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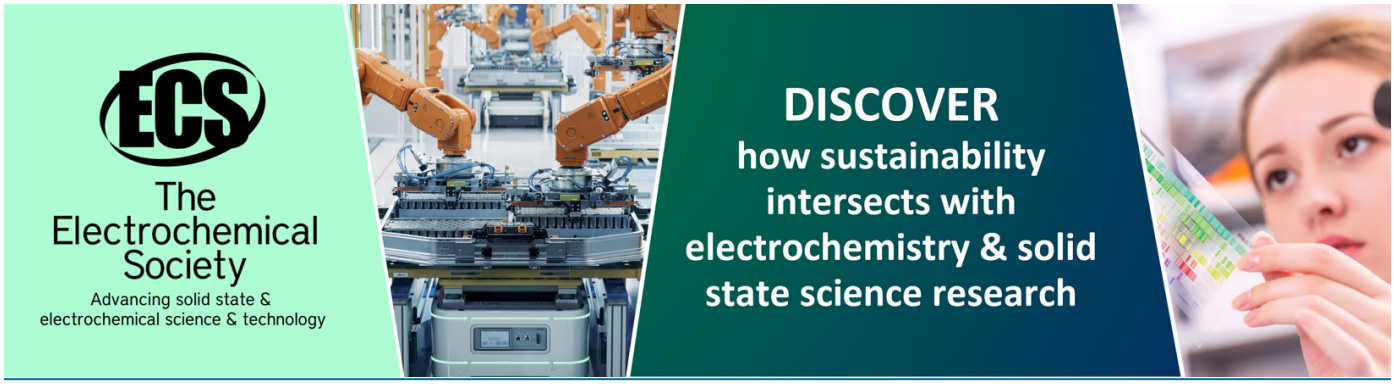

Pests of *Sonneratia caseolaris* seedlings in the mangrove restoration area nursery of Berbak-Sembilang National Park and its damage

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Abstract. *Sonneratia caseolaris* is one of the mangrove species that is widespread in Indonesia. It has important ecological functions to protect coastal foreshores. However, the *S. caseolaris* seedlings are rarely to be planted in mangrove restoration projects. One of the challenges in producing many *S. caseolaris* seedlings for mangrove restoration projects is pest infestation. However, the information on those pests is still limited. This study aimed to identify *S. caseolaris* pests that hinder the successfulness of cultivation. The incidence and intensity of pest infestation on *S. caseolaris* seedlings have also been assessed. This research was carried out in the nursery of the mangrove restoration area of Berbak-Sembilang National Park. The results showed that insect and rodentia were two major groups found infested *S. caseolaris* seedlings. Three species of insect pests were identified, namely *Pteroma plagiophleps*, *Ooecophylla* sp., and *Sexava* sp. The incidence and severity of *P. plagiophleps*, *Ooecophylla* sp., and *Sexava* sp. infestation were 16.38%; 21.02%; 6.68%; and 30.83%; 42.67%, 25.83%, respectively. For rodentia pest, the *Rattus* sp. was the only species found to infest the plant, with an incidence of 16.67%. These all pests significantly affect the growth performance of *S. caseolaris* seedlings.

1. Introduction

Mangrove forest is a type of forest that grows in tidal areas (especially on protected beaches, lagoons, and river estuaries) that are inundated at high tide and no inundation at low tide and whose plant communities are salt-tolerant [1]. Mangrove ecosystems have very important socio-economic, socio-cultural, and ecological functions. Mangrove forest is the largest habitat at Berbak-Sembilang National Park, extending inland for up to 35 km. The high diversity of ecosystems in the area becomes a special attraction for people around the Berbak-Sembilang National Park area to utilize the area's potential into ponds. The existence of ponds will increase the mangrove ecosystem degradation in the conservation area. The mangrove area in the conservation area of Berbak-Sembilang National Park has suffered damage due to the construction of the pond.

The decline in productivity of the mangrove ecosystem at Berbak-Sembilang National Park caused by aquaculture activities needs to be restored. Meanwhile, the current information on mangrove silviculture is still relatively rare. The species selection carried out sometimes unsuitable with its land requirement. Mangrove restoration usually uses propagules in planting. In fact, mangroves have specific zoning; thus, not all zones will be successfully restored if planting using propagules. The use of seeds needs to be adjusted to the zoning characteristics of mangroves.

