Vol.11 December 2017
Print ISSN 2244-4432 • Online ISSN 2984-7125
DOI: https://doi.org/10.59120/drj.v11i2.396

Disease Infestation and Insect Damage of Pygmy Trees in Mount Hamiguitan Range Wildlife Sanctuary

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ABSTRACT

The present study examined the disease infestation of pygmy trees in the pygmy field of Mount Hamiguitan Range Wildlife Sanctuary. It aimed to determine the degree of damage in pygmy tree species, describe the diseases, and determine the plant parts they commonly affect. A total of 10 stations were established in the study area, and sampling was conducted through the transect walking method. Three replicates of tree species in each station were examined. Collected samples were brought to the laboratory for further identification of the possible causes, vectors, and causative agents of the diseases.The result showed that among the 10 stations, bacteria, fungi, and insects were common agents of diseases. Five stations were infected by fungal diseases (stations 1-2, 5, 8, and 10), bacteria-contaminated station 6, and insect pests infected the other three stations—stations 1, 4, 6, and 9 experienced major insect infestation. Among the stations, the damage was severe at station 1, followed by stations 4, 6, and 9, while station 7 experienced the least harm. Symptoms of diseases include leaf scratches along the leaf blades, black spots, red lesions of leaves, and wilting. This study's result points to leaves commonly affected by diseases. One of the most common symptoms was leaf scratches along the leaf blades of stunted trees, which was damage caused by the pests. Fungi were dominant in causing internal infections in plant parts of the trees, leading to disease infestation in the pygmy forest in Mount Hamiguitan Range Wildlife Sanctuary.

Keywords: Disease, Mount Hamiguitan, pest, pygmy forest, wild sanctuary

INTRODUCTION

Forest ecosystems function as complex systems where microorganisms, soil, and plant cover work together to purify air and water, regulate climate, and recycle nutrients and waste (Krieger, 2001). Beyond their ecological roles, forests provide essential resources such as timber and food while offering a wide range of ecosystem services (Boyd et al., 2013). However, forests face increasing threats, particularly from bark beetles, which target trees weakened by drought, fire, overcrowding, and disease, leading to significant mortality rates, as observed in the Sierra Nevada (Ferrell, 1996). The impact of these pests is further exacerbated by climate change and globalization, with evidence from North America and Europe indicating that the challenges posed by invasive species and shifting environmental conditions are intensifying (Smith and Webber, 2017).

2004 Republic Act 9303 established approximately 6,954 ha of Mt. Hamiguitan in Davao Oriental as a Protected Area and Wildlife Sanctuary (Supreme Court E-Library, 2004). It is the only protected area in the Philippines featuring a pygmy forest, making it a priority site for conservation and protection (Polizon and Amoroso, 2014). Being home to numerous endemics and endangered, rare, and economically significant plant species, the mountain's pygmy forest is among the rarest in the world, enhancing its scenic beauty and serving as a critical wildlife habitat. Due to its ecological significance and uniqueness, Mt. Hamiguitan has high potential as a prime tourist destination (Amoroso et al., 2009). Since the pygmy forest is its main attraction, protecting and sustaining it is crucial to preserving its biodiversity and ensuring its natural treasures remain intact for future generations.

In this study, the diseases of pygmy trees were examined. So far, there have already been previous studies on pygmy trees in Mt. Hamiguitan, but they were focused on studying the richness and abundance of the tree species in the pygmy field. Surveying disease infestations could provide additional input to local policy to improve the area's management. The main objective of this study was to examine the disease infestation of pygmy trees in Mt. Hamiguitan Range Wildlife Sanctuary. Generally, this study contributes to the knowledge of the disease infestation of pygmy trees. Through this study, we can determine standard plant parts affected by diseases and the types of diseases in pygmy trees. Moreover, this study aimed to generate baseline data on the current health of pygmy trees to gauge the impact of human-induced activities or tourism in the future.

