Investigation of major harmful crustacean species in the mangrove ecosystem of Ha Tinh province

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Abstract

In the mangrove ecosystem, the major pests can degrade forest quality, even cause forest death. In order to determine the major pests and the level of damage to the mangrove ecosystem, the study conducted an investigation on the "Composition of major pests in the mangrove ecosystem of Ha Tinh province". The methods used in the study include: Investigation of the composition of major pests; identification of species names; identification of major pests; data processing and analysis. The initial results of the study recorded the composition of major pests, according to which there are 18 major pests belonging to 15 genera, 13 families in 7 orders, of which the Lepidoptera is the most diverse with 6 species (accounting for 33.3% of the total number of species), belonging to 6 genera and in 5 families (accounting for 38.5% of the total number of families). The study also identified 5 main harmful crustacean species belonging to 3 genera (Balanus; Metopograpsus; Sphaeroma), 3 families (Balanidae; Grapsidae; Sphaeromatidae) and 3 orders (Cirripedia, Decapoda, Isopoda). On that basis, it forms a scientific basis for preventing and controlling the decline in area and quality of mangrove forests.

Keywords: *Major pest, Mangroves, sphaeroma terebrans Bate, 1886.*
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1. INTRODUCTION

Ha Tinh province has a coastline of more than 137 kilometers from Cua Hoi to Deo Ngang. Along the coast there are 4 large river mouths: Cua Hoi (Hoi mouth area, Nghi Xuan district), Cua Sot (Sot mouth area, Thach Ha district, Loc Ha districts, Ha Tinh city), Cua Nhuong (Nhuong mouth area, Cam Xuyen district) and Cua Khau (Khau mouth area, Ky Anh town). According to the forest inventory data of the Ha Tinh Provincial Forest Protection Department in 2022, the total area of mangrove forests in the province is 687.9 hectares (ha), concentrated in 4 river mouths and mainly planted forests from 1996 - 2005. On August 18th, 2020, the Forest Protection Department of Region II coordinated with the Forest Plant Protection Center of Region IV, Vietnam Forestry Science Institute, Department of Agriculture and Rural Development of Ha Tinh province, Ha Tinh Department of Cultivation and Plant Protection, and the Management Board of the Mangrove Planting Project to conduct surveys, conduct field inspections, and collect samples of pests at various locations at the Mangrove Planting Project (specifically *Sonneratia caseolaris*) in the communes of Thach Mon, Thach Ha, and Ha Tinh City. Ha Tinh with an area of 25 hectares of sour mangroves, initially identified that the crop was attacked by the isopod crustacean *Sphaeroma terebrans* (family Sphaeromatidae, order Isopoda, class Malacostraca) causing the death of mangrove trees.

The ability to spread and the destructive power of harmful organisms is very large and causes serious consequences, this is a major challenge in the protection and development of mangrove forests in our country as well as in the world. In Ha Tinh province, there has not been any research project to determine the composition of harmful organisms on the mangrove ecosystem. Therefore, conducting: Investigation of the composition of the harmful crustacean species is an urgent task to determine the composition of the main harmful species, thereby providing scientific basis for effective prevention and control, stopping the decline in the area and quality of mangrove forests in Ha Tinh province.

2. MATERIALS AND METHODS

Research methods

* Time: Survey and sample collection from March to August 2024.

* Location: Collecting samples of pests according to habitats in 4 mangrove ecosystems: Cua Hoi (Hoi mouth mangrove area), Nghi Xuan district; Cua Sot (Sot mouth mangrove area), Loc Ha district, Thach Ha dictrict and Ha Tinh city; Cua Nhuong (Nhuong mouth mangrove area), Cam Xuyen district; Cua Khau (Khau mouth mangrove area), Ky Anh town. The habitats in the mangrove ecosystem are divided into: Cua Hoi mangrove habitat (SCCH); Cua Sot mangrove habitat (SCCS); Cua Nhuong mangrove