Research on the use of seeds is rarely conducted, and the data are still very limited. *Sonneratia caseolaris* is a type of mangrove plant that can be propagated by seed. This plant is often found in brackish water areas where mangrove forests grow [2], and it is a mangrove tree species with breath roots that emerge vertically from the ground. This plant produces fruit which is commonly known as *buah pedada* or mangrove apple. Mangrove apple contains protein, fat, carbohydrates, vitamins, and others. In several areas in South Sumatra, local people usually use mangrove apples to make syrup and chili sauce [3]. In addition, mangrove apple is also processed as a confection and candy [4] and jam [5].

S. caseolaris seeds are rarely planted in mangrove restoration projects due to the lack of cultivation knowledge, especially in the nursery stage. One of the challenges in propagating *S. caseolaris* seedlings for mangrove restoration projects is pest infestation. Pest infestation is one of the obstacles in cultivation that causes failure in nurseries. However, information on the pest species and their attacks on *S. caseolaris* seedlings is still very limited. Therefore, research on the identification of pests and their attack level is vital in pest management attempts to increase restoration success in mangrove areas.

This research aimed to identify the pest species that attacked *S. caseolaris* seedlings and examine the incidence and intensity of pest attacks on *S. caseolaris* seedlings.

2. Materials and Methods

2.1. Time and location

This research was conducted from April to November 2019 in a nursery in the mangrove restoration area of the Berbak-Sembilang National Park, located in Banyuasin Regency, South Sumatra Province. The coordinates of the research location were 02º09'52"S, 104º54'18"E (Figure 1), at an altitude of 1 m asl.

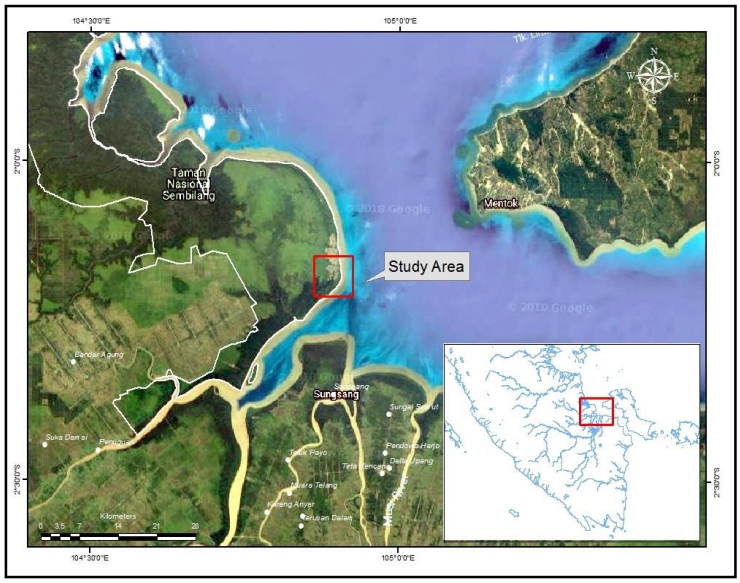

Figure 1. Research location map in Banyuasin Regency, South Sumatra.

2.2. Preparation for observation sample

S. caseolaris seeds were sprinkled on the sand media that was placed in the saw tube. After the seeds germinated, they were transferred to polybags as soon as possible. Watering was done regularly to keep moist of the planting media.

2.3. Observation for pest infestation

The pest observation included species and symptoms of pest infestation on *S. caseolaris* seedlings in 6 seedling blocks. The total *S. caseolaris* seedlings observed were 736 seedlings. The pest observation activities in the nursery were carried out biweekly, starting from the seeds being weaned in polybags until the seedlings were ready for planting. Pests found in the nursery, in both the prepubescent and adult stages (imago), were collected and kept for further identification.

2.4. Identification

The pest specimens were inserted into the specimen box and photographed for documentation. All pests obtained in the field were subsequently identified. The identification results were then tabulated and analyzed. The identification of insects obtained from the field was carried out using reference books according to [6] and [7]. The physical and morphological characteristics of the insects were then compared and matched with the characteristics contained in the key of insect determination.

