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Threats on the Natural Stand of Philippine Teak along Verde Island Passage Marine Corridor (VIPMC), Southern Luzon, Philippines

ABSTRACT

This study documents the threats of the critically endangered Tectona philippinensis in the backdrop of the past conservation policies and projects. Twelve 20m x 50m plots were distributed in three altitudinal strata (S1= 50 – 100 m asl, S2= 150 to 200 m asl, and S3= 250 – 300 m asl) using stratified random sampling. Every tree was examined to detect presence of pest and diseases on foliage, stem, buttress and exposed root system. Threats of anomalous weather patterns like intense drought and human disturbances were also recorded. Leaf skeletonizers, shotholes, buttrot, heartrot, rootrot, illegal harvesting, charcoal making, wind damages, and intense dry season are among the most alarming threats of T. philippinensis. Germinants and wildlings are most susceptible to wilting during intense drought during dry season. A number of interesting species of arthropods and macrofungi within the stand were also encountered. There are variations on the incidence and infection across altitudinal habitat and across diameter classes. Poles and standards at lower altitudinal habitat (<100 m asl) are the most disturbed and susceptible to the disturbances. Existing conservation and protection policies should be strictly implemented especially in hotspot habitats.

Key words: *Philippine Teak, critically endangered, forest survey, anthropogenic, disease infection*

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INTRODUCTION

Anthropogenic disturbances such as habitat conversion, over-exploitation and pollution are considered to be the most alarming threats to biodiversity. Along with these, the impacts of climate change which causes anomalous weather patterns as well as emergence of pests and diseases add and amplify the stresses to species survival. If there will be no intervention, mass extinction with adverse environmental consequences is highly probable. According to *Biello* (*2012*), losing 21 percent of species in an ecosystem would result to 10% reduction in biomass reduction. Species naturally extinct due to long-term shift on environment. Today, however, man-made disturbances like degradation, over-exploitation, spread of non-native species and disease accelerated the phase of species endangerment and extinction (*Patarkalashvili, 2017*). Reliable and updated data on natural and man-made forest disturbances are important to understand ecosystem condition, safeguard sustainable production of ecosystem goods and services (*Lierop et al. 2015*).

Several studies has been conducted around the globe regarding the threats on the survival of endangered and endemic flora. At global scale, *Lierop et al.* (*2015*) reported that between 2003 to 2012 approximately 67 M ha (1.7%) of forest land burned annually, 85 M ha are affected by insect pests, 28 M ha are affected by severe weather patterns especially in Asian region and 12.5 M ha are disturbed by diseases. Some location specific studies include of *Kim et al.* (*2016*) which found out that Korean fir trees was disturbed for longer than the last two decades, potentially by the browsing of the seedlings by ungulate Siberian roe deer and by the physical hindrance of the dwarf bamboo in Hallasan National Park, Jeju Island, Korea. Furthermore, competition with associated threes, herbs and shrubs can also affect growth and survival of endemic trees (*Kim et al. 2016*). Habitat loss is also one of the main factors that contribute to the genetic diversity reduction and reproductive failure of the endangered and endemic Santalum album in Indonesia (*Indrioko and Ratnaningrum 2015*). Severe overcutting and uprooting as well as disturbance through unmanaged human activities and increasing for fuel are the threats of

Phlomis aurea (*Shaltout et al. 2004; Moustafa and Abd El-Wahab 2013*). Agathis australis has been reduced by logging and fire however recent declines are primarily due to 'kauri dieback" a disease caused by *Phytophthora agathidicida* (*Weir et al. 2015*)

In the Philippines, endemic and endangered plants are also facing eminent extinction due to deforestation and forest land conversions (*Amoroso and Aspiras 2011*). *Tectona philippinensis* is a critically endangered and endemic flora with habitat concentration in southern Batangas and Iling Island of the Occidental Mindoro province (*Madulid and Agoo 199*0). Past studies regarding the population distribution and conservation status of Philippine teak recorded the presence of various potential threats (*Caringal 2004 and Madulid and Agoo 1990*). Currently, there very limited information on the existing environmental and anthropogenic threats of *T. philippinensis* aside from some onsite observation as part of pioneering studies. Previous studies focused on population distribution (*Caringal and Makahiya 2000*), conservation status (*Madulid and Agoo 1900; Caringal and Castillo 2002; and Caringal 2004*) and on phytogeography and physiognomy (*Caringal 2007*).

Studying threats on the natural stand of endangered trees is essential for formulation of proactive conservation and protection measures (*Macpherson et al. 2017*).

This study documents the different environmental and anthropogenic disturbances that threatened the survival of *T. philippinensis*. Moreover, some notable role of *T. philippinensis* forest on housing arthropods and macrofungi diversity were also documented. This information can be used in developing and implementing conservation and protection projects to ensure the long-term survival of this biological important and critically endangered flora.

MATERIALS AND METHODS

The Study Area

The study was conducted in Southeastern Batangas particularly in the municipality of Lobo which lies between 130° 38' 8" N latitude and 1210° 12' 6" E longitude (**Figure 1**). It is 36 km east of Batangas city and 170 km south of Manila and composed of 26 villages (barangays). This municipality, having areas rich in plant species, large number of endemic species and diverse range of habitat ranks 5th among the biodiversity hotspots in the Philippines.

