








First report of *Anastrepha obliqua* (Macquart) and *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) and the parasitoid *Doryctobracon areolatus* (Szépligeti) (Hymenoptera: Braconidae) in the oceanic archipelago of Fernando de Noronha, Brazil

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ABSTRACT

We recorded for the first time the presence of the two fruit flies pests, *Anastrepha obliqua* (Macquart) and *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) and the parasitoid *Doryctobracon areolatus* (Szépligeti) (Hymenoptera: Braconidae) in the oceanic archipelago of Fernando de Noronha, Pernambuco, Brazil. The specimens were collected in traps installed during June/2019 to February/2020. The fruit flies and the parasitoid species are widespread in the Brazilian mainland and have most likely been introduced accidentally in the archipelago.

The oceanic archipelago of Fernando de Noronha, state of Pernambuco, Brazil is located 360 km from the Brazilian continent and is a federal preservation area. The archipelago is entirely volcanic in origin and has never been connected to the continent. The total land area is 18.4 km², of which 16.9 km² is the main island of Fernando de Noronha (Lopes and Ulbrich, 2015).

The Fernando de Noronha archipelago (latitude 3°45'S to 3°57'S; longitude 32°19'W to 32°41'W) has a tropical oceanic climate (Awi - Köppen classification). The temperature ranges from 24.9°C to 27.5°C, with an annual mean of 26.2°C and annual precipitation of 1,292 mm, but with large interannual variability (CLIMATE-DATA.ORG, 2021). The archipelago has a harsh environment, lacking a permanent source of freshwater, with low vegetation diversity and a shallow soil that has little capacity for water retention (Freitas et al., 2013; Rafael et al., 2020).

The flora of the Fernando de Noronha archipelago was basically approached by Ridley (1888) that reported several species of plants, however without quantifying them, and Batistella (1996) that carried out a floristic survey and cataloged 60 dominant plant species in

the archipelago. Among the introduced species there are also some fruit trees, cultivated by the military (during military occupation in 1942) and that already reproduce naturally on the main island, such as cashews *Anacardium occidentale* L., mangoes *Mangifera indica* L., yellow mombin *Spondias mombin* L., red mombin *Spondias purpurea* (L.) (Anacardiaceae), sugar-apple *Annona squamosa*, soursop *Annona muricata* L. (Annonaceae), tamarinds *Tamarindus indica* (Fabaceae), guavas *Psidium guajava* L., cattley guava *Psidium cattleyanum* Sabine (Myrtaceae), avocados *Persea americana* Mill. (Lauraceae), star fruit *Averrhoa carambola* (Oxalidaceae), pitomba *Talisia esculenta* (Sapindaceae), coconut trees *Cocos nucifera* L. (Arecaceae), banana trees *Musa* spp. (Musaceae) and papayas *Carica papaya* L. (Caricaceae) (Guerriero, 2002; Teixeira et al., 2003; Serafini et al., 2010).

The entomofauna of this archipelago was listed, which currently comprises 454 species distributed in 21 orders of insects (Rafael et al., 2020). Recent studies have advanced in the knowledge of several orders, such as Diptera (Rafael et al., 2021a, 2021b), Embioptera (Costa-Pinto et al., 2021) and Hymenoptera (Fernandes et al., 2021).

Thus, the aim of this study was to identify the species of fruit flies (Tephritidae) and their possible parasitoid (Braconidae), collected in the oceanic archipelago of Fernando de Noronha, Brazil, during

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June/2019 to February/2020. Several sampling methods were used (with both, active and passive methods). Further details on the collection sites and methods can be found in Rafael et al. (2020; 2021b).

The specimens collected during this study was deposited in the following institutions: **INPA**, Instituto Nacional de Pesquisas da Amazônia, Manaus, Amazonas, Brazil (M.L. Oliveira, curator) and **CZMA**, Coleção Zoológica do Maranhão, Caxias, Maranhão, Brazil (F. Limeira-de-Oliveira, curator).

