

**CONSERVATION OF SPECIES IN URBAN GREEN AREAS: THE CASE OF  
*FICUS L.* (MORACEAE) AND ITS POLLINATING WASPS**

**CONSERVAÇÃO DE ESPÉCIES EM ÁREAS VERDES URBANAS: O CASO  
DE *FICUS L.* (MORACEAE) E SUAS VESPAS POLINIZADORAS**

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**ABSTRACT**

*Ex situ* conservation in green areas contributes to reduce of diversity' loss, however, there is a gap in the knowledge of the plant reproduction in environments another than their place of origin. The Horto Botânico do Museu Nacional - UFRJ (HBMN) is a green area located in Rio de Janeiro city, Rio de Janeiro State, Brazil, and has several species of *Ficus*. The objective of this work was verify if the pollinating wasps, which are specific for each species, are present in HBMN. There are 19 species, nine exotic and ten native. Of the natives, three are individuals who haven't yet produced figs; five have their specific pollinators; and *F. pertusa* and *F. pulchella* didn't present their pollinators. Considering that most native species have their specific pollinator, HBMN, if associated with other nearby areas, may be an effective site for the conservation of *Ficus*.

**Keywords:** *Ex situ* conservation. *Pegoscapus*. Reproduction.

## RESUMO

A conservação *ex situ* em áreas verdes contribui para a redução da perda de diversidade, no entanto, há uma lacuna no conhecimento da reprodução de plantas em ambientes diferentes do seu local de origem. O Horto Botânico do Museu Nacional - UFRJ (HBMN) é uma área verde localizada na cidade do Rio de Janeiro, Rio de Janeiro, Brasil, e possui várias espécies de *Ficus*. O objetivo deste trabalho foi verificar se as vespas polinizadoras, específicas para cada espécie, estão presentes no HBMN. Existem 19 espécies, nove exóticas e dez nativas. Das nativas, três são indivíduos que ainda não produziram sicônios; cinco têm seus polinizadores específicos; e *F. pertusa* e *F. pulchella* não apresentaram seus polinizadores. Considerando que, a maioria das espécies nativas tem seu polinizador específico, o HBMN, se associado a outras áreas próximas, pode ser um local efetivo para a conservação do *Ficus*.

**Palavras-chaves:** Conservação *ex situ*. *Pegoscapus*. Reprodução.

The *ex situ* conservation may help to reduce the loss of plant diversity and contribute to species survival (MAUNDER et al., 2004). The Convention on Biological Diversity suggests that the practice of *ex situ* conservation contributes to complementing *in situ* conservation (BRAZIL, 2006). The phenological monitoring indicating the reproductive phases of the plants and studies of reproductive biology in *ex situ* conservation areas allow a more consistent analysis of the behavior of the plants under conditions different from those of their natural environments (COSTA; MAUNDER; PEIXOTO, 2014). However, there is a large gap between ecological research and its application to *ex situ* conservation (MAUNDER et al, 2004). Research on the functional ecology of the species in these areas is important for the management plans (COSTA; MAUNDER; PEIXOTO, 2014).

Urban green areas can be places of *ex situ* conservation, as they have some vegetable cover, with trees, shrubs or herbaceous plants, that besides collaborating for the environmental balance of

the city minimizing the air pollution, improving the microclimatic conditions bringing well-being and improving the quality of life of the local population, can also preserve water resources and biodiversity, offering ecological stability (ARRAIS et al., 2014).

The Horto Botânico do Museu Nacional - UFRJ (HBMN) is a semi-public urban green area, adjacent to the Quinta da Boa Vista Park, located in the district of São Cristóvão, Rio de Janeiro city, Rio de Janeiro State, Brazil. It was created in 1892 (CARAUTA et al., 2004) to be a place of experimentation for researchers of the Museu Nacional and currently has about 20,000m<sup>2</sup> of wooded area. It presents a totally introduced vegetation of exotic and native species from several Brazilian ecosystems including *Ficus* species.