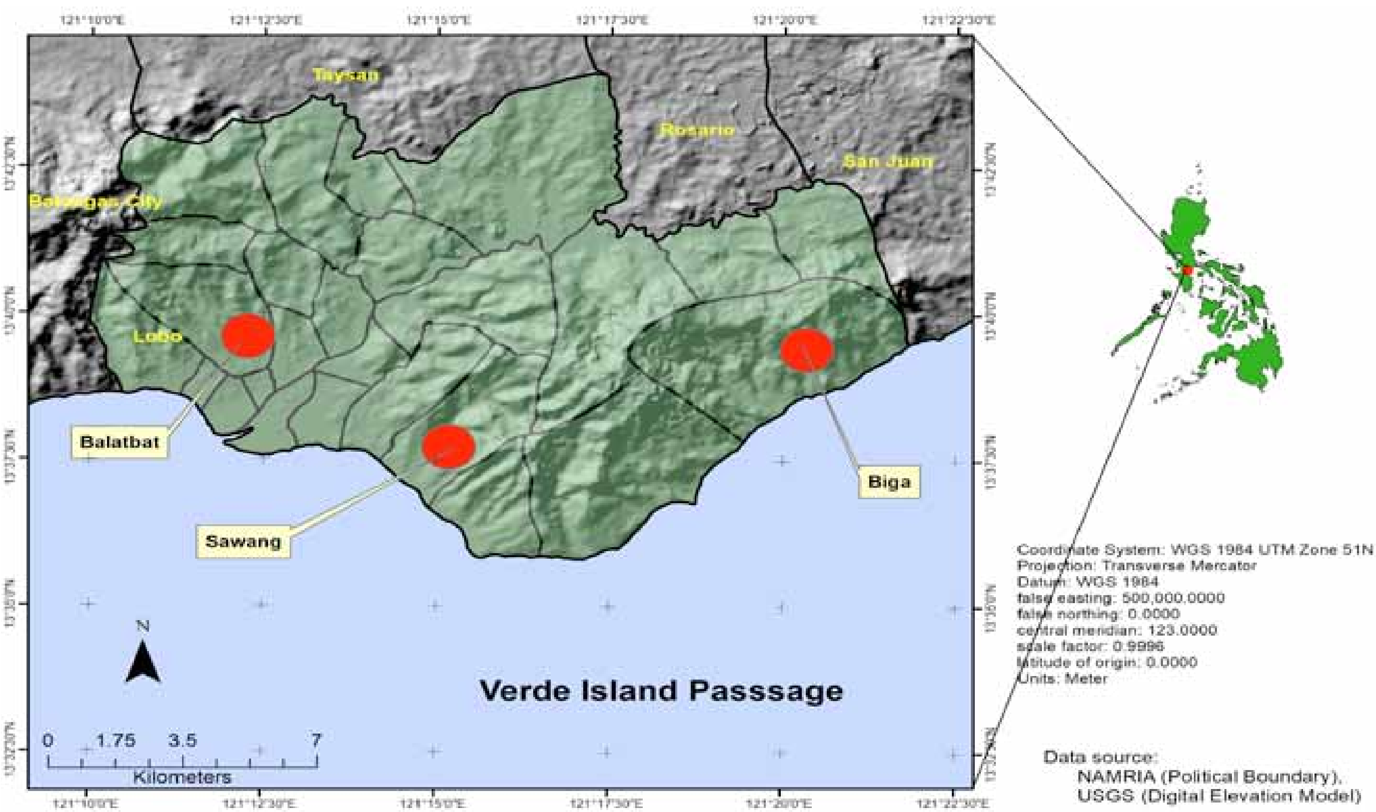

Figure 1. The location of the study showing the three localities with the highest concentration of Philippine Teak along Verde Island Passage.

This area was generally composed of mountain ranges which consist of volcanic materials of various ages; it consists of igneous rocks formed during Upper Miocene and Pliocene period; volcanic agglomerate (VA) during Middle Miocene and Pliocene time; and Andesite Basalt Series (N2V). Likewise, sedimentary rocks were formed during Pliocene-Pliestocene; Mt. Santiago Limestone (N3LS) during Upper Miocene-Pliocene as well as Mapulo Limestone (N2LS), and recently formed Alluvium. San Juan Metarocks (kpg) is also present in the area, it consist of extensive metamorphosed sediments and volcanic rocks made up chiefly of highly indurate greywacke and ferruginous sandstone and shale with occasional banded chert and basalt, andesite with some volcanic agglomerate (*MPDC Lobo 2000*).

Climatic regime falls under type III in Corona's and type D in Thronthwaite, Moh and Schmidt's classification (*Madulid and Agoo 1990*). There are two pronounced season in the locality, wet and dry. Dry season is prevalent from November to April while wet season occurs from June to October. Temperature ranges from 240-280°C. Low rainfall distribution was recorded at 30 mm while high distribution was noted in the month of August at 80 mm (*MPDC Lobo 2000*). Rainfall data for a three year period (1998-2000) gathered at the Lobo vicinities show that the total average annual rainfall was 2,060.40 mm or an overall all mean of 171.7 mm monthly (*Wallace 2001*).

