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Intensive folivory by Thraupis sayaca (Emberizidae: Thraupinae) in southeastern Brazil

Juan Carlos Guix and Xavier Ruiz
Departament de Biologia Animal (Vertebrats), Facultat de Biologia, Universitat de Barcelona, Avinguda Diagonal 645, E-08028 Barcelona, Spain. E-mail: xruiz@porthos.bio.ub.es

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RESUMO. **Folivoria intensiva por *Thraupis sayaca* (Emberizidae: Thraupinae) no sudeste do Brasil.** Descreve-se a observação de bandos de *Thraupis sayaca* alimentando-se repetidamente das folhas de uma árvore (*Guapira opposita*, Nyctaginaceae) até a quase completa defoliação da mesma. Durante o período de estudo, frutos carnosos maduros de dezoito espécies de plantas encontravam-se disponíveis em uma área de 350 ha ao redor do local onde foram feitas as observações. A existência de oxalato de cálcio, e/ou outros compostos químicos nas folhas de *G. opposita* poderia estar relacionada com este comportamento alimentar seletivo.
PALAVRAS-CHAVE: defesas químicas, folivoria, *Guapira opposita*, oxalato de cálcio, restinga arbustiva, *Thraupis sayaca*.
KEY WORDS: calcium oxalate, chemical defenses, folivory, *Guapira opposita*, shrubland restinga, *Thraupis sayaca*.

Phytophagy is a rather common feeding habit among birds, and numerous papers describe the consumption of different plant parts (Fleming *et al.* 1987, Abrahamson 1989). Birds usually consume fruits and seeds, but flowers, leaves, and roots can also be eaten (del Hoyo *et al.* 1992; Munson and Robinson, 1992). The ingestion of leaves (*i.e.*, folivory) appears to be rather widespread among animals (Kunz and Ingalls 1994), but among birds is most widespread in flightless or weakly-flying species (Dudley and Vermeij 1992, Kunz and Ingalls 1994, Grajal 1995). Few obligate folivorous birds are known. The only known species with a foregut fermentation system is the Hoatzin (*Opisthocomus hoazin* (Müller)) (Grajal *et al.* 1989). Occasional, facultative, or partial folivory, however, is more common, though usually less well documented (but see Karasov 1990, and references therein).

Neotropical tanagers (Emberizidae, Thraupinae) are facultative frugivorous birds that also feed on insects and ingest parts of flowers, foliar buds, and leaves (Sick 1985). The ingestion of leaves as a large-scale phenomenon, however, has not been reported for this taxon.

Between 13 and 29 July 1990, we observed *Thraupis sayaca* (Linnaeus) ingesting large amounts of leaves of the tree *Guapira opposita* (Vell.) Reitz var. *opposita* (Nyctaginaceae), in Parque Estadual da Ilha do Cardoso (25°10'S, 48°00'W) in southeastern Brazil. This 22,500 ha reserve is covered mainly by mature and secondary Atlantic rainforest, mangroves and "restinga" vegetation (Hueck 1972). "Restinga" vegetation grows on sandy plains near the sea and, depending on proximity to the ocean, has the appearance of semi-open shrublands or dense forests.

Guapira opposita var. *opposita* is a common tree both in the lowland Atlantic rainforest and "restinga" vegetation of southeastern Brazil. The leaves are very variable in shape, size, and texture. Leaves of trees in the shrubland "restinga" area are usually noticeably harder and smaller than those of forest trees (Reitz 1970).

The observations reported here were made on a 3.20 m tall individual of *G. opposita* in shrubland "restinga", 40 m from the seashore. Flocks of *T. sayaca* composed of 11 to 16 birds were regularly seen feeding in this tree, biting the leaves and removing gape-sized fragments (N = 19 observations in eight days; 1 to 4 observations per day). Mature and young leaves were indiscriminately mandibulated and ingested; only *T. sayaca* was seen feeding on *G. opposita* leaves.

On 29 of July of 1990 we estimated (by examining remains of leaves still connected to the branches) that up to 80% of the total foliage of the tree had been removed by *T. sayaca*. We returned to the area on 27 of October of 1990 and noted that the study tree had recovered its foliage completely. Although some of the younger leaves had traces of beak bites, we did not see any birds eating new leaves nor any flock of *T. sayaca* on the island.

As pointed out above, Neotropical tanagers typically forage on fruits and insects. Therefore, the question is why do *Thraupis sayaca* tanagers feed extensively on leaves, despite the additional challenges imposed by the presence of secondary compounds and long digestion?