2.5. Observation for pest damage level

The observation for the pest infestation level included the incidence and intensity of pest infestations on the *S. caseolaris* seedlings. The observation was started from growing sprouts until the seedlings were ready for planting and carried out biweekly. The incidence of pest infestation was defined as the ratio between the total plants attacked by the pest and the total plants observed, stated in a percentage.

$$\text{Incidence of pest infestation} = \frac{\text{Number of plants attacked}}{\text{Number of plants observed}} \text{ x } 100\%$$

The assessment of the intensity of the attack was carried out according to the criteria for the condition of the plant and its effect on the leaves. The leaf damage level was divided into five categories, where each category was assigned as values of 0, 1, 2, 3, and 4, sequentially according to its level. The use of these categories was based on Unterstenhofer's criteria [8]. The formula below was used to calculate the pest and disease attack intensity:

$$IS = \frac{\sum ni \text{ x } vi}{N \text{ x } Z} \text{ x } 100\%$$

Remarks:

IS : Pest attack intensity
N : Total attacked plant with a certain classification
V : Value for certain classification
I : Plant damage category in leaves
N : Total whole plant in a sample plot
Z : The highest value in classification

The classification of each criterion for assessing the attacked leaves is based on the number of leaves damaged by pests (Table 1).

Table 1. Classification of the level of plant damage.

Category of damage (i)	Classification value (v)	Symptoms on leaves	Level of damage
1	0	Leaves damage ≤ 5%	Healthy
2	1	Leaves damage 5% < x ≤ 25 %	Slight
3	2	Leaves damage 25% < x ≤ 50%	Moderate
4	3	Leaves damage 50% < x ≤ 75%	Heavy
5	4	Leaves damage 75% < x ≤ 100%	Very heavy

Source: [8].

2.6. Data analysis

The correlation was analyzed using the SAS 9.1.3 program to see the correlation between the incidence and intensity of pest attacks on plant growth.

3. Results and discussion

3.1. Type and damage symptom of S. caseolaris seedlings

Based on the observations, there were two classes of pests found: insects and mice. There were three insect group orders: Lepidoptera, Hymenoptera, and Orthoptera. The identification result of species and damage symptoms with the pest species that attacked the *S. caseolaris* seedlings are presented in Table 2.

Table 2. Species and damage symptom of *S. caseolaris* seedlings which pest infestation.

Pest				Part of the plant that is attacked	Damage symptom
Class	Ordo	Family	Species		
Insecta	Lepidoptera	Psychidae	*Pteroma plagiophleps*	Leaf	Holes in leaves and leaves edge
Insecta	Hymenoptera	Formicidae	*Oecophylla* sp.	Leaf	Roll up the leaves to make a nest
Insecta	Orthoptera	Tettigonidae	*Sexava* sp.	Leaf	Holes in leaves with a regular pattern
Mammalia	Rodentia	Muridae	*Rattus* sp.	Leaf and stem	Bite marks on leaves and stems

Several pest species were found to attack *S. caseolaris* seedlings were as follows:

- Bagworms (*P. plagiophleps*). This species is an insect belonging to the order Lepidoptera of the Psychidae family. This insect has the characteristic of having its larvae inside the bag (Figure 2a). The bag size of *P. plagiophleps* is not more than 16 mm, with conical and brown color. The bag is made of small pieces of the host's leaf and is neatly affixed using silk produced by the larvae. The cocoon is in the bag with variable positions; the bag is elliptical and hung by the silk thread using the leaves. Bagworms attack the leaves of *S. caseolaris* seedlings. There are holes on the leaves attacked by bagworms and on the edges of the leaves. Bagworms feed on the lower epidermal layer and the mesophyll tissue, leaving the upper epidermal tissue; the remaining leaf epidermis will dry out and leaves only the leaf bones.
- Weaver ants (*Oecophylla* sp.). *Oecophylla sp.* is an insect belonging to the order Hymenoptera of the Formicidae family. These insects are social insects and live in colonies. Weaver ants make their nests by folding some of the leaves of *S. caseolaris*. The social structure of weaver ants consists of the queen, males, workers and, soldiers. The queen is a female measuring 20-25 mm,

and is green or brown colored. The workers (female) measure 5-6 mm in size and are orange. While the soldiers (females) are 8-10 mm in size and are generally orange, they also have long antennae and long-strong legs (Figure 2b). Weaver ants attack the leaves of *S. caseolaris* by rolling them up and making them a nest. The young leaves are generally rolled by weaver ants.