Selection of Sampling Sites and Establishment of Sampling Plots

Stratified random sampling was used in plot selections. The survey was conducted to cover 544 trees or roughly 10% of the population in Lobo Batangas. The altitudinal habitat ranges range of Philippine teak is from from 50-300 msl (*Pangga 2002; Caringal and Castillo 2002*) and by chances can also be found on 500 msl (*Caringal 2004*). Since Philippine teak forest was not confined on a certain area and scattered on different localities and mountain ranges in southeastern Batangas, sampling plots were established on three selected villages of Brgy. Balatbat, Sawang, and Biga, all have relatively high population density. On this study, local habitats were classified and group on three altitudinal strata (S1= 50-100 m asl, S2= 150-200 m asl, and S3= 250-300 m asl). Using proportional allocation method eight plots were assigned to Strata 1, three plots on Strata 2, and one plot on the third strata. A total of 12 plots with the dimension of 20m x 50m were distributed on three altitudinal strata (**Figure 2**).

Figure 7. Distribution of twelve sampling plots on three altitudinal ranges in three local villages of Lobo, Batangas.

Pests and Diseases Survey

After the sampling plots have been laid out, survey of Philippine teak within the plots was conducted. For this purpose, a survey form was used to gather information on the pathological, entomological, anthropogenic and environmental threats for each individual tree. Included in the survey form are the basic biophysical and geographical data of the sampling plots. Every Philippine teak tree from wildlings to veteran was morphologically examined for the presence of root, stem, and foliage diseases. Symptoms and manifestation were recorded on every abnormalities and diseases encountered. Whenever fungal specimens are available from the diseased tree, they were collected and preserved for identification and verification. Other recognizable and possible pests like insects and other arthropods that tend to post harm to the species were also documented and identified. Likewise, whenever insects are not familiar to the researcher and on-site identification was not possible, specimens were collected. Survey and identification were done both on transition period of summer and rainy season. After the identity of pests was established, its alternative hosts were also searched. This was done on the summer were the foliage of Philippine teak stand was diseased which tend the parasites or defoliators to look for alternative source of food on nearby the stand. Every identified abnormalities and threats were recorded and photographed for the purpose of documentations.

Identification of Pests and Causal Organisms

The specimens collected during the survey were preserved for proper identification. Fruiting bodies of wood rooting fungi were dried and put in papers bags which are used as temporary storage and to transport for identification. Soft-bodied insect specimens were preserved using preservative chemicals inside vials as containers. Technical knowledge and background of the researcher in pathology and entomology were the primary tools used to identify the causal agents like fungi for the diseases and insects for the pests. Handbooks are used as identification key to establish the initial identity of the fungi. Collected specimens were brought to the experts for validation and confirmation of the initially established identity of the causal organism. Key handbooks for insects and other arthropods were also used in initial identification for insect pests. Consultation to several entomologist and pathologists/ mycologists were done to validate the initial identification done by the researchers.

Documentation of Other Environmental and Anthropogenic Factors

Field observations and documentations on anthropogenic disturbances such habitat destructions, shifting cultivations, extraction and land use conversion were done throughout the span of the study.

RESULTS AND DISCUSSIONS

Disturbances and threats to Philippine teak were classified into three general categories. First is the pest and diseases which include major wood rotting and leaf diseases, insect pests, and strangles and twiners. Seconds threats induced by anomalous climate such as strong wind and excessive rainfall brought about by tradewinds and typhoons. Lastly are threats by human which include unauthorized cutting for poles and charcoal as well damaged/slashed stem from various human activities inside the forest like fuel wood and fodder gathering.

Pest and diseases on Philippine teak forest

Insect pest is one of the important emerging causes of forest decline in around the world especially in temperate country (*Lierop et al. 2015*). However, there are considerable insect pests in the tropics including for Tectona philippinensis. The most obvious pest is a leaf skeletonizer which is larva of a moth from family Pyralidae of order Lepidoptera (**Figure 3**). It appears on rainy season probably from June to last part of the month of December when the stand has succulent foliage for larva to feed on. The larval feed on the younger leaf tissue leaving the midrib and vein structures. The detailed