MATERIALS AND METHODS

Study area

The study was conducted at the Pygmy Forest of Mt. Hamiguitan Range Wildlife Sanctuary, commonly known as the bonsai field. It is geographically located at 060 43 '24 north latitude and 1260 11 '11" east longitude. It is situated from 1,136-1,322m above sea level. This forest type occupies approximately 1,000 ha of the scenic beauty of the broad Kapatagan Valley of bonsai trees and many other species in the higher altitude of Mt. Hamiguitan Range. It is bounded by three municipalities: Mati City, San Isidro, and Governor Generoso, Province of Davao Oriental.

Data collection

A transect walking was employed in the study. A total of 10 stations were established every 100 m along the trail of more than 1000 ha of pygmy forest. In every station, three replicates were examined from stems and leaves to determine whether they had the presence of diseases. A GPS was used to determine the geographical location of the study area. Infected parts of pygmy trees were photographed to support details of identification. Samples of infected parts of pygmy trees were collected from the study area. The collected samples were placed in a sterile plastic bag or Ziplock to avoid contamination from other microorganisms. The mobile and stationing organisms, their body parts, plant parts (leaf or flowers), and scraped samples (stem or root) of bonsai trees were also placed in containers and labeled. They were brought to the microbiology laboratory of Davao Oriental State College of Science and Technology for closer examination.

Laboratory examination

Methods for examination of collected samples were performed at the Microbiology Laboratory of Davao Oriental State College of Science and Technology. A microscope was used to do a detailed examination of collected plant parts and samples. Taxonomic classification of observed organisms such as bacteria and fungi was classified at the family level. Reference materials published online (e.g., the websites of the International Union of Forest Research Organization, American Institute of Biological Sciences, and Centre for Biological Information Technology) and in print were used as guides in identifying diseases and gathering some other information. This study was conducted in April 2017 and lasted three days of fieldwork. The laboratory examination of collected samples took two days.

RESULTS AND DISCUSSION

Degree of damage and possible causes of disease infestation of pygmy trees Figures 1 – 5 show the different pygmy tree species examined for disease infestations in Mt. Hamiguitan range. Most tree species were infected with a disease caused mainly by fungi and insect infestations. Of all the pygmy tree species, the most infected was the Dacrydium elatum species, locally known as the cedar tree (Figure 1). Based on the examinations, the stems and leaves were all infected.

The plants' leaves were the most infected of all the plant parts examined in all the stations. Insects and fungi mainly cause infections. From the 10 stations established, the stations 1 (Figure 1), 4 (Figure 3), 6 (Figure 4), and 9 (Figure 5) experienced significant insect infestation on leaves. Among the stations, the degree of damage is highly severe at station 1 (Figure 1), followed by stations 4 (Figure 3), 6 (Figure 4) and 9 (Figure 5). The station that experienced the least damage was observed in station 7 (Figure 5B).

The degree of damage was highly severe in station 1, which was examined from a beech bark disease caused by fungi. It is situated near the streams, with a muddy substrate, and under a dense cover of trees. It is located near camp 3, which was closer to human anthropogenic activities. However, due to its high humidity, fungal diseases can easily develop. Hulcr et al. (2008) stated that the activity of naturally occurring pathogens may be influenced by relative humidity and that having greater humidity in the forests promotes more beetle success and abundance.

Station 7, which is observed with the least damage, was examined from a sandy-rocky substrate and warm temperature (Figure 5B). It is located at a higher location on a slope of the trail in the study area, which is more exposed to wind. According to Wood et al. (2010), the movement of air currents can occur on a large scale, over long distances, and with great strength, and can be of great importance in the migration and dispersal of forest insect pests. In that case, pest dispersal due to the high accuracy of wind influences a lower damage rate to plant species in station 7. He also explained that no one knows where the moths came from or where they went.' Aerial migrations of pests can occur on an enormous scale, and wind is the primary factor determining how far they can travel and in what direction.