▲ *Figure 1: Study site, survey lines and location of standard plots (OTC)*

habitat (SCCN); Cua Khau mangrove habitat (SCCK). Distribution states of mangrove species: Pure mangrove forest: (*Sonneratia caseolaris* (L.) Engl.): SCCH1; SCCS1; SCCK1; Pure *Sonneratia apetala* Buch-Ham forest: SCCH3; pure *Kandelia obovata* Sheue Liu &Yong forest: SCCS4; SCCN3; SCCK3; mixed forest: *Sonneratia caseolaris – K. Obovata* – Aegiceras corniculatum (L.) Blanco: SCCH2; (*S. caseolaris*) – *K. Obovata – Avicennia marina* (Forsk.) Veirh) – *Rhizophora stylosa* Griff. – *Ae. corniculatum*: SCCS2; SCCN1; *A. marina – K. obovata – Rh. Stylosa*: SCCN2; *K. obovata– A. marina – Rh. Stylosa – Ae. Corniculatum*: SCCK2; Mangrove distributes lagoon banks and sluice gates of aquaculture lagoons (SCBD-CC);

*** Method of investigating the composition of harmful organisms**

Collecting and investigating samples: Pest samples are collected according to the Handbook for monitoring and investigating biodiversity (World Wide Fund for Nature - WWF Indochina program, Hanoi, Vietnam, 2003): Method of studying benthic organisms: Use a 1 m^2 quantitative frame (1m x 1m) to collect samples in shallow intertidal areas and use a bottom rake to collect samples in subtidal flooded areas; Investigating and monitoring insects: Use a net (diameter 30 cm and a mesh bag made of synthetic fibers (dacron). Nylon net, the net bag is conical, the length of the mesh is 50 cm; the surf collects floating organisms 57 micrometer), flapping, sucking, trapping, filtering. Take 2 sets of samples in clean and good conditions, meaning complete appendages such as: Antennae, wings and legs. Use alcohol-resistant, leak-proof containers, such as plastic boxes, glass jars with lids, or plastic jars with screw caps to hold samples. Collecting samples at different stages in the life cycle can aid in the identification of the pest species.

Store samples in 70º alcohol solution, and label locations to bring them back to the laboratory for species composition analysis.

Specimen identification: Pest samples were collected and analyzed under a magnifying glass and Reiife M3T 4K camera trinocular stereomicroscope. Invertebrate identification was based on: Dang Ngoc Thanh, Thai Tran Bai, Pham Van Mien (1980), Thai Tran Ba; Crab group (Brachyura): Dai Ai-Yun and Yang Si-Liang, 1994; Jocelyn Crane, 1975; Bivalvia group: Kent E. Carpenter and Volker H. Niem, 1998; Han Raven, Jap Jan Vermeulen, 2006; Insects: Tiplehorn. C. A., Johnson. N.F., (2005), Chujo M.,(1968), P. Bouchard. et all., (2011), Kurosawa. Y, Hisamatsu. H and Sasaji. H (Eds)., (1985).

*** Mangrove survey methods**

The selected habitats in the mangrove ecosystem represent the factors (tree age, site, afforestation method, forest type, species composition...). Arrange 63 standard plots (OTC-size: 10 m x 10 m) and 8 survey lines with 2 survey lines for each estuarine mangrove system in 4 areas: 16 OTCs on 2 survey lines in Hoi estuary mangrove forest (18°43'56.44"N; 105°45'0.48"E), Nghi Xuan district; 16 OTCs on 2 survey lines in Sot estuary mangrove forest (18°24'32.02"N; 105°54'23.01"E) Loc Ha, Thach Ha districts and Ha Tinh city; 16 OTCs on 2 survey lines in Nhuong estuary mangrove forest (18°14'57.40"N; 106° 5'41.57"E) Cam Xuyen district; 15 OTCs on 2 survey routes

in the RNM Cua Khau (18° 6'39.76"N; 106°18'30.62"E), Ky Anh town. In each mangrove area, surveys were conducted in OTCs according to habitat, each OTC carefully observed all 30 trees in a zigzag pattern to detect and collect harmful organisms and determine the location and level of damage to the mangrove trees. In case the OTC does not have enough 30 trees, continue to expand the OTC to ensure that the survey includes n = 30 trees.

