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Consumption of insects by birds in guava orchards (*Psidium guajava* L.)

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ABSTRACT

The consumption of insect pests by birds can result in benefits for the farmer. In this sense, the present study aimed to investigate the consumption of insects by wild birds within guava orchards in the upper Sertão Sergipe. The records were conducted from 15 to 30 November 2018, using the direct observation method. 98 feeding events were recorded for 21 bird species. Among the insects consumed by birds, we highlight the caterpillars and bedbugs of the genus *Leptoglossus*, considered insects harmful to guava. Birds can reduce the populations of these insects and help with pest control. However, we recommend that experimental studies be performed for confirmation. This research can also be used to change farmers' perceptions of birds, who usually see birds only as animals harmful to crops.

Keywords: Guava tree, insectivory, pest insects, semi-arid.

Introduction

Bird foraging in agroecosystems can benefit the farmer by consuming insects harmful to agriculture (Wenny et al., 2011; Whelan et al., 2015). A recent study estimated that insectivorous birds consume between 400 to 500 million tons of insects and other arthropods globally per year, with approximately 28 million tons (about 7%) coming from areas only agricultural (Nyffeler et al., 2018). Various studies have shown that apple, coffee, palm oil, cocoa, and grape plantations significantly benefit from the suppression of pest insects by birds (Jedlicka et al., 2011; Karp et al., 2013; Maas et al., 2013; Railsback & Johnson, 2014; Maas et al., 2015; Peisley et al., 2015; Mangan et al., 2017). Therefore, important predators, such as birds that consume insects harmful to agriculture, need to be maintained in agricultural systems through good agricultural practices (Narayana et al., 2016). When installing nest boxes (artificial nests) for insectivorous birds in grape crops in California (United States), researchers found an increase in the rate of removal of pest insects, resulting in increased productivity (Jedlicka et al., 2011).

Guava (*Psidium guajava* L.) is an extremely popular and economically important fruit in Brazil (Gonçalves et al., 2016). In addition to the fruit with a high content of vitamins (vitamin C, A, and B), phosphorus, and iron (Gill, 2015), guava has a great capacity to adapt to different climatic conditions. However, the soil must be drained, and chemical pesticides used to guarantee greater productive efficiency (Piza Júnior & Kavati, 1997). In this context, Brazil has very favorable conditions for the commercial production of guava, which is an important aspect, both for its nutritional value and its role in industrial activity and its export potential (Rozane et al., 2003; Mendonça & Medeiros, 2011).

In the Northeast region, where the semi-arid climate prevails, guava culture has been growing annually due to favorable climatic conditions and modern irrigation techniques. In Sergipe State, guava culture has stood out in the agricultural settlements of Califórnia and Jacaré-Curituba, located in Canindé do São Francisco and Poço Redondo Municipalities (Silva et al., 2019). In 2017, guava production in these areas corresponded to 8,480 tons, with average

productivity of 19,953 kg.ha^{-1} (IBGE, 2018). However, guava is attacked by a great diversity of herbivorous insects, which can cause substantial damage to this crop (Calore, 2011; Boti et al., 2016).

Understanding the foraging behavior of insect-consuming birds can provide critical information for developing strategies aimed at reducing the use of chemical pesticides for crop protection. This understanding can also reduce production costs, increase productivity, and contribute to bird conservation (Wenny et al., 2011). Given the above, this research sought to investigate the consumption of insects by wild birds in guava orchards in the Sergipe's semi-arid region, aiming to contribute to the development of more sustainable agricultural practices associated with the conservation of local avifauna.

Materials and Methods

The study was carried out in guava orchards (var. Paluma) located in the agricultural settlements Califórnia and Jacaré-Curituba, in the municipalities of Canindé de São Francisco (09°38'31"S, 37°47'16"W) and Poço Redondo (06°48'21"S, 37°41'06"W), both belonging to the state of Sergipe, northeast Brazil. According to the Köppen classification, the climate of region is of the Bsh type (dry and hot semi-arid), characterized by scarcity of rain, high evaporation rates, and an average temperature above 25°C (CODEVASF, 2011).

In these settlements, activities are carried out in the primary sector of the economy, such as polyculture and livestock farming. Among the crops most produced by farmers are vegetables, legumes, and fruit, being okra (*Abelmoschus esculentus* L. Moench), manioc (*Manihot esculenta* Crantz), corn (*Zea mays* L.), beans (*Phaseolus vulgaris* L.), acerola (*Malpighia glabra* L.) and guava (*Psidium guajava* L.), the main explored crops (Silva et al., 2019).