Based on the observation, the leaf parts of the pygmy plants get more disease infestation. Although disease infestation was observed in the stems, leaf damage was more obvious. The disease was caused by fungal incursions, which could be due to the moist, cold temperature of the area. Another reason could be wind and splashing rain that carries spores of the pathogen around, making it land on susceptible plant tissue, which could eventually spread the disease throughout the canopy. Barlow (2007) explained that susceptible bonsai plants are sensitive to pathogen attacks that could result in harsh and harmful diseases. Though pests such as insects are host-specific, and although plants can be resistant to one pathogen, they can also be susceptible to another.

Several insects can colonize vulnerable but still living trees and kill them through their feeding. Among them are particular species of bark beetles. In this course, old, weak, or ill trees or trees under stress are eliminated. At the same time, however, this benefits the overall health and resistance of the forest (Wermelinger and Duelli, 2003). According to the US Department of Agriculture (2013), whenever a new insect or disease becomes established on plants, the extent of impact is determined by various factors, including the virulence of the pathogen and the type of damage from an insect. The seriousness and degree of the damage can also be caused by other traits of the pest, encompassing its host specificity, its generative and spreading capacity, and the attributes of the host tree.

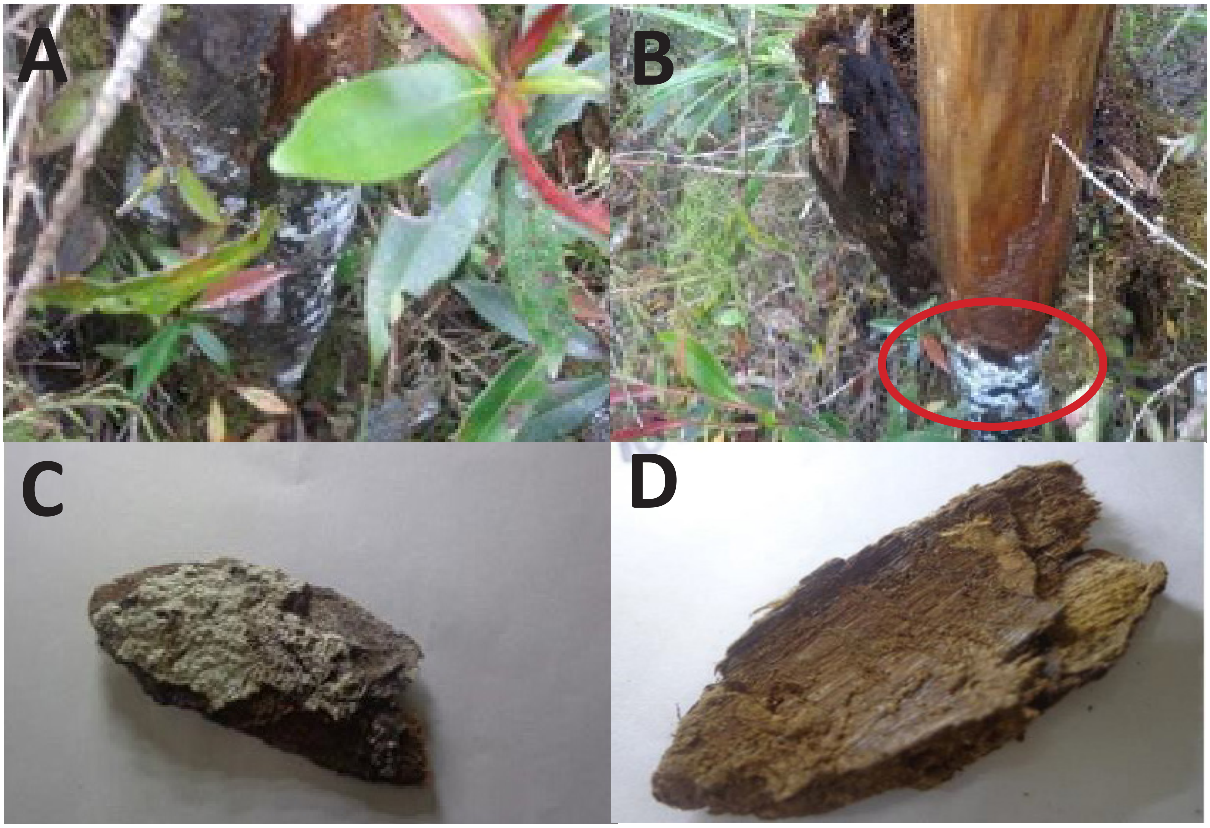

Figure 1. Infected plant parts in station 1.
Species Name: *Dacrydium elatum* (A. B, C, D)
Local Name: Cedar (A. B, C, D)
Disease: Beech Bark Disease

Beech bark disease