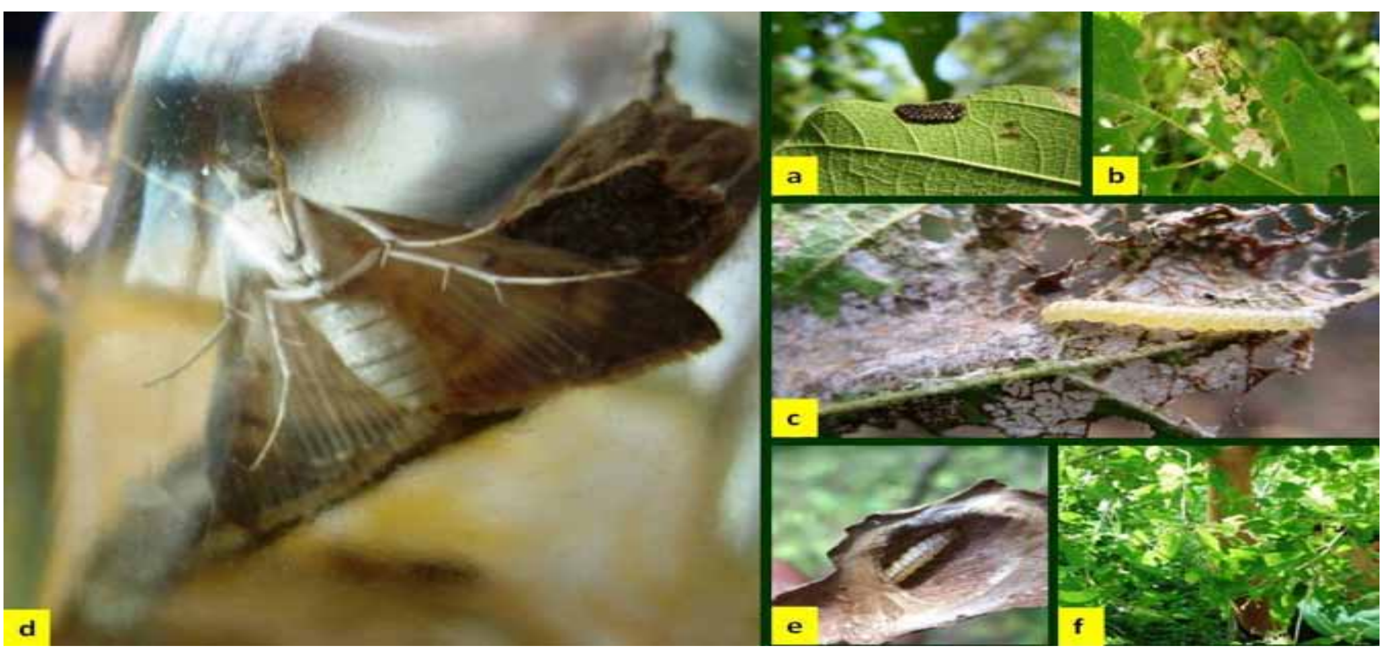

Figure 3. The leaf skeletonizer of Philippine teak showing its (a) eggs laid under the leaf, (b) partially skeletonized leaf (c) larvae consuming the leaf, (d) adult moth (e) a larvae which about to pupate under P. teak bark, and (f) heavily defoliated saplings.

life cycle and biological information of the Philippine teak skeletonizer were not yet determined in this study and only baseline information about its life cycle and physical feature was established. The moth laid their eggs beneath the surface of the leaf and after 2- 4 days hatched and start to feed on the leaf. Its pupal stage may last for about 4 to 5 days before the new adult emerges. Larva measure about 15 mm yellowish in color with pair spiny transparent hair on each segment while the adult was light brown in color light-brown to dark brown toward to wing tip. The head, thorax and abdomen are white and it has a wing span of about 20 to 25 mm (**Figure 4**) across. Leaf skeletonizer consume mostly succulent young leaves, although it may not totally kill the host tree, it can bring significant effect to growth rate the host tree by dramatically reducing the photosynthesis and growth increment. In the case of Philippine teak, defoliation by this insect as well as its effect may only last until foliage before the onset of summer from January to March.

Three most common wood rotting fungal diseases were studied and documented on the natural stand of Philippine teak (**Figure 4**). The heart rot which denoted by the rotting of the heartwood leaving the sapwood and phloem, the butt rot which is characterized by the rotting of heartwood and some portion of sapwood that is confined to the base of the tree, and the root rot which is characterized by decaying of roots frequently connected from the occurrence of butt rot and heart rot in a tree. Open wound of the bark or stem serve as entry point for fungi. This linked and interconnectedness of different disturbances are natural and common both in tropical and temperate forest around the world (*Lierop et al. 2015*). The class of fungi responsible for almost all of wood rotting fungal diseases belongs to the Basidiomycetes which was noticeable for their fruiting bodies. Among the wood rotting fungi found to have fruiting bodies in the natural stand of Philippine teak were *Auricularia mesenterica* (Dicks.) Pres, *Auricularia auricula*, *Cantharellus infundibuliformis*, *Daedalea palisoti*, *Fomes* sp., *Ganoderma lucidum*, *Hexagonia apiaria*, *Lenzites betulina*, *Panus rudis*, *Polyporus abieta* and *Polyporus* sp.

These diseases may not totally kill the tree but it has severe effect on its vitality. Infected stems lose much of its structural support to upper branches and to the crown. As in the case of Philippine teak in southeastern Batangas, majority of natural stand was located uphill from 50 m asl to 300 m asl and directly facing the sea, presence of wood rotting fungal diseases increases their susceptibility to be blown down or uprooted by strong wind during cyclone and strong monsoon. Foliage diseases like shot holes and leaf spot were also observed (**Figure 5**). *Cercospora* sp. is the most probable causal organism which is the most

Figure 4. Different wood rotting fungal diseases of Philippine teak: (a) standard sized tree infected with butt rot, (b) standard sized tree with trunk rot, (c) pole infected with root rot, (d) sapling arise from stump infected with hearth rot, (e) pole sized with heart rot, and (f) a pole arises from stump with heart rot.

