que los frutos nativos. Observaciones de las visitas por aves a los dos especies muestran un numerero significantemente más alto de visitas por aves a *Acnistus arborescens*, el especie nativo que al introducido, *Rubus rosifolius*. Esta diferencia peude ser explicada por dispersion de mamiferos y depredacion por los insectos. Especies de plantas con la potencial de ser invasoras deben ser monitoreados por un conocimiento major de los mecanismos de invasion.

INTRODUCTION

Invasive, non-native species can change the structure and functioning of ecosystems, which has been shown to threaten global biodiversity (Levine *et al.* 2003, MacDougall & Turkington 2005). These ecosystem level changes may affect the availability and/or quality of space and direct resources for native species (Levine *et al.* 2003). Although many tropical moist forests seem to resist non native plant invasions (Rejmánek 1996), there have been some documented cases like that of *Musa velutina*, in La Selva Biological Station in Costa Rica, which was most likely dispersed by birds (Orlando Vargas perscomm). A factor that increases the probability that a non-native plant species becomes invasive is its ability to incorporate native animal species in mutualistic interactions such as pollination or seed dispersal (Richardson et al. 2000). This disruption of native plant-native animal interactions can decrease effective seed dispersal and population growth of native plant species (Traveset and Richardson 2006). This effect has been observed in Europe with the introduction of *Impatiens glandulifera* (Himalayan balsam), an invasive non native plant species, that disrupted native plant and insect interactions resulting in a reduction of pollinators for native *Stachys palustris* by 50% and native seed set by 25% (Chittka and Schurkens 2001).

Non-native plant species that produce fleshy fruits may be more attractive to dispersers (Knight 1986). By producing larger more appealing fruits to attract dispersers or larger flowers to attract pollinators, non-native invasive plants exhibit a type of display competition. This type of competition was tested in Western Oregon, where American Robins were shown to choose *Crataegus monogyna* fruit by fruit abundance, fruit size, and fruit pulpiness; fruit abundance significantly explained 33% of variance found in fruit consumption and fruit size significantly explained 25% of variance found between shrubs (Sallabanks 1993).

In Neotropical wet forests, animals are the major seed dispersers for over 90% of trees and shrubs, birds being the most important diurnal disperser (Frankie et al. 1974). Because birds are major seed dispersers in tropical habitats, their foraging behavior can influence plant distribution patterns through fruit selection and preference (Herrera 1985, Lawton and Putz 1988). One study found that bird droppings commonly contained seeds from more that one plant species and composition of species found in bird droppings differed by species, showing that birds differ in fruit selection and show preferences for some fruit over others (Loiselle 1989). The important role birds play in their interactions with fruiting plants was demonstrated in the invasion of *Lonicera maackii* in North America, where one study found that four native bird species in southwest Ohio had incorporated *L. maackii* into their diet and served as seed dispersers for *L. maackii*; 94% of the *L. maackii* seeds found in American robin droppings were viable along with, 100% in hermit thrush, 83% in cedar waxwing, and 75% in northern mockingbird droppings (Bartuszevige and Gorchov 2006). Therefore, mechanisms to explain non-native invasive plant success include the ability of bird dispersers to incorporate non-native fruits into their diet, as well as the ability of non-native species to outcompete native species. This highly competitive nature of invasives is observed on oceanic islands where flora sizes doubled when including them as naturalized exotics (Sax et al. 2002).

In Monteverde, as with most developed areas, the practice of using non-native ornamental plant species in gardens is widespread. Since the community is located in close proximity to the Monteverde Cloud Forest Reserve and the Children's Eternal

Rainforest, it is important to monitor potential non-native invasives and investigate bird dispersal of introduced species. Two bird dispersed plants found in Monteverde are *Rubus rosifolius*, an introduced plant from Asian or Australian origin, commonly found along roadsides and *Acnistus arborescens*, a commonly used native garden ornamental. In this study I ask the questions: Are introduced or native fruits preferred by bird dispersers? Do fruit-eating birds visit native or introduced species more? I predict that birds do not discriminate between native and non native species but simply select what is available and visit each species equally, therefore, taking ripe fruits from both species at the same rate.