This disease results from invading a fungus into bark infested with beech scale, *Cryptococcus fagisuga*. At least two species of the Nectria fungus may be associated with the disease (Vance, 1995). Heyd (2005) explained that when several beech scales feed relative to each other, clusters of vascular cells in the tree collapse and cease functioning. This cell shrinkage causes fissures in the bark surface. The disease cycle begins when the fungal pathogens then infect these wounds, and, once established, hyphae of the fungus spread into and around the vascular tissues beneath the bark, eventually killing them. He added that typical symptoms of infestation and/or infection include canker formation, canopy thinning, limb dieback/breakage, and/or tree death. Trees infected with beech bark disease usually succumb and die within 5 to 10 years after initial infestations of beech scale, depending on site quality and the level of other environmental stresses.

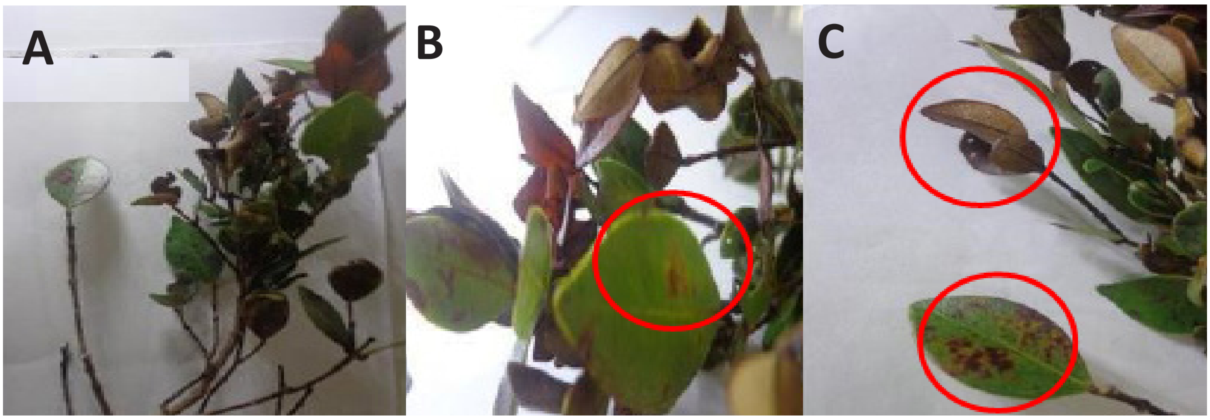

Figure 2. Infected plant parts in station 2.
Species Name: *Syzygium brevistylum* (A. B, C)
Local Name: Sagemsem (A. B, C)
Disease: Fire Blights

Beech bark disease

This disease results from invading a fungus into bark infested with beech scale, *Cryptococcus fagisuga*. At least two species of the Nectria fungus may be associated with the disease (Vance, 1995). Heyd (2005) explained that when several beech scales feed relative to each other, clusters of vascular cells in the tree collapse and cease functioning. This cell shrinkage causes fissures in the bark surface. The disease cycle begins when the fungal pathogens then infect these wounds, and, once established, hyphae of the fungus spread into and around the vascular tissues beneath the bark, eventually killing them. He added that typical symptoms of infestation and/or infection include canker formation, canopy thinning, limb dieback/breakage, and/or tree death. Trees infected with beech bark disease usually succumb and die within 5 to 10 years after initial infestations of beech scale, depending on site quality and the level of other environmental stresses.