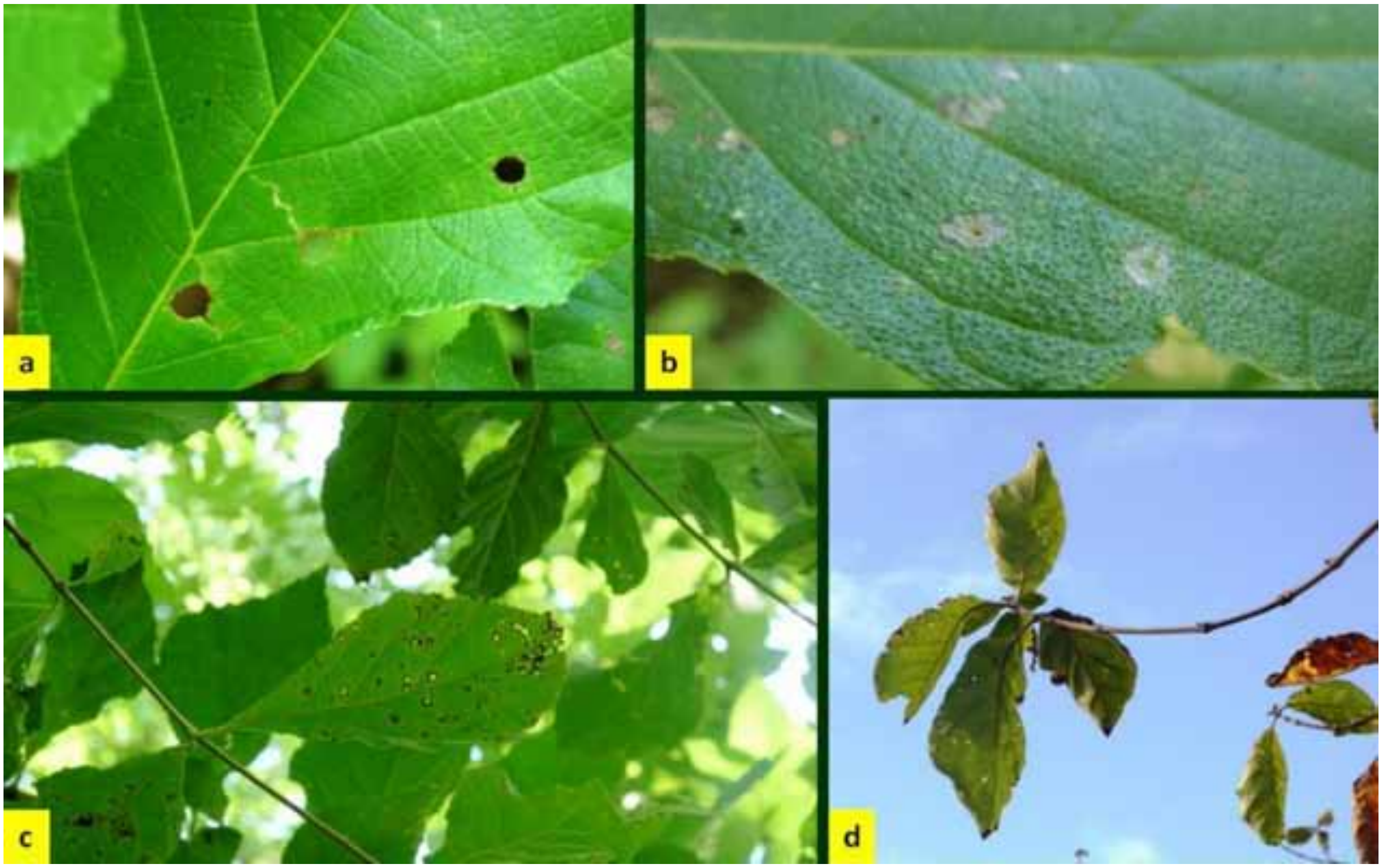

Figure 5. Leafspot and shotholes of Philippine teak which suspected to cause by Cercospora sp with the following features: (a) scattered circular holes after necrotic tissue falls, (b) leafspot, (c) & (d) infected leaves.

common for brown spot of hardwood species recorded in the Philippines base from the study of *Militante and Manalo* (*1990*) and by *Quiniones and Dayan* (*1988*). This genus also causes major losses in agriculture and forestry around the globe (*Zeng et al. 2017*). As of now, the lack of efforts to control or address these fungal diseases can contribute to uncertainty of the future of this critically endangered tree species (*Wyse et al. 2014*).

Vines, stranglers and twiners are enormously found in the natural stand of Philippine teak. These plants bring significant effect to stand by suppressing the growth of wildlings and saplings. There are many instances that regenerants and wildlings were totally gulp down by these plants putting too much stress on upward growth of the stem which resulted to stunted growth.

Disturbances by anomalous weather patterns

Aside from the defoliator and wood rotting diseases, other natural threats found on the natural stand of Philippine teak were damages due to strong wind, vines and stranglers, and effects of climate change (**Figure 6**). Philippines were frequently visited by strong monsoon and cyclonic typhoon which averages 20 typhoons per year. Lobo which is a coastal town in southern Batangas is one of area affected by these natural phenomena.

Temperature will continue to rise on the following decades which will affect all ecosystem of the world particularly the forest. Scientist predicted that several species of plants will move on higher elevations as the temperature get warmer. Fungal activities and proliferations are also affected due to shift of temperature along altitudinal gradient (*Cordier et al. 2012*). Extinction of plants and animals especially those that are endemic and sensitive to climatic changes are inevitable. The effect of this weather condition was apparent on the stand Philippine teak. Intense heat and severe drought lead to desiccation of its regenerants and wildlings. These conditions were further aggravated with unfavorable soil condition on the habitat of Philippine teak which results to massive wilting and eventually death of wildlings and regenerants (**Figure 7**). If the present trend continue, sudden population decline in the next few years is inevitable. Moreover, there is also very risk of occurrence wild fires because of high amount dry forest litters and branches which so combustible at very low moisture content that can spontaneously ignited by intense heat.

