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Original article

Symptoms, signs and incidence of insects and phytopathogens associated with mangrove species

Síntomas, signos e incidencia de insectos y fitopatógenos asociados a especies de mangle

Sintomas, Sinais e Incidência de Insetos e Fitopatógenos Associados a Espécies de Mangue

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SUMMARY

The research was carried out in the mangrove ecosystem of the Coloma-Las Canas sector, with the objective of characterizing symptoms and signs of insects and phytopathogens associated with mangrove species, such as: *Avicennia germinans* (L), *Rizophora mangle* (L) and *Conocarpus erectus* (L) as well as their degree of incidence on these. For this purpose, 10 sampling units of 10x10 meters were randomly established.

A sampling brigade made up of four previously trained researchers participated in the field data collection. Photographs of the symptoms and signs caused by insects and phytopathogens were taken in order to use them for their subsequent identification, through comparison with those reported in works carried out by other authors in the mangroves. In each sampling plot, the number of specimens of each of the mangrove species was counted, in order to determine their abundance, as well as the number of those affected by insects and phytopathogens, also determining the degree of incidence of each organism. All these data were processed in Microsoft Excel. The mangrove species on which the highest incidence of insects and phytopathogens was observed were: *A. germinans*, affected by the defoliating action of *Junonia spp,* moths and cankers and *Rhizophora mangle* and *C. erectus,* for cankers and termites

Keywords: Insects, cankers, incidence, mangrove

RESUMEN

La investigación se desarrolló en el ecosistema manglar del sector Coloma-Las Canas, con el objetivo de caracterizar síntomas y signos de insectos y fitopatógenos asociados a especies de mangle, tales como: *Avicennia germinans* (L), *Rizophora mangle* (L) y *Conocarpus erectus* (L) así como su grado de incidencia sobre estas. Para ello, se establecieron al azar 10 unidades de muestreo de 10X10 metros. Para llevar a cabo la recolección de datos de campo se contó con la participación de una brigada de muestreo conformada por cuatro investigadores previamente capacitados. Se realizaron fotos de los síntomas y signos provocados por insectos y fitopatógenos con el fin de emplearlas para su posterior identificación, mediante su comparación con las reportadas en trabajos realizados por otros autores en los manglares. En cada parcela de muestreo se contó el número de ejemplares de cada una de las especies de mangle, con el propósito de determinar su abundancia, así como el número de los que estaban afectados por insectos y fitopatógenos, determinándose, asimismo, el grado de incidencia de cada organismo. Todos estos datos fueron procesados en Microsoft Excel. Las especies de mangle sobre las que se observó mayor incidencia de insectos y fitopatógenos fueron: *A. germinans*, afectada por la acción defoliadora de *Junonia spp,* polillas y chancros y *Rhizophora mangle* y *C. erectus*, por chancros y termitas

Palabras clave: Insectos, cancros, incidencia, manglar

RESUMO

A pesquisa foi realizada no ecossistema de manguezal do Setor Coloma–Las Canas com o objetivo de caracterizar sintomas e sinais de insetos e fitopatógenos associados às espécies de mangue, tais como: *Avicennia germinans* (L.), *Rhizophora mangle* (L.) e *Conocarpus erectus* (L.), bem como seu grau de incidência. Para isso, foram estabelecidas aleatoriamente 10 unidades de amostragem de 10 × 10 metros. Para a coleta de dados de campo, contou-se com a participação de uma brigada de amostragem composta por quatro pesquisadores previamente capacitados. Foram tiradas fotos dos sintomas e sinais causados por insetos e fitopatógenos com a finalidade de usá-las posteriormente para identificação, por meio da comparação com aquelas relatadas em trabalhos realizados por outros autores em manguezais. Em cada parcela de amostragem foi contabilizado o número de exemplares de cada uma das espécies de mangue, com o propósito de determinar sua abundância, assim como o número de indivíduos afetados por insetos e fitopatógenos, sendo também determinado o grau de incidência de cada organismo. Todos os dados foram processados no Microsoft Excel. As espécies de mangue que apresentaram maior incidência de insetos e fitopatógenos foram: *A. germinans*, afetada pela ação desfolhadora de *Junonia* spp., mariposas e cancros, e *R. mangle* e *C. erectus*, por cancros e cupins.