METHODS

Study sites

This study was conducted at 1350 meters above sea levels along roadsides and residential and commercial gardens in Monteverde, Costa Rica from April to 11th to May 4th 2011. The observation location for *R. rosifolius* was conducted on a 150 m roadside stretch from La Colina to Finca Stuckey. Sampling for *R. rosifolius* was located at Rebecca's Cabina, a private residential property in order to control for human removal of *R. rosifolius* fruits. *Acnistus arborescens* observations were conducted at Casa de Arte and the CIEE study center in Cerro Plano, Monteverde. Sampling for *A. arborescens* was taken from the same observation areas as well as from la residence of Nuria Fonseca. All locations were within 100 m from each other.

Infructescence monitoring

Fruit from five infructescences of six *A. arborescens* individuals (30 infructescences total) were counted and marked numerically to observe ripeness for 11 days. Every day each fruit on all 30 infructescences was recorded as unripe, ripening, ripe or taken. Thirty infructescences on nine plants of *R. rosifolius* were also marked numerically and recorded for ripeness following the same procedure, but due to morphological differences between *A. arborescens* and *R. rosifolius* infuctescences, each *R. rosifolius* infructescence was counted as one fruit bunch or fruit unit. *Acnistus arborescens* produces tomato like berries while *R. rosifolius* produces black berry like clusters of aggregate drupes (Fig 1).

FIGURE 1. Infructescences. Left to right: non-native *R. rosifolius* cluster of aggregate drupes and native *A. arborescens* berries

Observation of *R. rosifolius* and *A. arborescens* fruit removal by birds

Bird visits to a patch of eight *A. arborescens* individuals and a 150 meter roadside area of *R. rosifolius* were observed over six different days for an hour at each site each day. Each bird species seen eating fruits or exhibiting foraging behavior was identified and recorded.

Data analysis

Data were taken on 240 *A. arborescens* fruits and 30 *R. rosifolius* fruit bunches over 11 days. To compare the mean number of days for the fruit of each species to ripen, the mean number of days each fruit or fruit bunch was ripe on the tree or plant before being eaten, the proportion of ripe fruits per day, and the proportion of mature fruits not taken t-tests were used. To compare the number of bird visits to the introduced *R. rosifolius* and native *A. arborescens* a chi-squared test was used.

RESULTS

The mean number of days for a *R. rosifolius* fruit to ripen 6.64 ± .014 was significantly higher than that of an *A. arborescens* fruit 4.94 ± .025 (*t test* = 1.99, $P < 0.05$).

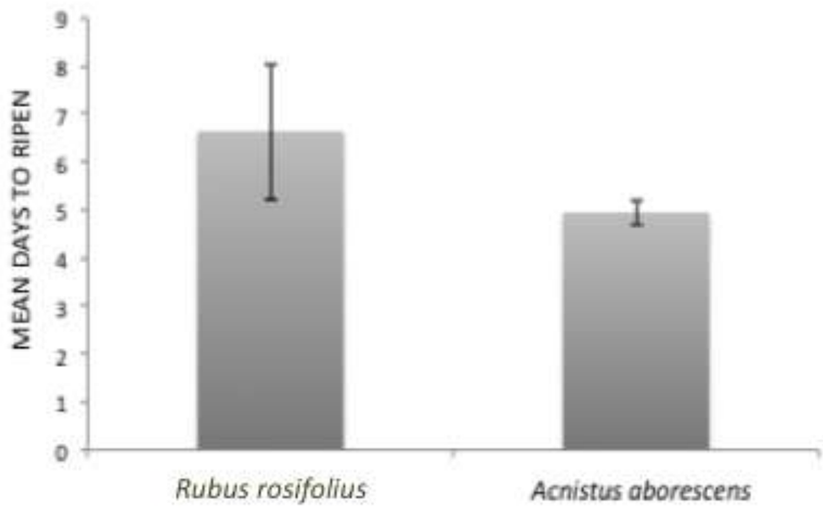

FIGURE 2. Average number of days for introduced *R. rosifolius* and native *A. arborescens* fruits to ripen. *R. rosifolius* fruits (N = 6) took more days to ripen than *A. arborescens* fruits (N = 25). Error bars express +/ - one standard error of the mean.

There were a smaller proportion of ripe fruits per day on *R. rosifolius* (0.17 ± .036) than *A. arborescens* (0.53 ± .026; *t test* = 6.75, $P < 0.05$).