Leaf mines

Symptoms involve drying out or early defoliation and mottled meandering around the affected leaf. This is caused by leafminers such as tortrix roller moths. Leafminers are insects that develop and live within the leaves of plants. Typically, the leaves are injured by the insect feeding on the soft interior tissues so that only the papery, thin covering of the exterior leaf surfaces remains. Many insects are leafminers, including sure flies, wasps, spinachs, and beetles. These insects' immature (larval) stage produces the distinctive mines (Wyatt, 2003).

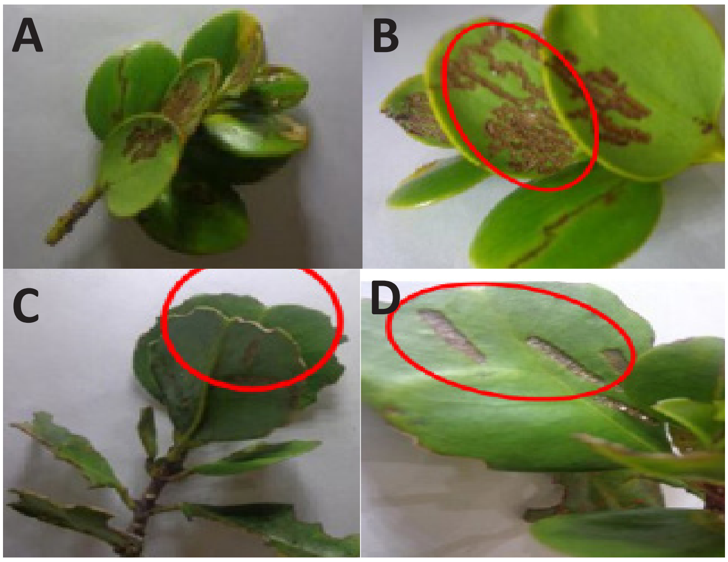

Figure 3. Infected plant parts in stations 3 and 4.
Species Name: *Agathis philippinensis* (A, B) and *Syzygium* sp. (C, D)
Local Name: Almasiga (A, B) and Lumboy-Lumboy (C, D)
Disease: Leaf Mines and Leaf Scratch

Leaf scratches

Leaf Scratch Bite-shaped damage around shrub leaf edges makes a scalloped pattern. According to Jang et al. (2009), the caterpillar (or larva) does the damage. The young caterpillars radiate from the egg masses, stripping the leaf surface and eating the leaf between the veins. Later, they become solitary and eat all the leaves, including the petioles. Primarily, they feed at night. The cream to golden-brown egg masses (4-7 mm diameter) are covered with hairy scales from the tip of the female's abdomen. After hatching, the caterpillars stay together. They vary in color: pale green at first, then dark green to brown. There are bright yellow stripes along the top of the body. The caterpillars molt five times during 15-30 days, depending

Figure 4. Infected plant parts in stations 5 and 6.
Species Name: *Leptospermum flavescens* (A, B) and *Lithocarpus* sp. (C, D)
Local Name: Tinikaran (A, B) and Ulayan (C, D)
Disease: Verticilium Wilt and Bacterial Leaf Scorch

on the temperature. Afterward, they pupate in the soil for 7-10 days. If the eggs are laid on an inedible plant, the young caterpillars drop silken threads and are carried in the wind to other potential hosts. The moth's body is grey-brown, 15-20 mm long, with a 30-40 mm wingspan.

Verticillium wilt

Leaves on one side of the tree wilt and curl, dry up, turn red or yellow between the veins, or appear scorched. Branches stunted growth and dieback. Verticillium has also been observed entering roots directly, but these infections rarely reach the vascular system, especially those that enter through root hairs.