Palavras-chave: Insetos; cancros; incidência; manguezal

INTRODUCTION

Inventories of harmful organisms in forests are the basic instrument for their management and are essential for the conservation of a good phytosanitary state in forest ecosystems, as well as for their use and profitability (López *et al.* Among these ecosystems, mangroves are no less vulnerable, but receive less attention in relation to this issue.

Mangroves are natural wetlands, considered ecologically one of the most productive ecosystems on the planet. These forests represent a transition between the maritime and terrestrial environments and are of great biological and economic importance, making them a strategic marine ecosystem. Worldwide, they are estimated to occupy only 3% of the Earth's land surface (Gómez *et al.*, 2023). According to a recent assessment, the global mangrove area in 2020 was estimated at 14.8 million hectares (FAO, 2023).

Mangrove ecosystems are among the most threatened in the world; their existence is even more endangered than that of tropical forests and coral reefs, with a 60% loss (Marcelo *et al.*, 2018), cited by Rodríguez *et al.*, (2021).

Mangroves in Cuba are present in more than 50% of the coasts and occupy about 5% of the country's surface, which represents 20% of its forest cover (Menéndez and Guzmán, 2010), cited by Menéndez (2013).

Mangrove forests are of great ecological and economic importance due to their role in reducing coastal erosion, storm protection, water quality control, and the constant flow of large nutrient-rich sediments (Wang *et al.*, 2020), cited by Muñoz *et al.*, 2024.

Despite the ecological and economic importance attributed to mangroves, their destruction and deterioration is occurring as population growth increases, generating greater pollution and indiscriminate logging, as well as the impact of hurricanes (Herrera, 2022).

There are around 68 species of mangroves globally, within the American continent only 10 species are found, among which the following stand out: the black mangrove (Avicennia *germinans* L.), red mangrove (Rhizophora *mangle)*, white mangrove (Laguncularia *racemosa)*, buttonwood mangrove (Conocarpus *erectus)*, salt mangrove (Avicennia *bicolor* Standl.) and yellow mangrove (Rhizophora *harrisonii*) (Gómez *et al.*, 2023).

The conservation of these forests is vitally important, as they are capable of protecting inland ecosystems from sea erosion and are also highly productive ecosystems. Therefore, it is necessary to conduct studies on the insects and phytopathogenic organisms associated with these forests as a tool to contribute to their conservation and

development. In Cuba, however, these organisms have received little research in relation to mangrove formation.

For the reasons stated above, it was decided to carry out this research, with the following objective: to characterize insects and phytopathogenic organisms associated with mangrove species, such as: *Avicennia germinans* (L), *Rizophora mangle* (L) and *Conocarpus erecta* (L), as well as their degree of incidence on these.

MATERIALS AND METHODS

Location of the workplace

The research was carried out in the Coloma-Las Canas coastal sector. La Coloma is located at 22.015 ' north latitude and 83.034 ' west longitude. This popular council is bordered to the north by the Las Taironas popular council, to the south by La Coloma cove, to the east by the San Luis municipality, and to the west by the Antonio Briones Montoto popular council. It has a territorial extension of 39.5 km ^{2} and its fundamental economic activity is fishing. with the La Coloma Industrial Fishing Combine.

Methodology

Ten sample plots measuring 10 by 10 meters were randomly established. Field data collection was carried out by a monitoring team composed of four researchers trained in topics related to sampling for mangrove pests and their effects, with an emphasis on identifying symptoms and signs caused by insects and plant pathogens. Photographs of the symptoms and signs caused by these organisms were taken for identification, comparing them with those reported in studies conducted by other authors in mangroves. In each sample plot, the number of specimens of each mangrove species was counted to determine their abundance, as well as the number of those damaged by the different organisms to determine their incidence. The following expression (equation 1) was used for this purpose:

$$Incidencia = \frac{\text{No de árboles infestados}}{\text{No total de individuos censados}} 100 (1)$$

All of this data was processed in Microsoft Excel.

RESULTS AND DISCUSSION

The greatest abundance of the inventoried mangrove species corresponded to *Avicennia germinans* (black mangrove), followed by *Rhizophora mangle* (red mangrove) and *Conocarpus erectus* (yana), Figure 1.