- Long-horned grasshoppers (*Sexava* sp.). It belongs to the order Orthoptera of the family Tettigoniidae. At the time of observation, only the nymphs of *Sexava* sp. were found. This insect nymph has a length of 8-9 mm. The young and dark nymphs are green but sometimes brownish or green-brown colored (Figure 2c). The adult stadia of *Sexava* sp. is green, approximately 9 cm in length, has delicate pink antennae, bright red limbs, and brown wings. The destructive stages are the nymph and imago. Grasshoppers *Sexava* sp. damage the leaves of *S. caseolaris* seedlings. Based on the observation, it was found that the damage symptoms caused by the *Sexava* sp. were irregular bite marks on the leaves. Late symptoms caused the leaves to dry up and fall off. The leaves attacked by *Sexava* sp. are usually the old leaves. However, when the old leaves run out, they can attack the young leaves.

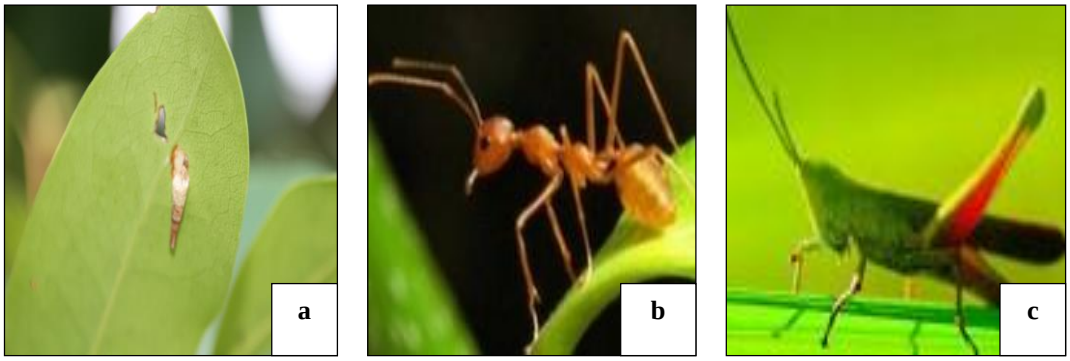

Figure 2. Some pests that attacked seedlings *S. caseolaris*: a) *P. plagiophleps*, b) *Oecophylla* sp., and c) *Sexava* sp.

- Rats (*Rattus* sp.). It is a mammal belonging to the order Rodentia of the Muridae family. *Rattus* sp. is commonly called house mouse, has a long tail, and is good at jumping. It is black or light brown, with a general body length of 15-20 cm. This animal usually attacks at night. These pests attack the leaves and stems of S. *caseolaris* seedlings, and they also attack even the seedlings that have just been planted (Figure 3). These rats ate the newly sown seeds and messed up the seeds, and they bit the stems and leaves of the *S. caseolaris* seedlings. The bite marks appear on the leaves, marked with torn leaves. If the attack level is heavy, it can cause seedlings to die because these pests destroy them randomly.

Figure 3. Symptom of *Rattus* sp. attacked.

3.2. Frequency when the pests found

Based on the frequency of the pests found in the nursery, generally, the weaver ants *Oecophylla* sp. were more common than other species of pests, while the rats *Rattus* sp. were the least common species compared to the other three pests species (Table 3). The frequencies when the pests were found for each species were as follows: *P. plagiophleps* with a frequency of 37.44%; *Oecophylla* sp. with a frequency of 46.3%; *Sexava* sp. with a frequency of 13.3%; and *Rattus* sp. amounted to 2.96%.

Table 3. Frequency of finding pests on *S. caseolaris* seedlings.

Pest	Frequency of finding pest (%)
P. plagiophleps	37.44
Oecophylla sp.	46.30
Sexava sp.	13.30
Rattus sp.	2.96

The four species of pests found infestation on the *S. caseolaris* seedlings were the common pests found in mangrove plants. [9] reported that the most common pests found in mangroves in Indonesia were bagworms. Bagworms are reported to be the dominant pests found in mangroves, even though they attack different species of mangrove plants. [10] reported that bagworms were the dominant species found in terms of population and damage and attacked *Rhizophora* seedlings in nurseries. [11] also reported that bagworms *P. plagiophleps* were found to attack mangrove seedlings and caused damage to mangrove nurseries. Likewise, [12] also reported that bagworms were found attacking mangroves in Ampar district, Kubu Raya Regency, West Kalimantan.