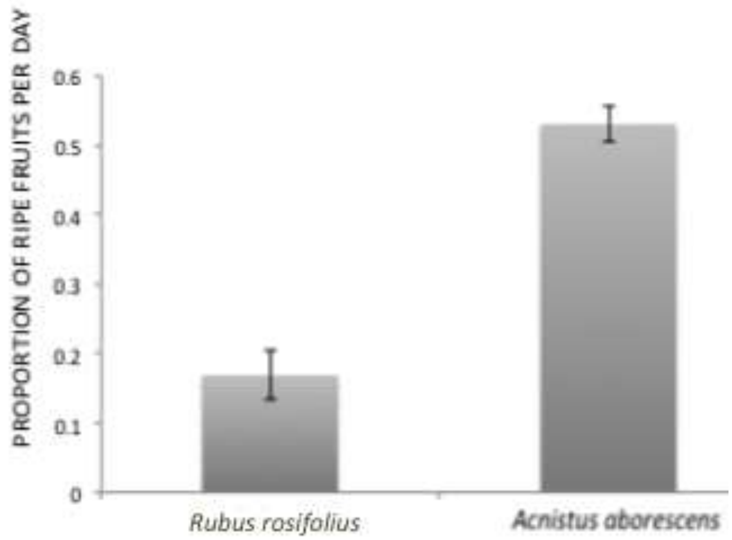

FIGURE 3. Mean proportion of ripe fruits per day found on introduced species, *R. rosifolius* and native species *A. arborescens.* The proportion of ripe *A. arborescens* fruits (N = 257) was significantly larger than the proportion of *R. rosifolius* ripe fruits per day (N = 66). Error bars express +/ - one standard error of the mean.

Ripe *R. rosifolius* fruit spent fewer days ripe before being removed (2.11 ± .186) than ripe *A.* arborescens (2.95 ± .184; *t test* = 2.04, $P < 0.05$).

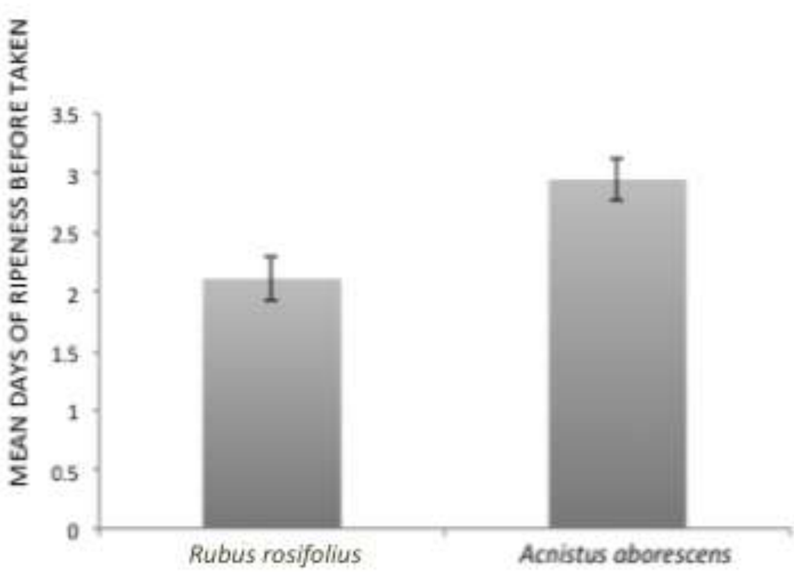

FIGURE 4. Average number of days for fruits to be ripe before being taken on introduced *R. rosifolius* and native *A. arborescens*. *R. rosifolius* fruits (N = 6) were taken sooner than *A. arborescens* fruits (N = 28) Error bars express +/ - one standard error of the mean.

The number of birds observed visiting *A. arborescens* (N = 51) was significantly higher than those visiting *R. rosifolius* (N = 3) (Chi-squared, X^2 = 42.67, df = 2; $P < 0.0001$). Bird species found in Table 1.