For data collection, three guava orchards were selected, according to the following criteria: (1) presence of fruits, (2) no pruning (suppression of vegetative parts of the plant), and (3) no use of chemical pesticides. Such criteria were adopted only to ensure the security of data collection. With fruits, because insects responsible for damage to the fruits would be present; and without pruning and without the use of pesticides, as this would certainly reduce the presence of insects and birds. The observation of insect consumption by birds occurred from 15 to 30 November 2018, through three samplings in each orchard. Samplings occurred from 6 am to 10 am, resulting in an effort of 36 hours. The method used was direct observation (Pizo, 2007), which consists of walking slowly through the orchards of avoiding chasing birds and registering feeding bouts. It was used a Nikon® 10x42 binoculars and a field guide (Sigrist, 2009) to assist in observations and identification of birds.

All attacks that resulted in the capture of an insect were considered a feeding bout. The nomenclature and taxonomy of bird species followed the recommendations of the Brazilian Committee for Ornithological Records (Piacentini et al., 2015). The determination of the birds' diet was based on Wilman et al. (2014). Whenever possible, insects were identified at the order level, according to Grazia et al. (2012).

Data were analyzed using descriptive statistics. The interactions between bird species (consumer) and insects (prey) were represented in a bipartite network graph, using the R software bipartite package (R Core Team, 2018).

Results and Discussion

Ninety-eight feeding about 21 different bird species belonging to nine families were registered (Table 1). The richest families were Tyrannidae, with six species, Furnariidae, with five species, and Cuculidae, with three species. Most registered birds (76%) were insectivorous, while the rest were omnivorous (Table 1). *Tyrannus melancholichus*, *Pitangus sulphuratus*, and *Troglodytes musculus* were the bird species with the highest number of feeding bouts (18, 14, and 12 records, respectively) (Table 1). *Pitangus sulphuratus* was the species that most consumed different insects (Figure 1).

Table 1. Birds recorded consuming insects in guava orchards in semi-arid of Sergipe State, Northeast Brazil, from 15 November to 30, 2018. IN = insectivore; ON = omnivorous; FB = Number of feeding bouts. Font: Silva et al. (2019).

Táxon	Diet	FB
Cuculidae Leach, 1820		
Coccyzus melacoryphus	IN	1
Crotophaga ani	IN	11
Guira guira	ON	1
Dendrocolaptidae Gray, 1840		

Lepidocolaptes angustirostris	IN	1
Furnariidae Gray, 1840		
Furnarius leucopus	IN	2
Furnarius rufus	IN	1
Pseudoseisura cristata	IN	5
Phacellodomus rufifrons	IN	4
Certhiaxis cinnamomeus	IN	1
Rhynchocyclidae Berlepsch, 1907		
Todirostrum cinereum	IN	8
Tyrannidae Vigors, 1825		
Camptostoma obsoletum	IN	1
Myiarchus swainsoni	IN	1
Pitangus sulphuratus	ON	14
Myiozetetes similis	ON	1
Tyrannus melancholicus	IN	18
Fluvicola nengeta	IN	2
Troglodytidae Swainson, 1831		
Troglodytes musculus	IN	12
Cantorchilus longirostris	IN	2
Polioptilidae Baird, 1858		
Polioptila plumbea	IN	7
Turdidae Rafinesque, 1815		
Turdus rufiventris	ON	3
Mimidae Bonaparte, 1853		
Mimus saturninus	ON	2

Some insects predated by birds during feeding events allowed their identification at the order level, such as caterpillars and butterflies/moths (Lepidoptera), dragonflies (Odonata), grasshoppers (Orthoptera), and bedbugs (Hemiptera). Of the total records, 22% of the insects were lepidopterans (16% caterpillars and 6% butterflies/moths), 11% orthopterans, 10% dragonflies, and 7% hemipterans. Miniature insects were not identified, despite being recorded in 49% of the events.

The results showed that birds were generalists about groups of insects. Beneficial insects and potential consumers of other pest insects, such as dragonflies, have also been consumed. However, dragonflies were consumed only by two species of birds (Figure 1). Although birds can also consume pollinators (Galeotti & Inglisa, 2001), resulting in a disservice, no bees were observed being consumed by birds. The main pollinating bees of guava (see *Xylocopa* spp., *Centris* spp. and *Apis melifera* in Silva et al., 2019) can be easily recognized because they are relatively large compared to tiny insects. However, studies of stomach content analysis could be carried out to confirm whether these bees and other pollinating insects are part of the diet of these birds.