The *Ficus* conservation is very complex because their pollination occurs through a species-specific intimate obligatory mutualistic relationship between plant-wasp (JANZEN, 1979). The small wasps of the Agaonidae family need the *Ficus* inflorescences for their reproduction using the ovary of the flowers to deposit their eggs (GALIL; EISIKOWITCH, 1968). The unisexual flowers of the *Ficus* species are within the fig which generally has a globular shape with a single orifice covered by bracts (BRONSTEIN; HOSSAERT-MCKEY, 1996, CARAUTA; DIAZ, 2002). There are two types of female flowers, the long-styled and the short-styled, which are regularly distributed (GALIL; EISIKOWITCH, 1968, JANZEN, 1979). The male flowers are smaller in number (JANZEN, 1979) and can be in some species, distributed regularly and in others concentrated near the orifice (VERKERKE, 1989). The fig goes through several phases during its development. When they reach a certain size, they may emit a characteristic odor attractive to the pollinating wasps (WARE et al., 1993), which arrive in large numbers up to the plant and enter the figs by the orifice. These females are ready to lay their eggs. Within the fig the females walk on the stigmas of the female flowers and introduce their ovipositors into the ovaries through the stigmas of the short-styled flowers, and usually place an egg in each ovary forming gall. The pollen that came in the female's body is deposited on the stigmas of long-styled flowers. Days later the females die inside

the fig. Then the eggs hatch becoming larvae. After their developmental period, they soak up and become adult wasps. The males emerge first in the interior of the fig before the females. With their strong jaw, they pierce the walls of the female galls and copulate with the females even though they are inside the gall. Subsequently the fertilized females enlarge the holes and emerge into the fig. The males pierce the fig wall to make a hole, and then they die. When the females emerge, they search to exit of the fig. On this occasion the male flowers are with the anthers open and the females impregnate your body with pollen and they leave the fig through the hole. When the females leave the fig they are fertilized and with pollen, then they fly looking for another individual of the same species that has figs in the odor emission phase (GALIL; EISIKOWITCH, 1968). In general, in a population of *Ficus*, individuals usually have asynchrony of flowering, always having an individual producing figs throughout the year, thus fig production is continuous (FIGUEIREDO; SAZIMA, 1997). This phenological behavior is important for the life cycle of the Agaonidae wasps, allowing the maintenance of their colonies (BRONSTEIN; HOSSAERT-MCKEY, 1995).

So, it is necessary have a population of pollinating wasps specific to each species, which is in continuous process of renewal. Therefore, it is believed that to maintain the wasp population, at least ten individuals of the same species of *Ficus* must be aggregated (CARAUTA; DIAZ, 2002). In this work the following questions were asked about the reproductive situation and the conservation of the *Ficus* species in the HBMN: Which species of *Ficus* and how many individuals exist of each species? Do these species present their pollinating wasps and are they producing seeds? Is HBMN a suitable place for the conservation of *Ficus* species?

This study was conducted from June 2015 to June 2016. All *Ficus* individuals were tagged, identified, observed weekly to verify the production of figs. The figs were collected and, opened to verify the presence of wasps and/or seeds. When galls were found inside the figs, they were placed in transparent plastic flasks with finely perforated lids and accompanied until the emergence of the wasps, when they were collected and fixed in 70% alcohol for identification. The location of *Ficus*

species in other localities of the Rio de Janeiro city was searched using data from the *SpeciesLink* platform (<http://splink.cria.org.br/>).

The HBMN presents 42 individuals of *Ficus* from 19 species, nine them are exotics and ten natives (Table 1). The only exotic species that presented its specific pollinating wasp was *Ficus religiosa*, the same pollinating species, *Platyscapa quadraticeps* Mayr (Figure 1F), found in its place of origin, on the Asia (GALIL; SNITZER-PASTERNAK, 1970). There is another occurrence of its presence in the Rio de Janeiro city (VIANNA-FILHO et al., 2017) and this pollinating wasp was also found colonizing *F. religiosa* in Africa (VAN NOORT; WANG; COMPTON, 2013).

**Table 1.** Species of *Ficus* from Horto Botânico do Museu Nacional - UFRJ with their respective places of origin, number of individuals, number of individuals that produced figs, presence or absence of pollinating wasps and seeds.