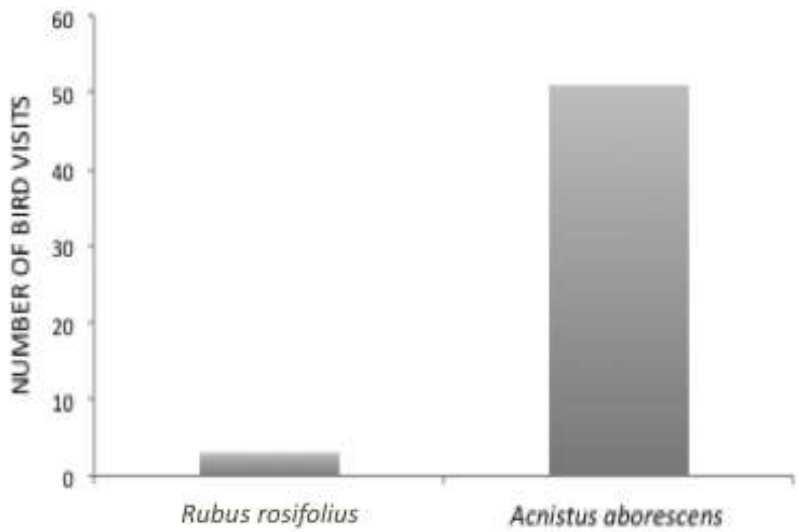

FIGURE 5. Observed bird visits to introduced species *R. rosifolius* and native species *A. arborescens*. A higher number of visits to native species (N = 51) than introduced species (N = 3).

TABLE 1. *Birds observed visiting R. rosifolius and A. arborescens*

A. arborescens	*R. rosifolius*
Black-headed Tody Flycatcher (Todirostrum nigriceps)	*Clay-colored Robin (Turdus grayi)*
Blue-gray Tanager (Thraupis episcopus)	
Bronzed Cowbird (Molothrus aeneus)	
Brown Jay (Cyanocorax morio)	
Clay-colored Robin (Turdus grayi)	
Dusky-capped Flycatcher (Myiarchus tuberculifer)	
Emrald toucanet (Aulacorhynchus prasinus)	
Yellow-throated Euphonia female (Euphonia hirundinacea)	
Flycatcher juvenile	
Grayish Saltator (Saltator coerulescens)	
Mistletoe Tyrannulet (Zimmerius vilissimus)	
Mountain Elaenia (Elaenia frantzii)	
Red-billed Pigeon (Columba flavirostris)	
Red-legged Honeycreeper (Cyanerpes cyaneus)	
Rufous-collared Sparrow (Zonotrichia capensis)	
Social Flycatcher (Myiozetetes similis)	
Unknown warbler male	
Unknown warbler female	
Yellow-faced Grassquit male (Tiaris olivacea)	
Yellow-faced Grassquit female (Tiaris olivacea)	
Yellow-throated Brush-finch (Atlapetes gutturalis)	
White-eared Ground-Sparrow (Melozone leucotis)	

DISCUSSION

R. rosifolius had a smaller proportion of ripe fruits per day than *A. arborescens,* meaning that fewer were available to be eaten per day. Given the display competition idea, this would suggest that dispersers are more likely to visit native *A. arborescens*, since it fruits in more in abundance than the *R. rosifolius*.

R. rosifolius fruit also took longer to ripen than *A. arborescens* fruit. One might conclude that taking longer to ripen would be unfavorable for *R. rosifolius* since dispersers seeking ripe fruits immediately would most likely visit other plants offering an abundance of ripe fruits, however data show that *R. rosifolius* fruits were removed faster than *A. arborescens*. These findings seem to differ from previous predictions, showing that dispersers are not indiscriminant in fruit selection, and therefore, suggest that dispersers favor *R. rosifolius* non-native fruit over native, *A. arborescens*, fruit.

Because birds are shown to visit non native *R. rosifolius* significantly less than *A. arborescens*, bird visit observations seem contradictory to fruit observations, however, from these observations one can conclude that birds are not the primary dispersers of *R. rosifolius* fruits and that mammal dispersal agents and depredation by insects are the most likely factors in the observed non native fruit preference. This is concordant with other studies where mammals have also been observed as non-native fruit dispersers as documented in the dispersal of *L. maackii* fruits by white-tailed deer (*Odocoileus virginianus)*(Bartuszevige and Gorchov 2006). Therefore, bird visit data suggest that birds prefer native *A. arborescens* fruits to non-native *R. rosifolius* fruits. This preference may be due to the larger display that *A. arborescens* offers, but because *R. rosifolius* is most likely primarily dispersed by mammals it would be better to test fruit display competition with a more comparable native fruit species such as *Rubus urticifolius.*