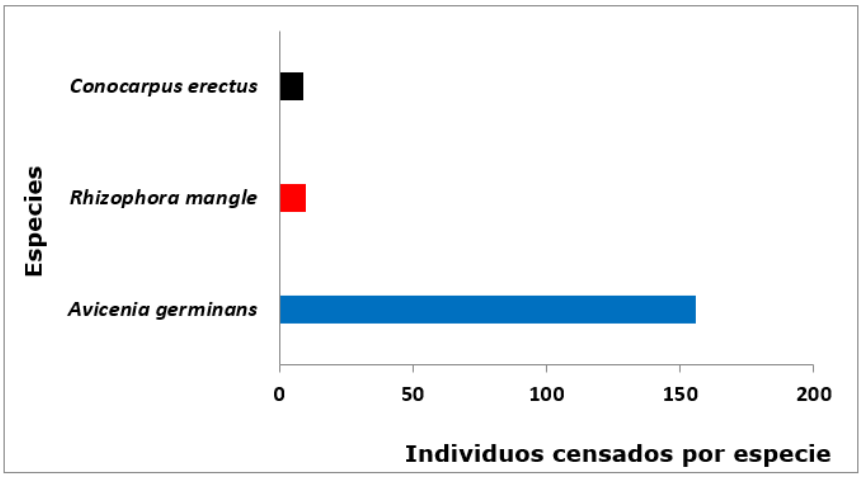

Figure 1. *- Abundance of inventoried mangrove species*

In Figure 1, it can be seen that the abundance of mangrove species in the location varied greatly, which may be influenced by several factors, including sedimentation or accretion of sediments, road construction, the advance of the agricultural frontier, livestock farming, timber extraction and illegal logging (Cruz and Pérez (2017). Also, Rodríguez *et al.*, (2021), when referring to factors that affect this same sense, mention indiscriminate logging, diseases, coastal erosion, construction of roads and trails, sea penetration and water pollution. Similarly, Osorio *et al.*, (2016) mention that the reproduction rate of mangroves is high; however, the survival rate is what could be compromised by changes resulting from the environment, such as insolation, salinity, flooding and pest attacks, among others. Herrera, (2022) points out that the destruction and deterioration of the mangrove is going to increasing as population growth progresses, generating greater pollution and indiscriminate logging, as well as the impact of hurricanes.

According to the sampling results, the symptoms and signs of insects predominated in the area with respect to phytophages, which agrees with Osorio (2016), cited by Bernal (2017), although it cannot be ruled out finding more symptoms and signs of phytopathogenic agents if the sampling continues. Another interesting fact is that the mangrove species with the most symptoms caused by insects was *A. germinans* , followed by *R. mangle and Conocarpus erectus.* Castillo (2001) points out that *A. germinans* is among the mangrove species with the greatest entomological diversity. In addition to pests, this plant provides habitat for countless saprophagous insects that feed on leaf, flower and fruit debris, and is also one of the most visited species by bees, wasps, flies and butterflies (Table 1).

Table 1. *- Insects associated with mangroves in the Coloma-Las Canas sector*

Species of mangrove	Insect	Order	Family	Part of the plant affected	Injuries observed
Avicennia germinans	*Junonia sp*	Lepidoptera	Nimphalidae	It feeds on shoots and leaves.	Gnawing of leaves from the edge inwards
Avicennia germinans	Moths	Lepidoptera	Noctuidae	It feeds on seeds and shoots	Seed destruction
Rhizophora mangle	*Nasutitermes sp*	Isoptera	Termitidae	Trunk and branches	Nests called balls, attacking standing trees
Conocarpus erectus	*Nasutitermes sp*	Isoptera	Termitidae	Trunk and branches	Nests called balls, attacking standing trees

Junonia sp

Junonia was detected sp. at the beginning of October 2023, obtaining photographs of larvae, pupae and adults (Figure 2A, B, C, D).

Figure 2. *- Presence of Juniona sp. A= larva, B= pupa, C= female adult, and D= male adult.*

The larval stage of *Junonia* sp. corresponds to a eruciform larva characterized by presenting five pairs of false legs with a dark brown to black coloration, with setae or hairs on the dorsal region, a reddish-brown head and masticatory mouthparts (Figure 2A). In Figure 2B, the pupal stage of this insect can be seen, which is of the obtecta type, characteristic of the order Lepidoptera. In Figures 2 C and D, the adult stage of the female and male are observed, respectively.