With the collections carried out, 90 specimens of two species of fruit flies were obtained, *Anastrepha obliqua* (Macquart) with 88 specimens (66 are females and 22 are males) and *Ceratitis capitata* (Wiedemann) with only two specimens. In the Boldró region, 10 females and 7 males of *A. obliqua* were collected with adapted McPhail traps (PET model trap and orange juice as attractant) and 52 females and 16 males, also with adapted McPhail traps (PET model trap and passion fruit juice as attractant); in the Sancho trail, one female and one male were collected with a Malaise trap, while in the Capim-Açu trail, only three females were collected, also with a Malaise trap. The two specimens of *C. capitata*, with only one female and one male were collected with a Shannon trap on the Sancho trail and, additionally, one female was photographed laying eggs in guava in the Boldró region (Figure 1).

Anastrepha comprises more than 300 species (Norrbon et al., 2018; Rodriguez and Norrbom, 2021) and 128 of them occur in Brazil mainland, and among them *A. obliqua*, which has already been reported in 26 Brazilian states infesting a total of 70 host species in different botanical families (Zucchi and Moraes, 2021a). *Ceratitis capitata* is an important worldwide pest in fruit crops, due its extensive human spread all over the world (Hernández-Ortiz et al., 2010). This species has already been reported in 25 Brazilian states infesting a total of 115 host species in 31 botanical families (Zucchi and Moraes, 2021b). Despite its wide geographical distribution, this is the first record of both species in the archipelago of Fernando de Noronha, Brazil.

Aside from fruit flies, the parasitoid *Doryctobracon areolatus* (Szépligeti) (Hymenoptera: Braconidae) was also collected in the present study. The specimens (3 females) were collected on the Capim-Açu trail with Malaise trap. In Brazil, this parasitoid is present in the 26 states

(Shimbori et al., 2021) and can parasitize both *A. obliqua* and *C. capitata* (Marinho et al., 2018).

It is uncertain whether these species have been brought to Fernando de Noronha by man or it was a natural dispersal. It is known that the island's fauna and flora has been greatly modified by anthropic action over the years, with intentional introductions of several species of fruits (Guerriero, 2002).

Additionally, there has been active commerce between the continent and Fernando de Noronha over the years, which most likely has facilitated the transport of both species as immatures (eggs, larvae or pupae) or as adults. It is possible that immatures were transported by ships or planes in fruits, or adult female specimens were trapped in one or both these means of transport. Cargo ships are not inspected to control the introduction of exotic species in Fernando de Noronha.

Another, less plausible hypothesis, is the possibility that these species have migrated naturally to the island. Alves et al. (2019) verified the presence of species of three orders of insects (Hemiptera, Lepidoptera and Odonata) collected attracted by light in a boat on the high sea about 389 km from the coast of Brazil. Due to the fact that the Fernando de Noronha archipelago is located about 360 km from the Brazilian coast, this possibility cannot be completely ruled out.

Thus, we think that the fruit flies species from Fernando de Noronha were probably imported by man and are now colonizing fruit farms on the main island and "Ilha da Rata". Our hypothesis is based on the fact that we found both the flies and the parasitoid, which leads us to believe that the accidental introduction most likely happened via fruit infested with flies and parasitoids.

It is important to emphasize that precautions must be taken regarding the entry of fruits from the mainland to the island (both by air and by sea). The introduction of new pests in this environment can generate economic impact on local crops, as well as increase the possibility of an even greater spread using the island as a source for new dispersions.

Therefore, further studies are needed, and continuous monitoring of these species is necessary to trace their route of introduction to the island, and also, to verify the possible impact of this pest on other fruit trees grown by local residents.



Figure 1 Female of *Ceratitis capitata* in guava fruit, in archipelago of Fernando de Noronha, Brazil, February 2020.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Author contribution statement

DRRF, ELA, DWAM, FLO and JAR Conceptualization-Equal, Investigation-equal, Writing – original draft-Equal, Writing – review & editing-Equal.

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