Species	Origin	Total number	Ind. with figs	Polinator	Seeds
<i>F. arpazusa</i> Casar.	Brazil	1	1	presence	presence
<i>Ficus aspera</i> G. Forst.	Oceania	1	1	absence	absence
<i>F. benghalensis</i> L.	Asia	2	2	absence	absence
<i>F. benjamina</i> L.	Asia Oceania	3	2	absence	absence
<i>F. clusiifolia</i> Schott	Brazil	2	0	absence	absence
<i>F. crocata</i> (Miq.) Mart. ex Miq.	Brazil	10	5	presence	presence
<i>F. cyclophylla</i> (Miq.) Miq.	Brazil	4	1	presence	presence
<i>F. enormis</i> (Miq.) Miq.	Brazil	2	1	presence	presence
<i>F. eximia</i> Schott	Brazil	2	0	absence	absence
<i>F. gomelleira</i> Kunth & C.D.Bouché	Brazil	1	0	absence	absence
<i>F. luschnathiana</i> (Miq.) Miq.	Brazil	2	2	absence	presence
<i>F. lyrata</i> Warb.	Africa	1	1	absence	absence
<i>F. microcarpa</i> L. f.	Asia Oceania	3	0	absence	absence

<i>Ficus natalensis</i> subsp. <i>leprieurii</i> (Miq.) C.C.Berg	Africa	1	1	absence	absence
<i>F. pertusa</i> L. f.	Brazil	2	2	absence	absence
<i>F. pulchella</i> Schott ex Spreng	Brazil	1	1	absence	absence
<i>F. religiosa</i> L.	Asia	2	2	presence	presence
<i>F. sagittifolia</i> Warb. ex Mildbr. & Burret	Africa	1	1	absence	absence
<i>F. sur</i> Forssk	Africa	1	1	absence	absence

Pollinating wasps and seeds were found in *Ficus arpazusa*, *F. crocata*, *F. cyclophylla* and *F. enormis*, each of these native species were associated with a different *Pegoscapus* Cameron species (Figure 1 A-E). As the review of the genus *Pegoscapus* is still in progress, the specific name of the species has not yet been determined.

**Figure 1.** Pollinating fig wasps sampled in this study. **(A)** *Pegoscapus* sp. ex. *F. arpazuza*. **(B)** *Pegoscapus* sp. ex. *F. crocata*. **(C)** *Pegoscapus* sp. ex. *F. cyclophylla*. **(D)** *Pegoscapus* sp. ex. *F. cyclophylla*, detail. **(E)** *Pegoscapus* sp. ex. *F. enormis*. **(F)** *Platyscapa quadraticeps* (Mayr, 1885) ex. *F. religiosa*. Scale bars: 500  $\mu\text{m}$  (A-C,E-F), 200  $\mu\text{m}$  (D).



In *Ficus luschnathiana* it was not possible to collect the pollinating wasps, but seeds were formed, which indicates that the pollinator occurs in the study area. The difficulty of collecting the pollinating wasps in this species was probably due to the fact that its present asynchrony of the figs production within the individual (FIGUEIREDO; SAZIMA, 1997) and, as the plant has figs in different stages of development at the same time, we collected figs whose wasps had emerged from the galls.

We evaluated the situation of the native species of the HBMN and verified that, three species, *F. clusiifolia*, *F. eximia*, *F. gomelleira*, whose individuals are very young and have not yet

begun to produce figs. *Ficus crocata* presented intrapopulational asynchrony where five individuals alternately produced figs throughout the year, a strategy that occurs in natural populations of most species of *Ficus* and that ensures the maintenance of the populations of their pollinating wasps in the area (BRONSTEIN; HOSSAERT-MCKEY, 1996). There are still 15 adult individuals of *F. crocata* in Quinta da Boa Vista Park (PEREIRA; ESBÉRARD, 2009), ensuring the minimum number of individuals recommended for the maintenance of pollinating wasp (CARAUTA; DIAZ, 2002).