***Method for determining the main harmful species**

Based on TCVN 8928-2013 and TCVN 8927: 2013, to determine the main harmful species, it is necessary to rely on the abundance n'(%), disease incidence P(%), disease severity R(%), loss index, similarity (S), species diversity H'. These indicators are determined according to the following formula:

- Richness: n'(%) = ni/N x 100

In which:

ni: Number of individuals of species i in the study area;

N: number of individuals of all species in the study area

- Disease level: The average value calculated as a percentage of the total number of diseased plants at each disease level at each corresponding disease level compared to the total number of investigated plants and the number of damaged levels is calculated by the following

Formula:

$$R(\%) = \frac{\sum_{i=0}^{4} ni.vi}{N.V} x100$$

In which:

R (%) is the disease level;

ni is the number of damaged plants at level i;

vi is the value of damage level i, with a value from 0-4;

N is the total number of investigated plants;

V is the highest damage level value (V = 4)

Based on the R (%) value, the disease level is divided into the following levels:

No damage: healthy trees have an R (%) value less than 10%

Slight damage has an R (%) value from 10 to 25%

Moderate damage has an R (%) value from 25 to 50%

Severe damage has an R (%) value from 50 to 75%

Very severe damage has an R (%) value greater than 75%

- Disease infected area: The forest area calculated in hectares (ha) affected by the disease, with a level of damage from mild damage or higher (R greater than 10%). The infected area is calculated directly by measuring the area on the disease distribution map or by using the following formula;

S (ha) = n/N x A

In which:

S is the infected area; n is the number of infected standard plots;

N is the total number of OTCs;

A: Area of the survey area

- Damage rate: is the percentage of diseased samples over the total number of surveyed samples

P (%) = n/N x 100

In which:

P (%) is the damage rate; n is the number of damaged trees;

N is the total number of surveyed trees

- Disease index: Calculated by the product of the disease rate and the disease level

DI = P (%) x R (%)

In which:

DI is the loss index; P (%) is the damage rate; R (damage level)

- Species similarity:

+ Use the Sorensen species similarity index (Krebc, 1999).

$$S = \frac{2C}{A+B} x \; A\frac{2C}{A+B} x \; A$$

In which:

A is the number of species in mangrove area A,

B is the number of species in mangrove area B and C is the number of common species between the 2 compared mangroves;

S is the Sorensen species similarity index.

+ Using the biodiversity index or Shannon index (H'):

$$H' = -\sum_{i=1}^{n} (ni/N) \log 2 (ni/N)$$

In which:

H' is the species diversity index or Shannon-Wiener index; ni is the number of individuals of the i-th species and N is the total number of individuals of all species at the study location.

**** Data processing and analysis:*** Data are calculated using statistical software SPSS V.20 and Microsoft office Excell 2019.

3. RESULTS AND DISCUSSION

**** Pest species composition structure***

Pest species composition structure was collected at 4 ecosystems: Hoi mouth mangrove ecosystem, Sot mouth mangrove ecosystem, Nhuong mouth mangrove ecosystem and Khau mouth mangrove ecosystem. Accordingly, 18 species of pests belonging to 15 genera, 13 families in 7 orders were recorded (Table 1). Among the collected pests, the Lepidoptera order is the most diverse with 6 species

(accounting for 33.3% of the total species collected during the survey), belonging to 6 genera and 5 families (accounting for 38.5% of the total families). When arranged in decreasing order of the number of species, genera and families belonging to the orders, there is a change in the position of the Lepidoptera order, the Orthoptera order and the Hemiptera order. Specifically:

- The order in decreasing order of families is: Lepidoptera: 5 families (accounting for 38.5%), followed by Orthoptera and Hemiptera (both have 2 families, 15.4%), then the remaining 4 orders (1 family, 7.7%): Ostreida; Cirripedia; Decapoda; Isopoda.

- The order of arrangement of the orders in decreasing number of species: Lepidoptera with 6 species, accounting for 33.3%, followed by Orthoptera and Decapoda with 3 species, accounting for 18.8%, then Hemiptera and Ostreida with 2 species, accounting for 12.5%, finally Isopoda, Cirripedia, with 1 species, accounting for 6.3%.