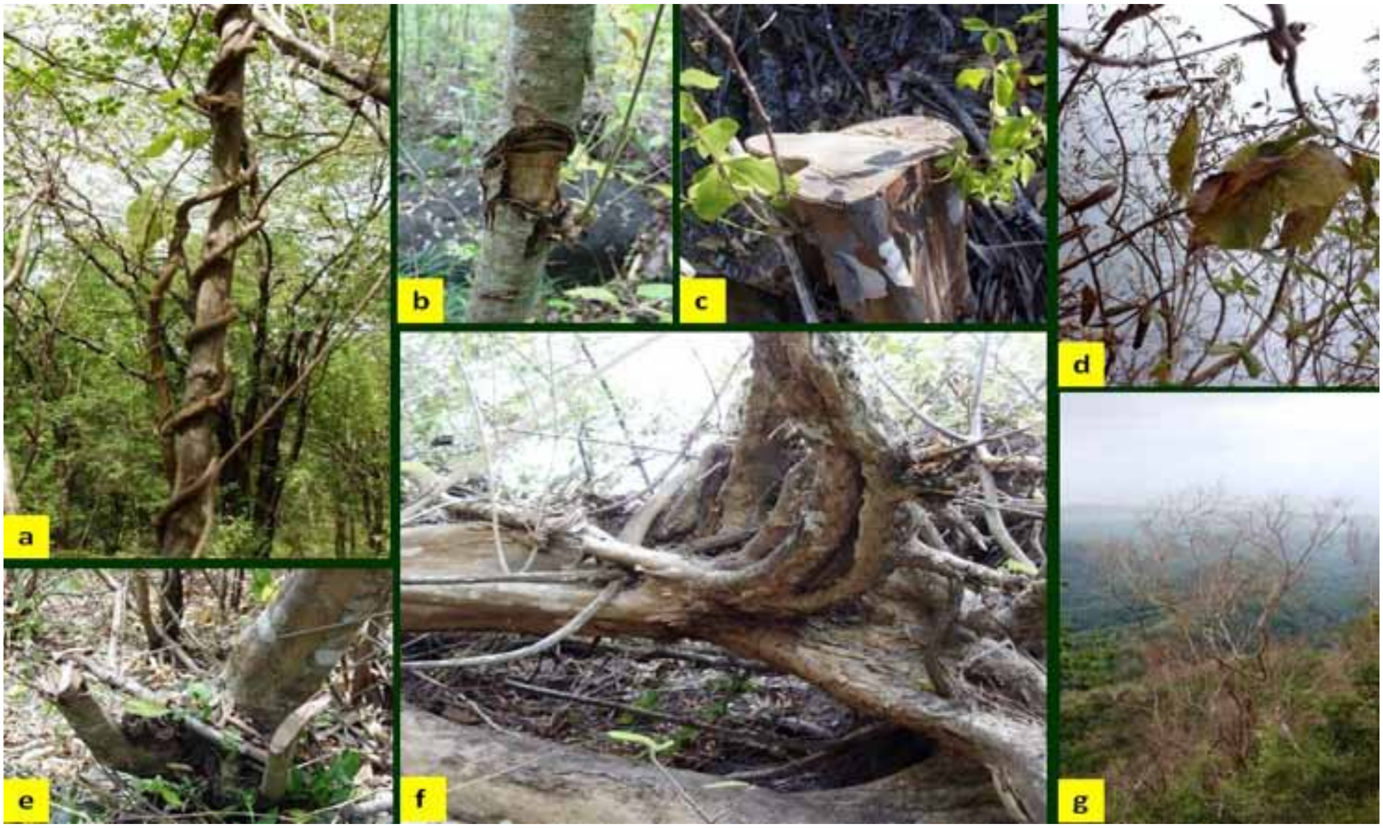

Figure 6. Other natural and anthropogenic threats on the natural stand of Philippine teak: (a) sapling entangled with woody vines, (b) sapling wind slashed bark (c) stump of a harvested pole, (d) and (g) desiccated leaves due to extreme heat and drought, (e) a pole size tree with cut branches, and (f) a standard size brown down by strong wind, and (g) leafless stand Philippine teak during intense summer.