Itioka and Yamauti (2004) stated that once the pathogen enters the host, it goes to the vascular system, specifically the xylem. The fungi can spread as hyphae through the plant but can also spread as spores. Verticillium produces conidia on conidiophores, and once conidia are released in the xylem, they can quickly colonize the plant. So, the spread throughout the plant can occur very soon.

Sometimes, the flow of conidia will be stopped by cross sections of the xylem, and here, the conidia will spawn. The fungal hyphae can overcome the barrier and produce more conidia on the other side. A heavily infected plant can succumb to the disease and die (McCullough et al., 2001).

Bacterial Leaf Scorch

Infection is perennial; bacteria can survive yearly in the host vascular system. Bacteria interfere with water transport in the xylem. Therefore, the symptoms closely resemble those of drought and other vascular diseases. Leaf margins turn red or yellow; leaves will wilt and turn brown, especially during the summer months. A red or yellow band often separates brown from green tissue.

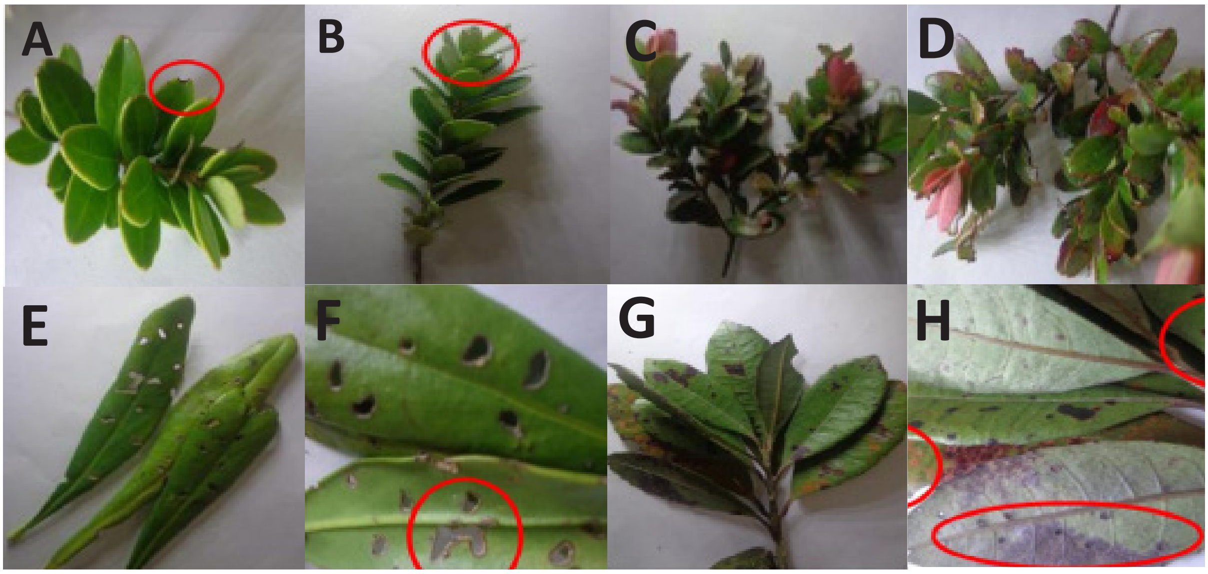

Figure 5. Infected plant parts in stations 7, 8, 9, 10.
Species Name: *Ilex* sp. (A, B), *Vaccinium* sp. (C, D), *Scaebola* sp. (E, F), and *Ternstroemia* sp. (G, H)Local Name: Tagibinlod (A, B), Wilberry Tree (C, D), Unidentified (E, F), and Unidentified (G, H Disease: Leaf scratch (A, B), Septoria leaf spot (C, D), Shot hole (E, F), and Anthracnose (G, H)

Older leaves are usually scorched first, with symptoms progressing towards shoot tips. Scorched leaves are retained on the tree into the fall. Trees may have delayed bud break, reduced growth, stunting, branch dieback, and death. Symptoms may initially appear in isolated branches or sections of the crown but eventually spread throughout the tree. Symptoms can vary in severity from year to year US Department of Agriculture (2013).