Species composition of pests in mangrove ecosystems. Of the total 18 species collected in the study area, the Sot mouth mangrove ecosystem recorded 15 species of pests, accounting for 83.3% of the total species, followed by the Hoi mouth mangrove ecosystem with 13 species accounting for 72.2%; Nhuong mouth mangrove ecosystem and Khau mouth mangrove ecosystem recorded 11 species, accounting for 61.1%. According to O.K. Remadevi et al. (2019), 3 species of caterpillars including Brachycyttarus sp., Pteroma plagiophleps, Metisa sp. were found to be the main pests on Rhizophora mucronata trees along the West Indian coast and only focused on the group of pests in the insect group. According to Pham Quang Thu and colleagues (2006, 2008), there are 16 species of pests, 12 species of worms and 4 species of diseases on mangrove trees in the Can Gio mangrove ecosystem. Of these, 3 main harmful species are the white worm that causes stem and branch tumors, Xyleutes sp, the brown stem borer Zeuzera conferta and the hair clipper Trirachys bilobulartus, which specializes in borers, causing medium damage.

The research results did not show any difference in the composition of harmful organisms in the 4 mangrove ecosystems, the similarity index of harmful organisms was high in the mangrove ecosystems including: Hoi mouth mangrove ecosystem– Sot mouth mangrove ecosystem: S = 0.80; Sot mouth mangrove ecosystem – Nhuong mouth mangrove ecosystem: S = 0.79 and the lowest similarity index was Sot mouth mangrove ecosystem - Khau mouth mangrove ecosystem: S = 0.71 with lower similarity. The biodiversity index of harmful organisms in the studied mangrove ecosystems was low, the highest H' index was in Nhuong mouth mangrove ecosystem: H' = 1.92; Khau mouth mangrove ecosystem: H' = 1.90; Hoi mouth mangrove ecosystem: H' = 1.41; and the lowest was in Sot mouth mangrove ecosystem H' = 1.3; The SCBD-CC habitat has a high biodiversity index H' = 2.51, this is a habitat with an intersection and transition between the mangrove ecosystem and the agricultural ecosystem. Therefore, harmful species are found only in the SCBD-CC habitat (*Spodoptera litura* F,. 1775; *Halyomorpha halys* Stal, 1855; *Actratomorpha lata* Motschulsky, 1886; *Pseudoxya diminuta* Walker, 1871) but not in other typical habitats of the mangrove ecosystem; 5/18 to 9/18 species have a wide distribution, the level of damage is more common. The number of species tends to increase in habitats with a more diverse structure of mangrove species. The SCBD-CC habitat has the highest number of species (16 species). SCCN1; SCCS4 has the least number of species (5 species). Analysis of differences in the number of harmful species according to ecosystems by Two-Way ANOVA showed that the number of species did not have a significant difference between ecosystems ($p = 0.575 > 0.05$) but there were differences according to habitats ($p < 0.05$).

Table 1: Structure of species composition of harmful organisms

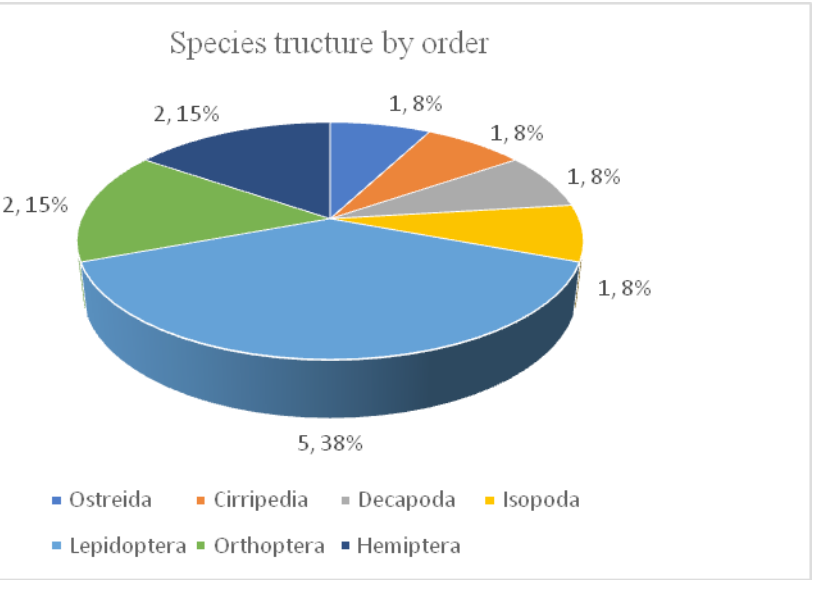
No	Scientific name	Vietnamese name	Family		Genus		Species	
			Quantity	Percentage (%)	Quantity	Percentage (%)	Quantity	Percentage (%)
1	Ostreida	Bộ hàu	1	7,7	1	6,7	2	11,1
2	Cirripedia	Bộ giáp xác chân tơ	1	7,7	1	6,7	1	5,6
3	Decapoda	Bộ giáp xác mười chân	1	7,7	1	6,7	3	16,7
4	Isopoda	Bộ chân đều	1	7,7	1	6,7	1	5,6
5	Lepidoptera	Bộ cánh vảy	5	38,5	6	40,0	6	33,3
6	Orthoptera	Bộ cánh thẳng	2	15,4	3	20,0	3	16,7
7	Hemiptera	Bộ cánh nửa	2	15,4	2	13,3	2	11,1
Total			**13**	**100**	**15**	**100**	**18**	100