Species that presented only one or two individuals producing figs, and that nevertheless presented their pollinating wasps, such as *F. enormis*, *F. arpazusa*, *F. cyclophylla* and *F. luschnathiana*, probably present other individuals of the same species in places near the HBMN, like Quinta da Boa Vista Park, where there are several individuals of *F. enormis* and *F. luschnathiana*. However, there isn't record of the existence of *F. arpazusa* and *F. cyclophylla* in Quinta da Boa Vista Park, but there is *F. arpazusa* in Tijuca Forest (CARAUTA; DIAZ, 2002), about 10 km distant from HBMN and in the neighborhood of Santa Tereza distant 4.6 km. For *F. cyclophylla* there is an individual in Salgado Filho Square about 7 km from the HBMN. According to Nazareno and Carvalho (2009) wasps can fly up to a distance of about 5.6 km in natural environments.

*Ficus pertusa*, although having two individuals producing figs, didn't present its pollinating wasps. There are records of this species in places such as Salgado Filho Square and Horto Botânico da Ilha do Fundão about 10 km away from the HBMN, however, probably its pollinating wasp species is not present also in these places. For this case, a management action would be to increase the number of individuals of *F. pertusa* in HBMN and Quinta da Boa Vista Park and to introduce the pollinating wasps in the area.

Another species with reproductive difficulties is *Ficus pulchella*. It is classified as vulnerable by IUCN due to loss of its natural habitat (IUCN, 2016) and by the difficulty in finding



individuals that produce seeds (CARAUTA; DIAZ, 2002). However, the National Center for Plant Conservation (CNCFlora 2012) considered the state of conservation of *F. pulchella* as the least concern, since this species presents individuals in several areas of environmental preservation. However, its reproductive difficulty, still not determined by the lack of studies, can be a problem for its conservation. Further study is needed of the reproductive biology of this species to know why only some individuals produce seeds and others do not (CARAUTA; DIAZ, 2002). It is only through the results of this study that conservation strategies for this species can be planned.

*Ficus cyclophylla* has been classified as endangered due to the degradation of its habitat (IUCN 2016) because it occurs at restinga, sandbank coastal vegetation, that are seriously impacted, mainly by real estate speculation (CNCFlora 2012). The low regeneration of its population is also another risk factor, but this must happen because of the degradation of the environment, which does not allow the development of new individuals, and not for lack of its pollinating wasps, since in the HBMN this species has only one individual producing figs and presented his pollinating wasps.

It is concluded with the result of this work that it is possible to conserve *Ficus* species in green areas because the pollinating wasps seem to be adapted to the urban environment. The Horto Botânico do Museu Nacional - UFRJ, together with other nearby green areas such as Quinta da Boa Vista Park, can be considered an effective place for the conservation of native *Ficus* species and their specific pollinating wasps.

## REFERENCES

ARRAIS, A.M.A.C.; COSTA, C.T.F.; LOPES, E.R.N.; SILVA, M.R. Preservação das áreas verdes urbanas: um estudo sobre o Parque Ecológico das Timbaúbas. **Revista NAU Social**, Salvador, v.5, n.8, p.9-19. 2014.

BOZA, H.S.; MEDEROS, K.Q. Principales especies de *Ficus* (Moraceae) en Cuba y sus avispa polinizadoras Agaoninae. **Revista del Jardín Botánico Nacional**, La Habana, v.27, p.115-121.

2006.

BRASIL. Ministério do Meio Ambiente. **Convenção sobre Diversidade Biológica-CDB**. Brasília, MMA, Série Biodiversidade 2. 2006. 30p.

BRONSTEIN, J.L.; HOSSAERT-MCKEY, M. Hurricane Andrew and a Florida fig pollination mutualism: resilience of an obligate interaction. **Biotropica**, Washington, v.27, p.373-381. 1995.

BRONSTEIN, J. L.; HOSSAERT-MCKEY, M. Fig trees and their associated animals. **Journal of Biogeography**, New Jersey, v.23, n.4, p.433-446. 1996.

CARAUTA, J.P.P.; DIAZ, B.E. **Figueiras do Brasil**. Rio de Janeiro: Editora UFRJ, 2002. 208p.