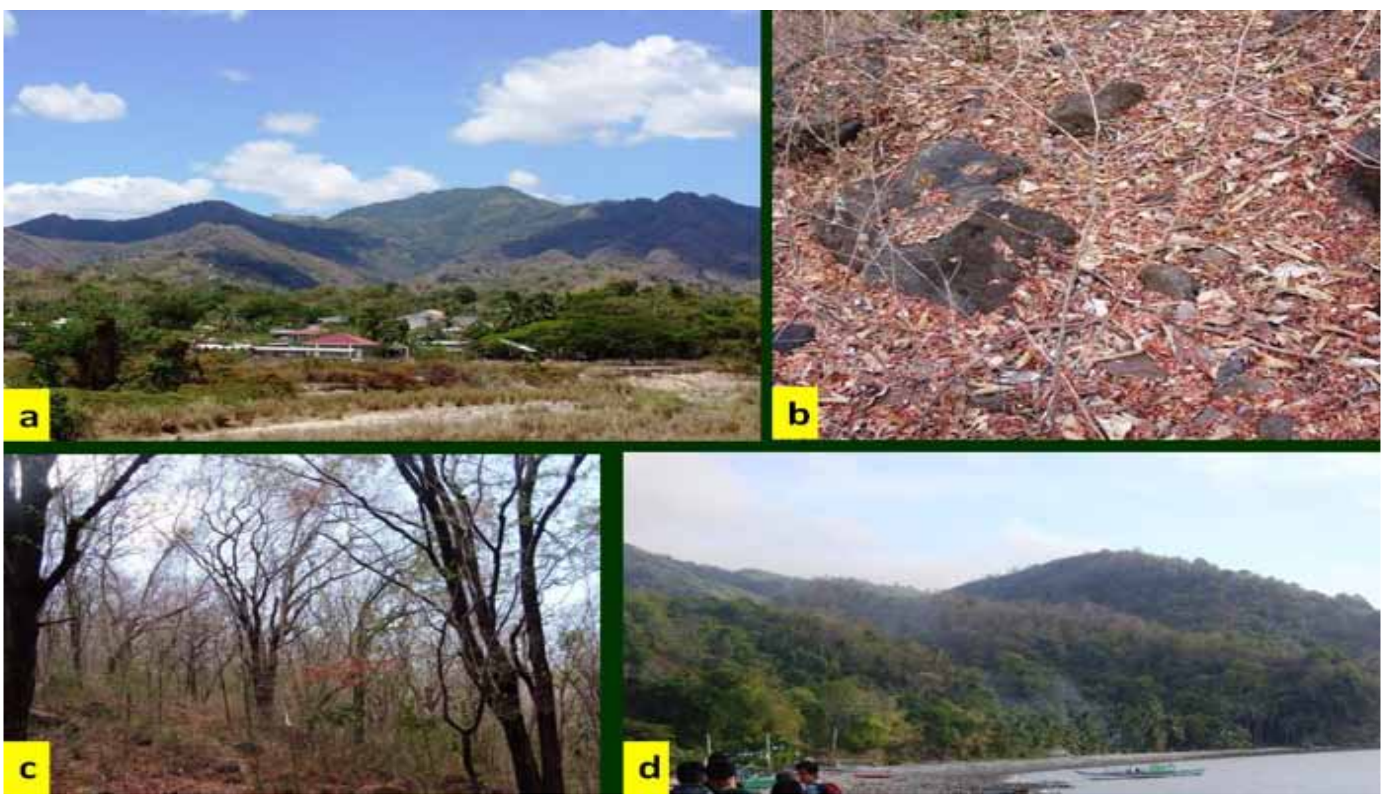

Figure 7. (a) Panoramic view of northern part of Lobo Batangas which include Mt.Banoy during the onset of summer, (b) a leafless regenerants in a very dry and rocky soil (c) leafless Philippine teak forest (d) Philippine teak forest adjacent to the sea.

Anthropogenic disturbances

A municipal ordinance that was enacted on 2003 that prohibits the cutting and gathering of Philippine teak however illegal cutting and harvesting is still being practice. Harvesting of the stem is being committed primarily for domestic uses such house and furniture construction but in some cases for charcoal production (**Figure 6**). There is also large number of damaged and slashed stem due to various human like firewood and fodder gathering. One of the reasons that drive local community to harvest this protected tree is that it possesses good quality of wood making it suitable for building material. Even in the past, its wood together with other premium hardwoods like molave (*Vitex parviflora*) and dungon (*Heritiera sylvatica*) were used as building material for galleon ship that plied the Manila-Acapulco route during the Spanish era. Another reason, is the proximity of its habitat to local villages making it readily accessible for consumption as the need for wood arises. This illegal harvesting activity threatened the longterm survival of *T. philippinensis* and sustainable functioning of the forest stand (*Ploeg et al. 2017*).

Extent of damage and infection

There were 11 observed threats and disturbances in the natural stand of the *T. philippinensis*. Of these, six are under pest and diseases, two are man-induced and three are due to extreme weather patterns (**Table 1**). Defoliators parasitized 2.76 % of the trees survey. This was fairly low in terms of severity and may seem not so alarming. This was because the actual survey was done during the seasonal transition when insect's activity and food source are dramatically decreasing. But during the preliminary survey conducted last July 2009, it was estimated that 90-100% of the stand was colonized by this defoliator. Although it doesn't consider as direct threats, rate of presence of other insects and arthropods was included in the listing with 63.6 % occurrence on the stand. Moving from tree to tree to source out for food, these organisms may be vector for the spread of wood rotting diseases by carrying the spores from infected tree to healthy one. Furthermore, fungal diversity with is high on *T. philippinensis* are correlated to tree diversity on which can contribute to high incidence of fungal diseases (*Nguyen et al. 2016*).

On the other hand, leaf diseases in the form of leaf spots and shotholes recoded 57.72% infection on the population, all of them with observed symptoms. Among the wood rotting diseases, trunk rot are the most prevalent with 22.06% infection while root rot being the less conspicuous has lowest with 5.7%. Other natural threats like presence of entanglers and veins and casualties due to strong wind are also common with 40.44% and 2.57% respectively. Considerable part of population (8.64%) was harvested by local community for domestic consumption. The researchers observed the human disturbances are still the most important threats to the natural stand of *T. philippinensis*.

Disturbances across altitudinal habitat

Of the 544 trees, majority (74%) were surveyed within 50-100 m asl followed by 150-200 m asl and 300 -350

Table 1. Summary table of percentages of occurrence of all identified threats on the natural stand of Philippine teak.