The larva feeds on the leaves of the black mangrove, devouring them from the edge to the center, leaving the central nerve intact and producing irregular cuts (Figure 3).

Figure 3. *- The larva feeds on the leaves of the black mangrove, devouring them from the edge to the center, leaving the central nerve intact and producing irregular cuts*

Moths

A. germinans , produced by moths, were identified, and after reviewing the literature it was found that they coincided with those reported by Bernal (2017) in mangroves of the "Los Petenes" Nature Reserve, Mexico.

There are antecedents of moths in *Avicennia* ssp ., feeding on seeds; because of this, it is considered a major pest. It is estimated that, in mangrove ecosystems, a single larva can destroy up to eight fruits, and pupate in the last one (Peter and Sivasothi , 2001), cited by Bernal (2017).

Termites

Termites were observed on branches and trunks of *R. mangle* and *C. erectus.* In the case of red mangrove, termite nests are associated with the cankers found on this species, although they were observed in only two of the ten sampled plots (Fig. 4A and B).

Figure 4. *- Branches and trunk of mangrove affected by termites, A= R. mamgle, B= C. erectus*

Observed bioregulators

Pheidole) was observed in the leaves of *A. germinans. megacephla*) developing biological control of *Junonia pupae* sp. This ant belongs to the Hymenoptera Order and the Formicidae family, subfamily Mymicinae.

Pathogens associated with mangrove species

Table 2 reflects the results of observations on symptoms of phytopathogenic organisms present in the area, affecting species such as: *A. germinans and R. mangle,* lodging on

different parts (roots, trunks and branches), manifesting in the form of cankers or cankers (hypertrophies and/or hyperplasias).

Table 2. *- Pathogens associated with mangrove species*

Species of mangrove	Causal agent	Class	Part of the plant affected	Symptoms
Avicennia germinans	Unidentified	Unknown	Trunk and branch	Bark canker
Rhizophora managle	Unidentified	Unknown	Branch and root	Chancre

The manifestations of these diseases on the mangrove species reflected in Table 2 are shown in the following (Figure 5 A, B y C).

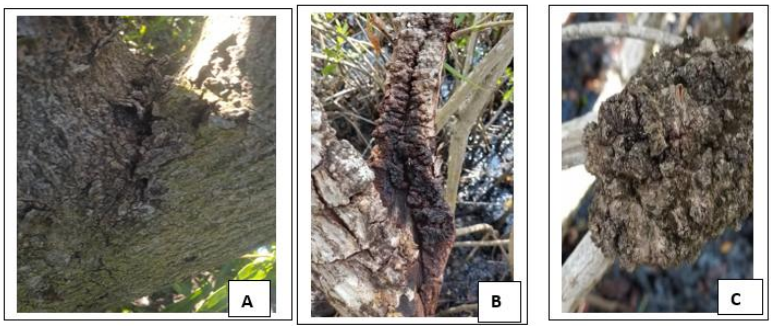

Figure 5. *- Illustrations of the cankers located on trunks and branches of A. germinans (A and B) and C on the root of R. mangle*

According to Bernal (2017) and CONAFOR (2020) National Forestry Commission (Campeche State Management) they indicate that most of these cankers are associated with fungi of the *Microthia genus.* sp. and *Eutypella* sp. and These infections can occur through lenticels in the bark as opposed to wounds or insect feeding sites or galleries, it is also believed that the development of cankers may be related to the production of indoleacetic acid by the fungi that cause them; other evidence suggests that mites can spread the pathogen and that temperature plays an important role in limiting its distribution. For his part, Zacarias- Coxic (2023) points out that symptoms similar to those in Figure 5 C are caused by different organisms, including *Agrobacterium* sp , *Fusarium sp* and *Cylodendron* sp, and they are called "Red Mangrove Gall".

In Cuba, the presence of canker (gangrene) symptoms has also been reported in other forest species such as the canker or gangrene of the *Eucalyptus genus* caused by the fungus *Chrysophorte cubensis* and majagua gangrene (*Taliparitis elatum*), caused by a fungus of the Hipocraceae family, and considered the most interesting among the diseases during the period 1997-2001 (López *et al.*, 2003). These same diseases were recently reported by Hernández *et al.* (2021) and Guanche *et al.* (2022) in work carried out on urban trees in towns of Pinar del Río, Cuba.