Likewise, with ants, this species is also often found attacking several species of mangrove plants. [13] reported that ants were found in many mangrove ecosystems, and the ants associated with mangroves varied widely. [12] also reported that ants were found attacking mangrove plants: in the arboretum at the seedling level, and the field from seedling to the sapling. The ants *Oecophylla* sp. are mostly found in mangrove communities on Hoga Island, Wakatobi National Park [14]. [15] also reported that *Oecophylla* sp. is one species of pests that destroyed *Rhizophora stylosa* mangrove seedlings in the nursery area of Mempawah Mangrove Park. *Sexava* sp. also reported attacking *Rhizopora* mangrove seedlings [15, 16].

Based on observation time, the most pest population was generally found at the third observation, where the seedlings were 1.5 months old. As for the fourth observation, the least four species of pests were found in the nursery (Figure 4). At each observation time, the *Oecophylla* sp. were found more, and the *Rattus* sp. were least found compared to other pests species. The ants were found more than other pests because the ants attacked the plants on the *S. caseolaris* leaves by making nests, in which the ants were found in groups. The long-horned grasshoppers were the least found than the bagworms and ants because they were more mobile and could quickly move actively from one plant to another.

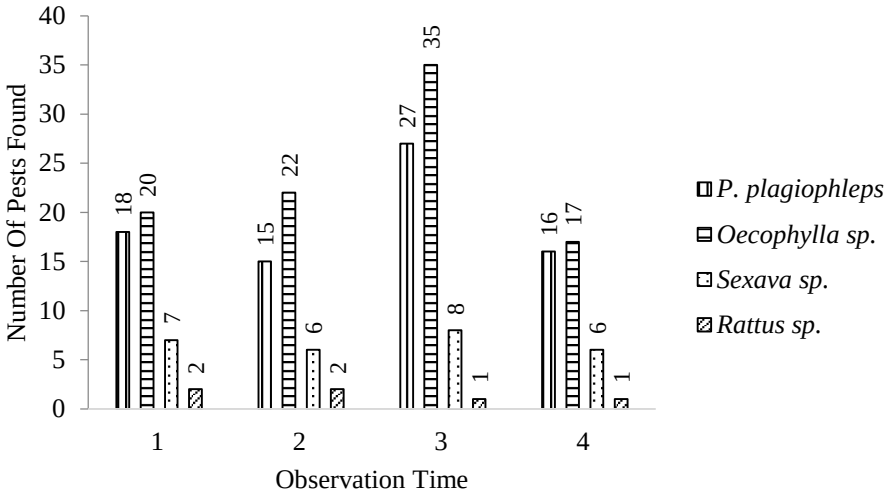

Figure 4. The number of pests found at each observation time.

The existence and population of insect pests are influenced by various factors. Insect internal factors and environmental factors greatly influence the presence and abundance of insects. Internal factors for insects, such as their way of life, feed, and reproduction, greatly influence insects' presence. The availability of food also greatly influences the population of insect pests. The insect pest population can proliferate in conditions of abundant food or host plants and low insect populations. The host plant is a source of nutrients needed by insects to survive and thrive. If food is available in suitable quality and sufficient quantity, the insect population will increase rapidly, and vice versa. Likewise, nocturnal insects will be difficult to find in the morning with the insects' way of life. Based on the observations, for example, very few rats were found in the morning; at night, the *Rattus* sp. damaged the *S. caseolaris* seeds even more.

Environmental factors also influence the presence and population of insect pests, both biotic and abiotic factors. [17] reported that biotic and abiotic factors and the interactions between these factors influenced the population dynamics of insect pests.[18] and [19] reported that abiotic factors such as temperature and humidity influenced the dynamics of pest populations. The temperature influences insect activities, geographic and local distribution, and development. Humidity influences the evaporation of insect body fluids and the selection of suitable habitats.

[20] also reported that environmental factors influenced insect life in their habitat and ecosystem. Furthermore, [21] reported that the presence and population of insect pests were influenced by several factors such as temperature and humidity, cultivation/planting systems, and the presence of natural enemies of insect pests such as parasitoids.

3.3. *Incidence and intensity of pest infestation*

The incidence of pest infestation is the level of damage to plants in the field. Therefore, it can be seen how many plants are attacked by pests, while the intensity of attacks is the level of severity per plant caused by pest infestation. The incidence of pest infestation in each observation fluctuated for each pest species, as presented in Figure 5. For example, the highest incidence of bagworm attack occurred in the first observation (23.42%) and the lowest in the second observation (18.62%). In the third observation, the incidence of *Oecophylla* sp. and *Rattus* sp. were the highest, while the second observation was the lowest (Figure 5). Meanwhile, the incidence of *Sexava* sp. on the second observation was the highest (7.1%), and the lowest incidence was at the first observation (6.26%).