Among the insects predated by birds, caterpillars (Lepidoptera) and bedbugs (Hemiptera) call attention for being harmful insects to guava. Among caterpillars, according to Pereira & Bortoli (2020), there are more than 25 species of caterpillars that cause damage to the guava culture. Caterpillars cause damage to the branches, buds, leaves, and trunks of plants. Our results showed that caterpillars were attacked by nine species of birds (Figure 1). As for bedbugs, these were attacked by three species of birds (Figure 1). These bedbugs had a generally dark brown color and wider hind legs with lateral expansions in the tibia region, characteristic of adults of the genus *Leptoglossus* (Grazia et al., 2012). Many bedbugs are usually harmful to fruit species, including guava (Calore, 2011; Boti et al., 2016). They cause damage to the leaves, branches, and fruits (Gallo et al., 1988). In addition, they can impair the development of immature fruits by injecting toxins while feeding on the sap (Brailovsky & Sánches, 1982).

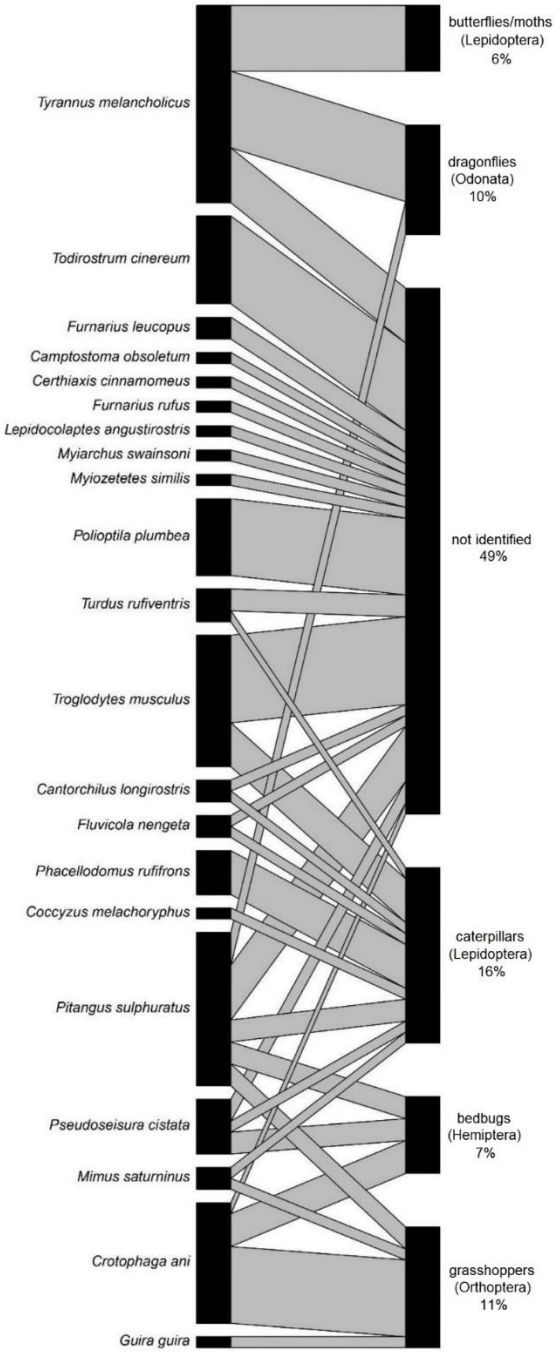

Figure 1. Interactions network between birds (consumer) and insects (prey) in guava orchards, in the semi-arid of Sergipe State (Canindé de São Francisco and Poço Redondo Municipalities, Northeast Brazil). On the left side are the bird species, and on the right are the groups of consumed insects, with their respective orders and percentages of records. Wider lines represent greater interaction between consumer and prey, and less wide lines, less interaction. Font: Silva et al. (2019).

Conclusion

Bird species registered feeding on insects in the guava orchards can be interesting from an economic point of view because some of these can consume harmful insects to the guava culture. Although it needs to be tested, these bird species may reduce the populations of these harmful insects. Therefore, it is important to verify if adopting some practices favorable to the maintenance of birds in agricultural environments can be useful to keep these animals in these environments and guarantee help in combating pest insects, reducing production costs.

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