Leaf scratch

Leaf scratch Bite-shaped damage around the leaf edges of shrub leaves, making a scalloped pattern. According to Jang et al. (2009), the caterpillar (or larva) does the damage. The young caterpillars radiate from the egg masses, stripping the leaf surface and eating the leaf between the veins. Later, they become solitary and eat all the leaves, including the petioles. Primarily, they feed at night. The cream to golden-brown egg masses (4-7 mm diameter) are covered with hairy scales from the tip of the female's abdomen. After hatching, the caterpillars stay together. They vary in color: pale green at first, then dark green to brown. There are bright yellow stripes along the top of the body. The caterpillars molt five times during 15-30 days, depending on the temperature. Afterward, they pupate in the soil for 7-10 days. If the eggs are laid on an inedible plant, the young caterpillars drop silken threads and are carried in the wind to other potential hosts. The moth's body is grey-brown, 15-20 mm long, with a 30-40 mm wingspan.

Septoria leaf spot

Septoria Leaf Spot is caused by the fungus Septoria lycopersici. This fungus can attack tomatoes at any stage of development, but symptoms usually first appear on the older, lower leaves and stems when plants are setting fruit. Symptoms commonly develop on leaves but can occur on petioles, stems, and the calyx. The initial symptoms are minor, water-soaked circular spots 1/16 to 1/8" in diameter on older leaves. The centers of these spots gradually turn gray to tan and have dark brown margins. The spots are distinctively circular and are often quite numerous. As the spots age, they sometimes enlarge and usually coalesce US Department of Agriculture (2013).

Shot hole

Feeding produces various tissue responses, including scar formation, leaf holes, and distorted growth. (Moritz et al., 2007) Pest species are plant feeders that discolor and scar leaf, flower, and fruit surfaces and distort plant parts or vector plant pathogens.

Most adult thrips are elongate, slender, minute (less than 1/20 inch long), and have long fringes on the margins of both pairs of their long, narrow wings. Immatures (called larvae or nymphs) are oblong or slender and elongate and lack wings. Most thrips range in color from translucent white or yellowish to dark brown or black. A few species are brightly colored, such as the distinctive reddish-orange larvae of the predatory thrips, *Franklinothrips orizabensis, and F. vespiformis* (Moritz et al., 2007).

Anthracnose

Irregular, brown to reddish-brown (often papery) areas develop along and sometimes between veins and at leaf margins. Lesions tend to begin along leaf veins (because the depressions along veins hold water for a more extended period, and spores tend to collect there) but often rapidly expand. Severely infected leaves may appear scorched, almost entirely brown, wilted, or cupped. Most anthracnose fungi infect their hosts during the spring, just as the first new leaves expand and continue through the summer while environmental conditions are suitable.

Jones and Elliot (1986) explained that spores are released from last year's diseased tissue (most commonly from fallen leaves). Spores can be spread by wind or rain splash and can only infect soft, succulent tissues such as new shoots, flowers, and fruits, but leaves are the most severely infected. The fungus obtains nutrients from plant cells, killing the cells and creating the leaf lesion. The lesion expands as the fungus spreads. During sustained wetness and cool temperatures, spores from leaf lesions can re-infect the same leaf or neighboring leaves. New infections usually do not occur after mid-summer because conditions are too warm and dry (Jones and Elliot, 1986).

Symptoms of disease in Pygmy Trees

Table 1 shows the selected representative pygmy tree species and the symptoms observed in their infected parts. Several disease symptoms had been observed on the pygmy trees of Mt. Hamiguitan. One of the most common symptoms is leaf scratches along the leaf blades of stunted trees such as *Syzygium* sp. and *Vacciinium* sp., which was damage caused by pests such as tortrix roller moth. Thorpe et al. (2007) said that tortrix moth caterpillars are the larval stages of a type of moth belonging to the Tortricidae family, which includes hundreds of tortrix moth species. They further explained that these caterpillars develop from the egg stage to caterpillar very quickly, usually in two to three weeks only. The caterpillars, which pupate into cocoons inside the rolled leaf, emerge in early summer and late autumn. The sampling was conducted in April, which was in the summer period. This could be why these traces of scratches on the leaf of the pygmy leaves were observed during sampling; the environmental condition was suitable for them.