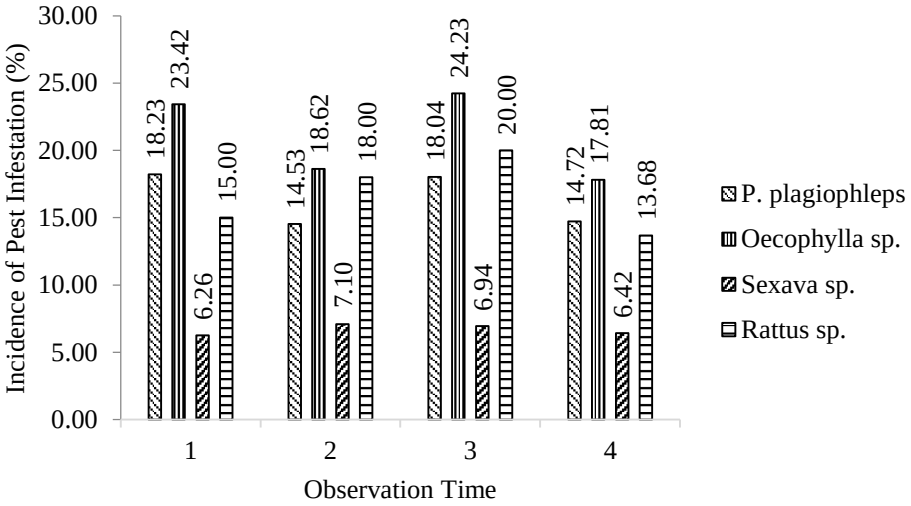

Figure 5. The average incidence of pest infestation at several observation times.

The intensity of pest infestations fluctuated at each observation time (Figure 6). The intensity of *P. plagiophleps* infestation in the third observation was the highest (33.34%), and the lowest (28.33%) were in the first and fourth observations. The *Oecophylla* sp. attack intensity in the third observation was the highest (45%) and the lowest in the fourth observation (40.33%) compared to others. The attack intensity of *Sexava* sp. was higher in the first and third observations (26.67%) than in the second and fourth observations (25%). Meanwhile, the attack intensity of *Rattus* sp. in the first observation was the highest, and it gradually decreased in the subsequent observations.

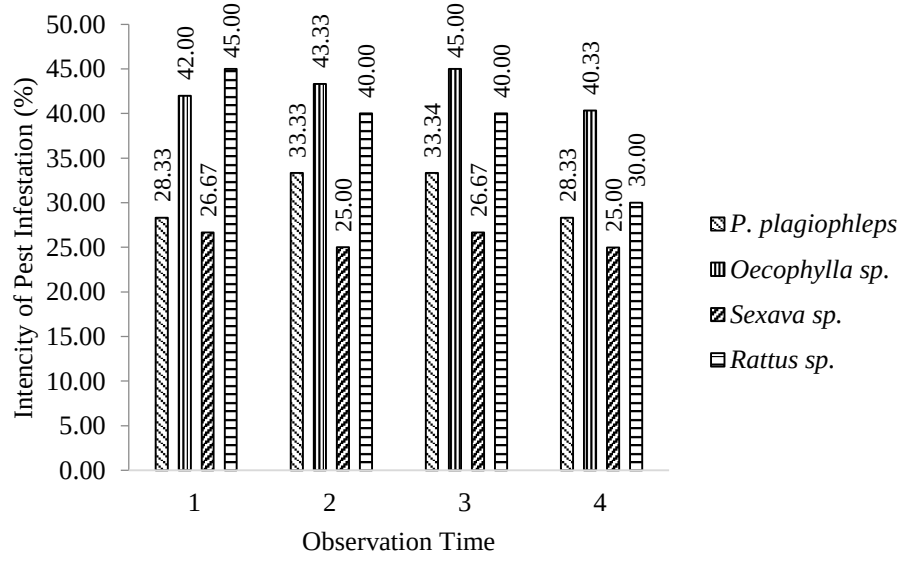

Figure 6. The average intensity of pest infestation at several observation times.