The first point is that such an unusual behavior is not an isolated case. Sick (1985), reported *T. sayaca* feeding on leaves of *Cassia* sp., and *T. bonariensis* (Gmelin) on those of *Carica papaya*; both plant species produce powerful alkaloids and other chemical compounds (Hoehne 1978). However, intensive feeding bouts such as described here have never been reported before. This suggests that birds were

using leaves as a very important food resource and that, perhaps, they switched to such a diet because of a lack of more conventional resources (*i.e.*, insects and fruits).

We have no data on insect availability, but between June and September, the area is intermittently under the influence of polar air masses, which cause sudden temperature drops (Bigarella 1978). Owing to these climatic conditions, which are unfavorable to insect activity, several species of tanagers living in southeastern Brazil, including *T. sayaca*, rely markedly on a frugivorous diet during winter (Guix 1995).

During the study period, we observed ripe fruits of at least 18 different plant species in a 350 ha area comprised within the semicircle defined by a radius of 1,500 m around the defoliated tree, an area easily accessible to *T. sayaca* in their daily movements. Eleven of these 18 species were found in "restinga" formations and 10 in lowland and hillside Atlantic rainforests (table 1). Moreover, during July 1990, we observed *T. sayaca* flocks mainly exploiting "restinga" fruit resources, including *Bromelia antiacantha* Bertol. (Bromeliaceae) and *Eugenia umbelliflora* Berg (Myrtaceae).

Leaves of *G. opposita* have large amounts of raphides rich in calcium oxalate, like other members of the Nyctaginaceae family (Hoehne *et al.* 1941, Armando C. Cervi, pers. comm.). Calcium oxalate ingestion is known to induce diverse pathologies in mammals, ranging from edema to renal disease (Gardner 1994, Hackett *et al.* 1994), although little is known about its effects on birds. We surmise that the accumulation of this compound in plants is linked with defense against defoliation (but see Cannon *et al.* 1995, for an alternative, non-mutually exclusive role in the phosphorous cycle).

Table 1. Plant species with ripe fruits in an area of 350 ha around the location were *T. sayaca* flocks were ingesting *Guapira opposita* leaves.

	RESTINGA	RAINFOREST
ARECACEAE:		
Euterpe edulis Mart.	x	x
Syagrus romanzoffiana (Cham.) Glasn	x	
BROMELIACEAE:		
Bromelia antiacantha Bertol.	x	
CECROPIACEAE:		
Cecropia pachystachya Tréc.	x	
Cecropia sp.		x
CELASTRACEAE:		
Maytenus alaternoides Reissek	x	
MELASTOMATACEAE:		
Miconia latecrenata Naud.	x	
Miconia sp. (#2)	x	
Miconia sp. (#3)		x
MELIACEAE:		
Guarea macrophylla ssp. *tuberculata* (Vell.) Penn.		x
MONIMIACEAE:		
Mollinedia uleana Perkins	x	
MYRTACEAE:		
Calyptranthes lanceolata var. *catharinensis* Legr.		x
Campomanesia guaviroba (DC.) Kiaersk.		x
Eugenia umbelliflora Berg.	x	
Psidium guajava L. (*)	x	x
Eugenia sp. (#2)		x
Myrcia sp.		x
MORACEAE:		
Ficus cf. *enormis* (Mart. ex Miq.) Miq.	x	x

(*) introduced species.

Adaptations to frugivory include the ability to tolerate, or overcome, to a certain extent, the effects of plant secondary compounds (Rosenthal and Janzen 1979, Stiles 1989). This ability can be employed even in the consumption of aposematic insects presenting chemical defenses against predators (Herrera 1985) and, rarely, in the consumption of unripe fruits (Souza *et al.* 1992), which present secondary compounds similar to leaves (Stiles 1989). Kunz and Ingalls (1994), citing extensive folivory by phyllostomid bats (Zortéa 1993, Zortéa and Mendes 1993) suggested that folivory is derived from frugivory.

It has also been suggested that leaves of certain plants can store relatively large amounts of proteins and, therefore, are used by frugivores to supplement their usually protein-deficient diets (Kunz and Ingalls 1994). Alternatively, leaves serve as sources of dietary calcium, hormonal precursors, secondary compounds that inhibit protein metabolism, de-parasitizing agents, micronutrients, or vitamins (Morton 1978, Kunz and Ingalls 1994, Kunz and Dias 1995).

Since most plant species have high concentrations of different secondary compounds in their leaves (Waterman and McKey 1989), it is rather difficult, even after isolating the compounds, to discern which are used by animals, and therefore to identify the functional value of the foraging behaviour. Clearly, aviary experiments to see how readily *Thraupis sayaca* would feed on leaves and their physiological responses are needed to elucidate this point.

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