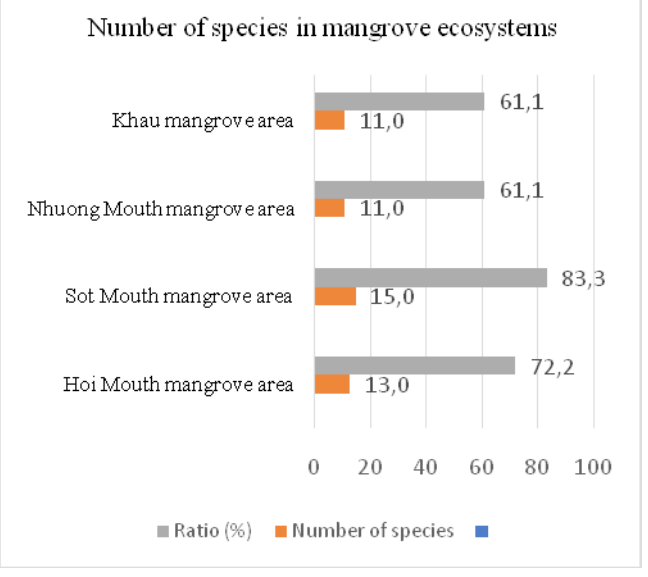
*** Main species composition of harmful organisms**

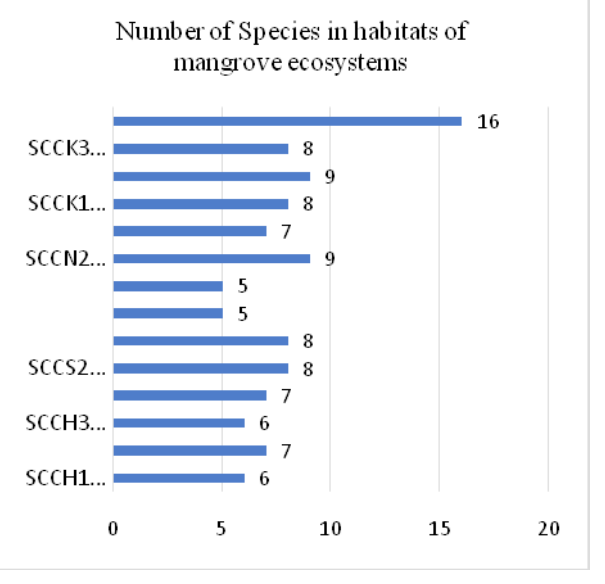
The research results show that the richness and ability to attack mangrove trees are concentrated in a number of species: There are 6 species of crustaceans that attack the stems and roots (accounting for 33.3%), using the stems and roots as food (*Metopograpsus latifrons* White, 1847. n' = 6.63%; Metopograpsus quadridentatus Stimpson, 1858. n' = 1.81%; *Metopograpsus thukuhar* Owen, 1839. n' = 1.34%, or the stems as a substrate (*Ostrea lurida* Carpenter, 1864. n' = 3.73%; *Ostrea edulis* L., 1758. n' = 9.72%; *Balanus amphitrite* Darwin, 1854. n' = 37.83%;) and habitat (*Sphaeroma terebrans* Bate,1866. n' = 34.23%), 3 species attack the stem and leaves (accounting for 16.7%) using the stem and leaves as food, 11 species attack the leaves (accounting for 61.1%) accounting for more than half of the total species and mainly use the leaves as food, which also includes species in the pest stage of the order Lepidoptera. The group of leaf-eating pests will be able to change the structure and function of the mangrove forest, affecting the growth rate of the mangrove forest and the survival rate of the tree.