The most observed symptoms in the stem and barks are leaf scorch, red lesions on the leaf, and fungal incursions on the stem. Thomas (1995) mentioned that the beech scale Cryptococcus fagisuga caused the signs. However, at least two species of the Nectria fungus may also be associated with the disease.

Table 1. The pygmy tree species and symptoms observed on their infected parts.

Station	Species name	Local name	Symptoms
1	*Dacrydium elatum*	Cedar tree	Leaf Scorch, Red Lesions(leaf), and White dots at the bark
2	*Syzygium brevistylum*	Sagemsem	Red leaf blight and Shepherd's crook form
3	*Agathis philippinensis*	Almasiga tree	Leaf scars
4	*Syzygium* sp	Lumboy-lumboy	Leaf scratch and Leaf scars
5	*Leptospermum flavescens*	Tinikaran	Leaf scratch and wilting
6	*Lithocarpus* sp.	Ulayan	Leaf holes and yellowish in color and decayed stem
7	*Ilex* sp.	Tagibinlod	Black dotted leaves and leaf scratch
8	*Vaccinium* sp.	Wildberry tree	White spots with red margins, Leaf scratch and few small red spots
9	*Scaevola* sp.	Unidentified	Leaf holes and Leaf scratch
10	*Ternstroemia* sp.	Unidentified	Red dotted leaves with scars

According to Thorpe et al. (2007), moths molt during the spring and lay eggs in the early summer. Eggs hatch from mid-summer to early winter, and crawlers migrate to other parts of the tree or are transported by wind to other beech trees. Once crawlers settle, they feed by inserting their stylets into the inner bark. The crawlers prefer rough bark areas, such as cracks and crevices. Tiny injuries caused by feeding provide wounds for the fungus to enter, which could have caused the disease.

CONCLUSION

In conclusion, 10 stations were established in the study area, with fungal and insect-related diseases being the most common. Six stations—specifically stations 1, 2, 5, 8, and 10—were infected by fungal diseases, while station 6 was affected by bacteria. The remaining four stations suffered from pest infestations. Stations 1, 4, 6, and 9 experienced significant insect infestations, with station 1 having the most severe damage, followed by stations 4, 6, and 9, while station 7 had the least. During sampling, it was determined that leaves were more prone to diseases than stems and roots. The identified diseases included Beech Disease, Fire Blight, Leaf Mines, Leaf Scratches, Verticillium Wilt, Bacterial Leaf Scorch, Septoria Leaf Spot, Shot Hole, and Anthracnose, with fungi being the most common vectors.

Additionally, pest-related damage was observed, such as leaf scratches caused by caterpillars and beetles. Fungal diseases were the most dominant, primarily attacking leaves. Environmental factors played a significant role in the spread and severity of these plant disturbances.

ACKNOWLEDGMENT

The author would like to thank Dr. Susan Labasano, Dr. Joy Sorrosa, and Sir Clint Michael Cleofe, for their guidance in improving this research. Thanks also to the Local Government of Mati, LGU-San Isidro, DENR-PENRO, PAMB, and MHRWS PASu Office for their support during our sampling. Special thanks to Sir Giovanni Tampos, the Mt. Hamiguitan Bantay Gubat Team, Tatay Pidoy for their assistance and shared knowledge in the field, to Mr. Jahar Gayta and Mark Kevin Camposo, the school laboratory aides, and to Ma'am Leah Jiminez, Director of RIC IX, for kindly allowing the use of laboratory apparatus and facilities, and to Joshua G. Templa for revising the paper for the IMRAD format.

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