Degree of incidence of insects and phytopathogenic organisms associated with the mangrove

Figure 6 shows the degree of incidence of insects and phytopathogens associated with mangrove species, with greater impact by *Junonia being evident.* sp . on *A. germinans,* since it was the one on which the greatest number of attacks were observed on the foliage, being considered severe, being greater than 10 %. Bernal (2017) points out that an infestation by *Junonia* prevented the recovery of *A. germinans*, Since the insect feeds on propagules, seedlings, and pneumatophores, the abundant rainfall also led to high fruit production, which served as additional food for the insect, generating sites with 100% mortality. Alonso *et al.* (2020) determined that *J. genoveva* larvae are the main herbivore on *A. germinans* seedlings in the Bay of Panama. Similar results were obtained by Vargas *et al.* (2023) at the same site.

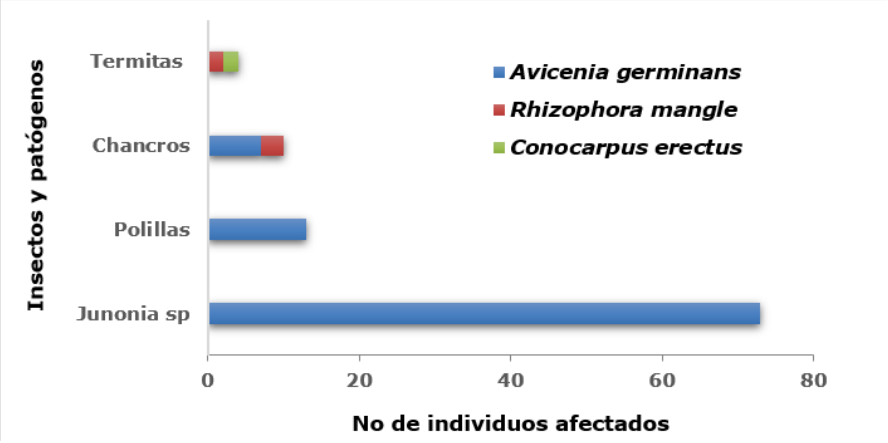

Figure 6. *- Incidence in percent of insects and phytopathogenic organisms associated with mangrove species*

For the rest of the harmful organisms, according to the percentage of incidence (greater than 10%) their attacks can also be considered strong, however, the species on which they appeared producing effects (R. *mangle* and *C. erectus)* were poorly represented in the area. In the specific case of the attacks observed by moths on fruits and seeds of *A. germinans*, were higher than 13%, and are considered equally high.

Regarding termites, these were located on *Rhizophora mangle* (red mangrove) and *Conocarpus erectus* (yana) damaging 20 and 22 % of the individuals counted respectively, being located in different parts (trunks and branches) and the main characteristic is that they had cardboard consistency nests and well called balls, these attack both trees and other cellulose material. Their nests constitute true structural works. In Cuba the species are reported *Nasutitermes costalis and N. rippertii* associated with other forest species (Cruz *et al*., 2004). For his part, Bernal (2017) reports *Nasutitermes nigriceps* as one of the termite species that affect *A. germinans*, *R. mangle* and *Lagungularia racemosa* in the "Los Petenes" Biosphere Reserve, Mexico. The results, regarding the degree of affectation by these insects, coincide with those of (Ríos *et al*., 2021), who found in work carried out in mangroves in Playa "El Retén", Panama, that these insects damaged more than 14% of the trees.

Regarding the insect species of the order Coleoptera and family *Curculionidae* associated with *A. germinans,* its incidence rate turned out to be low (1.2%), while for cankers it varied between 4 and 30%).

CONCLUSIONS

In the composition of harmful organisms associated with the mangrove, insects predominate and the mangrove species that presented the greatest number of these was *A. germinans, with Junonia* being among the most important pests. sp , with defoliating activity on *Avicennia germinans* (black mangrove) and termites that attack *Rhizophora mangle* (red mangrove) and *A. germinans*.

As evidence of phytopathogenic agents, canker symptoms are identified that equally affect roots, branches and trunks of *Rhizophora mangle* and *Avicennia germinans*.

The presence of the African lion ant (Pheidole*) in the area is reported megacephala) exerting biological control over Junonia* pupae sp.

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The authors have participated in the writing of the work and analysis of the documents.