CARAUTA, J.P.P.; NEVES, L.J.; DIAZ, B.E.; ROCHA, E.S.F.; MACHADO, A.F.P. Urticinaeae (Urticales) do Horto do Museu Nacional, Rio de Janeiro (Nota prévia). **Albertoa Sér. Urticineae (Urticales)**, Rio de Janeiro, v.17, p.105-109. 2004.

CNCFlora (2012) **Lista Vermelha da flora brasileira versão 2012.2**. Centro Nacional de Conservação da Flora. Disponível em <<http://cncflora.jbrj.gov.br>>. Acesso em 20 outubro 2016.

COSTA, M.L.M.N.; MAUNDER, M.; PEIXOTO, A.L. O múltiplo papel dos Jardins Botânicos na conservação da Mata Atlântica. In: COSTA, M.L.M.N. **Conservação de espécies ameaçadas de extinção nos jardins botânicos**. Tese (Doutorado) - Escola Nacional de Botânica Tropical, IPJBRJ, Rio de Janeiro, RJ. 2014. p.75-112.

FIGUEIREDO, R.A.; SAZIMA, M. Phenology and pollination ecology of three Brazilian fig species (Moraceae). **Botanica acta**, Stuttgart, v.110, p.73-78. 1997.

GALIL, J.; ESIKOWITCH, D. On the pollination ecology of *Ficus sycomorus* in East Africa. **Ecology**, Washington, v.49, n.2, p.259-269. 1968.

GALIL, J.; SNITZER-PASTERNAK, Y. Pollination in *Ficus religiosa* L. as connected with the structure and mode of action of the pollen pockets of *Blastophaga quadriceps* Mayr. **New Phytologist**, London. v. 69, p.775-784. 1970.

IUCN - International Union for Conservation of Nature and Natural Resources (2016) **The IUCN Red List of Threatened Species**. Disponível em: <<http://www.iucnredlist.org/>>. Acessado em: outubro de 2016.

JANZEN, D.H. How to be a fig. **Annual Review of Ecology, Evolution, and Systematics**, Aschehoug, v.10, p.13-51. 1979.

MAUNDER, M.; HAVENS, K.; GUERRANT JR., E.O.; FALK, D.A. *Ex situ* methods: a vital but underused set of conservation resources. In: GUERRANT JR., E.O., HAVENS, K., MAUNDER, M. (Eds.). **Ex situ plant conservation: supporting species survival in the wild**. London, Island Press, 2004. p.3-20.

NADEL, H.; FRANK, J.H.; KNIGHT-JR, R.J. Escapees and accomplices: the naturalization of exotic *Ficus* and their associated faunas in Florida. **Florida Entomologist**, Lutz, v.75, n.1, p.29-38, 1992.

NAZARENO, A.G.; CARVALHO, D. What the reasons for no inbreeding and high genetic diversity of the neotropical fig tree *Ficus arpausa*? **Conservation Genetics**, Amsterdam, v.10, p.1789–1793. 2009.

PEREIRA, A.F.; ESBÉRARD, C.E.L. Captura de morcegos frugívoros junto a *Ficus tomentella* (Moraceae). **Revista Brasileira de Zoociências**, v.11, n.1, p.19- 23. 2009.

VAN NOORT, S.; WANG, R.; COMPTON, S. G. Fig wasps (Hymenoptera, Chalcidoidea: Agaonidae, Pteromalidae) associated with Asian fig trees (*Ficus*, Moraceae) in Southern Africa: Asian followers and African colonists. **African Invertebrates**, KwaZulu-Natal, v.54, n.2, p.381-400. 2013.

VERKERKE, W. Structure and function of the fig. **Experientia**, Basel, v.45, p.612-621. 1989.

VIANNA-FILHO, M.D.M.; ALVES, R.J.V.; PENG, Y.; PEREIRA, R.A.S. Naturalization of the Bodhi fig tree (*Ficus religiosa* L. - Moraceae) in Brazil. **Bioscience Journal**, Uberlândia, v.33, n.1, p.177-182. 2017.

WARE, A. B.; KAYE, P. T.; COMPTON, S. G.; VAN NOORT, S. Fig volatiles: their role in attracting pollinators and maintaining pollinator specificity. **Plant Systematics and Evolution**, Wien, v.186, p.147-156. 1993.