Elisha Mrabu Jenoh et al 2016, determined the level of insect infestation in 2 mangrove areas (Gazi and Mida) along the entire Kenyan coast. Two wood-eating insect species were identified: a Metarbelid moth (Lepidoptera, Cossoidea) of an undescribed genus and the bark beetle Bottegia rubra (Cerambycidae, Lamiinae). B. rubra occurred at low densities in Gazi and high densities in Mida, Kilifi and Ngomeni, with densities decreasing towards the north. Insect infestation levels reached 18% in Gazi and 25% in Mida.

Assessing the ability to cause damage from light to death, the group of organisms that cause damage by boring into the trunk, base (*Sphaeroma terebrans*, wingless Sphaeroma, Amuridae, Rhizophora) and breathing roots (*Sphaeroma terebrans*, wingless Sphaeroma, Rhizophora) are the most dangerous, because they often kill the whole tree or all parts of the tree from the damaged location. The most dangerous representative of this group is the isopod crustacean Sphaeroma terebrans Bate, 1866. n' = 34.23%, high abundance, found in all mangrove habitats, boring into tree trunks to make nests and causing damage to all mangrove species at the position of the tree trunk near the ground, causing the tree to die slowly, but the most favorite are Sphaeroma terebrans, wingless Sphaeroma and Rhizophora. Some groups of the Lepidoptera also have a stem-boring stage, this group often causes damage at positions higher than the tidal range, at small breaks and is less dangerous. The group of plant species that cause damage to the outer bark







▲ *Figure 3: Number of harmful species in mangrove ecosystems and mangrove habitats*

Table 2: Pest species composition, abundance, damaged parts and damage hierarchy

No.	Scientific name	Hoi mouth area *(n'%)*	Sot mouth area *(n'%)*	Nhuong mouth area *(n'%)*	Khau mouth area *(n'%)*	Gate of aquaculture *(n'%)*	Damaged parts	Damage
	MOLLUSCA							
	BIVALVIA							
	OSTREIDA							
	Ostreidae							
	Ostrea							
1	*Ostrea lurida* Carpenter, 1864	*3,5*	*1,1*	1,1	*4,7*	*8,3*	Stem	Mildly harmful
2	*Ostrea edulis* L., 1758	*16,4*	*9,0*	8,0	*5,4*	*9,7*	Stem, roots	Mildly harmful
	ARTHROPODA							
	THEOCOSTRACA							
	CIRRIPEDIA							
	Balanidae							
	Balanus							
3	*Balanus amphitrite* Darwin, 1854	*30,4*	*27,9*	43,5	*51,6*	*35,7*	Stem, roots, leaf	Heavily/ very heavily harmful
	MALACOSTRACA							
	DECAPODA							
	Grapsidae							
	Metopograpsus							
4	*Metopograpsus latifrons* White, 1847	5,7	*6,6*	8,1	*7,8*	*5,0*	Stem, roots	Mildly harmful
5	*Metopograpsus*	*3,2*	*4,4*	0,9	*0,7*		Stem, roots	Mildly harmful
6	*Metopograpsus thukuhar* Owen, 1839	*3,8*	*0,2*	1,2	1,4		Stem, roots	Mildly harmful
	ISOPODA							
	Sphaeromatidae							
	Sphaeroma							
7	*Sphaeroma terebrans* Bate,1866	*35,4*	*48,9*	34,2	*27,1*	*25,7*	Stem, roots	Heavily/ very heavily harmful
	INSECTA							
	LEPIDOPTERA							
	Gracillariidae							
	Phyllocnistis							