Based on the infestations of the four species of pests, seen from their incidence and intensity, it showed that pest attacks were found starting from 2-week-old seeds, and the pest infestations were still found until the seeds were two months old. [22] reported that mangroves were usually very favored by pests such as insects and crabs, from seeding until the age of 1 year; thus, about 60-70% of mangroves would die before one year due to pest attacks. Likewise, [15] reported that pest infestations were found

in 2-months-old *Rhizopora stylosa* seedlings. This showed that, at the time of seedlings, mangrove plants were also susceptible to pests.

Based on the severity level or pest damage level, all species of pests that attacked *S. caseolaris* seedlings were classified as moderate (Table 4). The average incidence and intensity of *P. plagiophleps* were 16.38% and 30.83%, respectively (Table 4). Based on this average value, the *P. plagiophleps* attack on *S. caseolaris* seedlings was moderate because it had an attacking intensity ranging from 25-50%. The average incidence and intensity of *Oecophylla* sp. amounted to 21.02% and 42.67% (Table 4); based on these mean values, the attack was moderate. The observations also showed that the average incidence and intensity of the *Sexava* sp. attacks, respectively 6.68% and 25.83%, therefore the level of this pest attack was categorized as moderate. Likewise, the rats had an average incidence and intensity attacks of 16.67% and 38.75%, respectively; thus, the attack of rats was also categorized as a moderate attack.

Table 4. Average of incidence and intensity of pest infestation on *S. caseolaris* seedlings.

Pest	Incidence of pest infestation (%)	Intensity of pest infestation (%)	Category of pest infestation
P. plagiophleps	16.38	30.83	moderate damage
Ooecophylla sp.	21.02	42.67	moderate damage
Sexava sp.	6.68	25.83	moderate damage
Rattus sp.	16.67	38.75	moderate damage

Based on the incidence and intensity of pest infestations on *S. caseolaris* seedlings, it showed that the level of attacks of the weaver ants *Oecophylla* sp. and bagworms *P. plagiophleps* were higher than those of *Sexava* sp. and *Rattus* sp. Therefore, both pests species need to be anticipated for the presence and extent of their attacks. As reported by [11], 90% of mangrove seedlings were attacked by *P. plagiophleps* and caused damage to mangrove seedlings which was one of the causes of unsuccessful rehabilitation of mangrove ecosystems.

3.4. Effects of pest infestations on the growth of S. caseolaris seedlings

The correlation analysis test results between the incidence of pest infestations and the height of *S. caseolaris* seedlings showed a negative correlation ($r = -0.27$; $p = 0.0389$). This correlation value indicated that the higher the incidence of pest infestations, the lower the height of seedlings' growth value. Meanwhile, the intensity of pest infestations had no significant effect on height ($r = 0.46$; $p = 0.1333$). Likewise, the incidence and intensity of pest infestations had no significant effect on the increase in the diameter of *S. caseolaris* seedlings, as presented in Table 5.

The results of the correlation analysis test between incidence and intensity of pest infestations showed a positive correlation ($r = 0.58$; $p = 0.0470$), as presented in Table 5. Furthermore, the correlation value showed a strong relationship where the higher the incidence of pest infestations, the higher the intensity.

Table 5. Value of the correlation coefficient between seedlings height, seedlings diameter, incidence and intensity of pest infestations.

Parameter	Height	Diameter	Incidence	Intensity
Height	1.00			
Diameter	0.22ns	1.00		
Incidence	-0.27*	-0.29ns	1.00	
Intensity	0.46ns	-0.32ns	0.58*	1.00

Remarks: * = significant at level α = 0, 05, ns = not significant

The results showed that the pest infestation was able to significantly affect plant growth, especially the height of the seedlings. Furthermore, pest management activities are very important to prevent and

suppress pest infestations to not interfere with plant growth. Moreover, pest management activities are the key to the success of *S. caseolaris* nurseries to improve the restoration of mangrove areas.

4. Conclusion

There are two major groups found that infested *S. caseolaris* seedlings, insect and rodent. These pests began to infest the seedlings at two weeks old. Three species of insect pests were identified, namely *Pteroma plagiophleps* bagworm, *Ooecophylla* sp. ants, and *Sexava* sp. grasshopper. The incidence and severity of *Pteroma plagiophleps*, *Ooecophylla* sp., and *Sexava* sp. infestation were 16.38%; 21.02%; 6.68%; 30.83%; 42.67%, and 25.83%, respectively. For Rodentia pest, the *Rattus* sp. was the only species found to infest the plant, with an incidence of 16.67%. These all pests significantly affected the growth performance of *S. caseolaris* seedlings.

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