Extensive ecological damage by exotic invasive species has not yet occurred in Costa Rica but has in the United States. According to Pimentel et al., economic costs linked to invasive species in the USA are about $137 billion annually (2000). Although negative impacts of invasive non-native plant species on ecosystems are known from the United States, the methods and biological adaptations of non-native plant species for outcompeting native plant species are still under investigation. Future studies of *Rubus* sp. could involve germinating native and exotic seeds in the same microhabitat as well as observing plant – animal interactions in terms of mammals dispersal systems. Potential invasives in Monteverde should be continually observed for a better understanding of underlying mechanisms of invasions.

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LITERATURE CITED

Bartuszevige, A. M. and D. Gorchov. 2006. Avian seed dispersal of an invasive shrub. Biological Invasions. 8: 1013-1022.

Chittka, L. and S. Schurkens. 2001. Successful invasion of a floral market. Nature 411: 653.

Frankie G. W., H. G. Baker, and P. A. Opler. 1974. Comparative phenological studies of trees in tropical wet and dry forests in the low-lands of Costa Rica. J. Ecology 62:881-919.

Herrera, C. M .1985. Habitat-consumer interactions in frugivorous birds. In: Cody ML (ed) Habitat selection in birds. Academic Press, New York, NY, pp 341-365.

Knight, R. S. 1986. A comparative analysis of fleshy fruit displays in alien and indigenous plants. In: MacDonald IAW, Kruger FJ and Ferrar AA (eds) The Ecology and Management of Biological Invasions in Southern Africa, pp 171–177. Oxford University Press, Capetown.

Lawton, R. O. and F. E. Putz. 1988.Natural disturbance and gap-phase regeneration in a wind exposed tropical lower montane rain forest. Ecology 69:764 -777.

Levine, J. M. et al. 2003. Mechanisms underlying the impacts of exotic plant invasions. Proc. R. Soc. B 270: 775–781. In Traveset, A. and D. M. Richardson. 2006. Biological invasions as disruptors of plant reproductive mutualisms. Ecology and Evolution 21: 213.

Loiselle, B. A. 1989. Seeds in droppings of tropical fruit-eating birds: importance of considering seed composition. Oecologia 82:494-500.

MacDougall, A. S. and R. Turkington. 2005. Are invasive species the drivers or passengers of change in degraded ecosystems? Ecology 86: 42–55.

Oatley, T. B. 1984. Exploitation of a new niche by the Rameron Pigeon Columba arquatrix in Natal. In Proceedings of the Fifth Pan-African Ornithological Congress (Ledger, J.A., ed.), pp. 323–330, Southern African Ornithological Society In Traveset, A. and Richardson, D.M. (2006) Biological invasions as disruptors of plant reproductive mutualisms. Ecology and Evolution 21: 213.

Pimentel, D. et al. 2000. Environmental and economic costs of nonindegenous species in the United States. Bioscience 50: 53-65. In Lee, C. Evolutionary genetics of invasive species.2002.Trends in Ecology and Evolution. 17: 386-389.

Rejmánek, M. 1996. Species richness and resistance to invasions. In G. Orians, R. Dirzo, and J. H. Cushman (Eds.). Biodiversity and Ecosystem Proesses in Tropical Forests, pp. 153–172. Springer, New York. Simberloff, D., and P. Stiling. 1996. How risky is biological control? Ecology 77: 1965–1974.

Richardson, D. M., N. Allsopp, C. M. D'Antonio, S. J. Milton and M. Rejmánek. 2000. Plant invasions – the role of mutualisms. Biological Review 75: 65–93.

Sallabanks, R. 1993. Hierarchical mechanisms of fruit selection by an avian frugivore. Ecology. 74: 1326 -1336.

Sax, D. F., S. D. Gaines, and J. H. Brown. 2002. Species invasions exceed extinctions on islands worldwide: A comparative study of plants and birds. Am. Nat. 160: 766–783.

Traveset, A. and D. M. Richardson. 2006. Biological invasions as disruptors of plant reproductive mutualisms. Ecology and Evolution 21: 213