No.	Scientific name	Hoi mouth area *(n'%)*	Sot mouth area *(n'%)*	Nhuong mouth area *(n'%)*	Khau mouth area *(n'%)*	Gate of aquaculture *(n'%)*	Damaged parts	Damage
8	*Phyllocnistis citrella* Stainton, 1856					*0,9*	Leaf	Mildly harmful
	Noctuide							
	Agrotis							
9	*Agrotis ipsilon* Hufnagel, 1776	*0,6*		0,9		*2,1*	Leaf	Mildly harmful
	Spodoptera							
10	*Spodoptera litura F,.* 1775					*2,4*	Leaf	Mildly harmful
	Hyblaeidae							
	Hyplaea							
11	*Hyplaea puera* Cramer, 1777		*0,8*		*0,3*	*2,4*	Leaf	Mildly harmful
	Cossidae							
	Zeuzare							
12	*Zeuzare conferta* Walker, 1856		*0,8*	1,1	*0,7*	*0,9*	Stem	Mildly harmful
	Lasiocampidae							
	Trabala							
13	*Trabala vishnou* Lefèbvre, 1827	*0,5*	*0,3*	1,0	*0,3*	*1,2*	Leaf	Mildly harmful
	Orthoptera							
	Acrididae							
	Oxya							
14	*Oxya velox* F., 1787					*0,9*	Leaf	Mildly harmful
	Pseudoxya							
15	*Pseudoxya diminuta* Walker, 1871					*1,8*	Leaf	Mildly harmful
	Pyrgomorphidae							
	Actratomorpha							
16	*Actratomorpha lata* Motschulsky, 1886					*1,5*	Leaf	Mildly harmful
	Hemiptera							
	Pentatomidae							
	Halyomorpha							
17	*Halyomorpha halys* Stal, 1855					*1,2*	Stem, leaf	Mildly harmful
	Erthesina							
18	*Erthesina fullo* Thunberg, 1783					*0,6*	Stem, leaf	Mildly harmful
	Total	**99,5**	**100,0**	**100,0**	**100,0**	**100,0**		

Table 3: Analytical indicators to evaluate the rate, level and Disease index

Locality	Hectare (ha)	R (%)	P (%)	S (ha)	DI	Level of harm	Treatment
Hoi mouth area	53,9	32,8	13,4	33,7	4,4	Severity	Prevention-control
Sot mouth area	253,78	40,2	14,5		4,9	Severity	Prevention-control
Nhuong mouth area	59,54	17,1	9,6	29,8	1,6	Moderately	Disease prevention
Khau mouth area	320,75	12,7	7,7		1	Moderately	Disease prevention
Total	**687,79**			**387**			

greatly affects the growth of mature trees and causes death to seedlings and regenerated trees: representatives of this group are the barnacle (*Balanus amphitrite* Darwin, 1854.) with high average abundance: n' = 37.83%; large bivalve oyster (*Ostrea lurida* Carpenter, 1864) and rock oyster (*Ostrea edulis* L., 1758); the clam (*Metopograpsus latifrons* White, 1847) with abundance n' = 6.63% causes damage to the basal stem position, however, they often cause damage to young trees, newly planted mangrove trees and when the environment is scarce in food, they will attack the trees.

Disease incidence P (%) (damaged): The rate of trees damaged by crustaceans is high in Sot mouth mangrove area (P = 14.5%), Hoi mouth mangrove area (P = 13.4%) and the rate of damaged trees is low in Nhuong mouth mangrove area (P = 9.6%), Khau mouth mangrove area (P = 7.7%).

Disease incidence R (%) (damaged): Indicates the number of levels of damage and the total number of damaged trees, Sot mouth mangrove area has the most severe damage: R = 40.2%; Hoi mouth mangrove area mangrove: R = 32.8% and the damage level is lighter than Nhuong mouth mangrove area: R = 7.1% and Khau mouth mangrove area: R = 2.7%

Disease infected area S (hactare) and Disease index (DI): The highest damaged area is Sot mouth mangrove area: S = 142.8/253.78 ha with severe damage level (DI = 4.9); Khau mouth mangrove area is damaged S = 80.7/320.75 hactares with moderate damage level (DI = 1); Hoi mouth mangrove area has damaged area S = 33.7/53.9 hactares with severe damage level (DI = 4.4); Nhuong mouth mangrove area has damaged area S = 29.8/59.54 hactares with moderate damage level (DI = 1.6).

Analysis of the indicators shows that 5 crustacean species are the main pests of mangroves with a wide ecological spectrum, high abundance and distribution in preferred habitats (Table 4).

From the above results, urgent measures need to be taken to apply to the mangrove systems of Hoi mouth mangrove area, Sotmouth mangrove area, Nhuong mouth mangrove area, Khau mouth mangrove area, which are to prevent and control harmful organisms, including:

Table 4: Major crustacean species causing damage to typical habitats of mangrove ecosystems

No.	Scientific name	Hoi	Sot Mouth area (n'%)	Nhuong Mouth area (n'%)	Khau Mouth area (n'%)	Damaged part	Preferred habitas
1	*Ostrea lurida* Carpenter, 1864	*3,5*	*1,1*	1,1	*4,7*	Stem	SCCN2; SCCS2; SCCN1
2	*Ostrea edulis* L., 1758	*16,4*	*9,0*	8,0	*5,4*	Stem, roots	SCCN2; SCCS2; SCCN1
3	*Balanus amphitrite* Darwin, 1854	*30,4*	*27,9*	43,5	*51,6*	Stem, roots, leaf	SCCH3; SCCS4; SCCN3; SCCK3
4	*Metopograpsus latifrons* White, 1847	*5,7*	*6,6*	8,1	*7,8*	Stem, roots	SCCH1; SCCS1; SCCCK1; SCCS4; SCCN3; SCCK3
5	*Sphaeroma terebrans* Bate, 1866	*35,4*	*48,9*	34,2	*27,1*	Stem, roots	SCCH3; SCCS4; SCCN3; SCCK3

Testing silvicultural solutions: Selecting seedling species for new planting and restoration of mangrove, silvicultural techniques applied to mangrove trees, especially studies on biological and ecological characteristics of mangrove trees adapted to soil conditions, hydro-climate in the coastal area of Ha Tinh province.

Testing to evaluate the effectiveness of pest control (especially harmful crustaceans) by the following measures: Using bait poles (using poles for pests to cling to); physical barriers (layers of material wrapped around the body to protect the body); methods of trapping pests in the tidal environment of mangrove (using boxes, trap nets); Measures to repel and limit the attachment of harmful organisms by biological products, biological measures for mangrove areas being attacked by harmful organisms.

4. CONCLUSION

The main species composition of pests collected in the study area included 18 species of pests belonging to 15 genera, 13 families in 7 orders. Among the collected pests, the Lepidoptera was the most diverse with 6 species (accounting for 33.3% of the total species collected during the survey), belonging to 6 genera and 5 families (accounting for 38.5% of the total families). When arranged in descending order of species, genera and families in the orders, the results were Lepidoptera, Orthoptera and Hemiptera. The rate of trees damaged by pests is high in Sot mouth mangrove forest (P = 14.5%), Hoi mouth mangrove forest (P = 13.4%), the rate of damaged trees is low in Nhuong mouth mangrove area (P = 9.6%), Khau mouth mangrove area (P = 7.7%), the level of damage to Sot mouth mangrove area and Hoi mouth mangrove area is more and more serious than Nhuong mouth mangrove area and Khau mouth mangrove area. The area damaged by pests accounts for more than 50% of the mangrove area of Ha Tinh province, in which the level of damage is severe (DI = 4.9 Sot mouth mangrove area; DI = 4.4 Hoi mouth mangrove area and moderate damage in the two ecosystems of Nhuong mouth area and Khau mouth area. The study also identified 5 main species of harmful crustaceans belonging to 3 genera (Balanus; Metopograpsus; Sphaeroma), 3 families (Balanidae; Grapsidae; Sphaeromatidae) and 3 orders (Cirripedia, Decapoda, Isopoda). Therefore, urgent measures need to be applied to the Hoi and Sot mangrove ecosystems to prevent and control harmful organisms; Nhuong and Khau mangroves need to have measures to prevent harmful organisms from continuing to harm mangrove trees. Due to the short research time, this study has not yet studied the nutritional and reproductive habits of the 5 main species of crustaceans that are harmful to mangrove trees; it is necessary to continue to study these biological characteristics as a scientific basis for the prevention and control of the main species of harmful crustaceans ▪

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