Different Threats	Total Number of Trees Surveyed	Number of Tree Infected/ Affected	Percentage (%)
Pest and diseases			
Defoliator/ Skeletonizer	544	15	2.76
*Other arthropods	544	346	63.60
Butt rot	544	97	17.83
Trunk rot	544	120	22.06
Root rot	544	31	5.70
Leaf spot/shotholes	544	314	57.72
With stranglers and twiners	544	220	40.44
Anthropogenic threats			
Slashed bark and stem	544	159	29.23
Pole and wood harvesting	544	47	8.64
Other natural threats			
Wind damages			
(Broken branches and stem)	544	75	13.79
(Totally uprooted)	544	14	2.57
Desiccated regenerants due to intense dry season	544	223	42.83

m asl with 16% and 10% respectively. Clearly, *T. philippinensis* primary habitat is low elevated coastal areas along southeastern Batangas coast (*Caringal 2004*). Frequency of disturbances and threats across the three altitudinal habitat was examined to determine variations. Results showed that wood rotting diseases such as butt rot, trunk rot and root rot are most prevalent within 150 to 200 m altitudinal habitat with 40%, 46% and 13% infection of the total surveyed trees respectively (**Table 2**). It is interesting to note that on this elevation range, there is also highest incidence (30%) of damage stem and branches probably due to strong wind during monsoon and typhoons. Moreover, this is high number insects and arthropods thriving under the flaky bark of *T. philippinensis* within this altitudinal habitat. These two factors together damaging human activities are the suspected cause for high occurrences of wood rotting diseases within this elevation as pointed out by *Eusebio* (*1998*) and *Tadiosa* (*1998*). Variation on infection of wood rotting fungi across elevation gradient can be attributed to differences on microclimatic factors such as moisture, temperature, relative humidity, and wind velocity and direction can affect the fungal composition, activity, and growth within a given area as pointed out by *Cordier et al.* (*2012*) and *Tadiosa* (*1998*). Meanwhile, P. teak skeletonizers are almost equally present in all altitudinal habitat while leaf diseases such as skeletonizer, leafspots and shotholes are more prevalent within 50-100 m altitudinal habitat while least incidence within higher altitudinal habitat (300-350 m asl).

These variations in geographical scales of foliar fungi has also been observed by *Terhonen et al.* (*2011*) and *Millberg et al.* (*2015*).

Twiners and stranglers suppress the growth of regenerants that are mostly located at lower altitude (50-100 m asl). Disturbance from extreme weather patterns such as strong wind is highest in middle altitude (150-200 m asl) with 30% of trees damaged in the form of broken branches and splits while and 5% were totally blown down. Wounds from the broken branches will serve as entry point (*Eusebio 1998*) for wood rooting fungi.

High incidence of illegal harvesting and forest related activities inside the Philippine teak forest were found within 50 to 100 m asl. Inside this altitudinal range, 33.83% out of 405 trees surveyed were found to have damaged stem as result of various human activities. Similarly, prevalence of illegal harvesting for pole and charcoal making were observed in the same range with 11.60% out of 405 trees surveyed was utilized for these purposes. These areas are near to the communities which are the immediate utilizers of wood and other derivatives of Philippine teak. On the other hand, there are observed sudden decreased of those mentioned threats as the elevation increases. Altitudinal habitat from 300m asl to 350 m asl has 9.62% stem damage and no observed harvesting. These habitat areas are of steep slopes and far enough for immediate consumption of local communities.

Table 2. Frequency and the corresponding percentage of natural and anthropogenic threats on the three-altitudinal habitat of *T. philippinensis*.

Disturbances and threats	Altitudinal habitat range (msl)		
	50-100	150-200	300-350
	Number of individuals surveyed		
	405	87	52
	Frequency of infection/ damage		
Butt rot	52(13)	35(40)	10(19)
Trunk rot	74(18)	40(46)	6(12)
Root rot	11(3)	13(15)	7(13)
Twiners and stranglers	181(45)	14(16)	25(48)
Leaf Skeletonizer	11(3)	2(2)	2(4)
Leaf Spot	90(22)	4(5)	0(0)
Shootholes	188(46)	32(37)	0(0)
Broken/damaged stem	44(11)	26(30)	5(10)
Uprooted	9(2)	4(5)	1(2)
with Slashed on stem	137(34)	17(20)	5(10)
Harvested	47(12)	0(0)	0(0)

Disturbances across diameter classes

A total of 544 trees were surveyed composed of 62 wildlings, 196 saplings, 266 poles, and 20 standards with corresponding percentage of 11%, 36%, 49%, and 4% respectively. There was no veteran tree encountered but there were 4224+ regenerants counted within the 12 established plots from elevation of 50 m asl to 300 m asl. Incidence wood rotting diseases is directly proportional with the age and diameter of the trees. Around half of the standard was infected of butt rot (45%) and trunk rot (60%) which are also prevalent also among the associated trees in the area (**Table 3**). Although there is no recorded occurrences of root rot yet in the Philippines (*Eusebio 1998*), 10% of the standard suspected to have root rot with obvious and observable symptoms. Wildlings and saplings have the lowest rate of occurrence of wood rooting diseases with 8.06% and 13.78% infection of butt rot, 4.84% and 3.23% infection of trunk rot, and 3.23% and 4.08% infection of root rot. These occurrences may be surprising for saplings and wildling but it worth noting that these infection cases are coppices arises from infected trees. Like most of tree species in the natural forest, susceptibility to wood rotting diseases increases

Table 3. Frequency and the corresponding percentage of natural and anthropogenic threats on different diameter class of *T. philippinensis*.

Disturbances and threats	Diameter class			
	Wildlings	**Saplings**	**Pole**	**Standard**
	Number of trees surveyed			
	62	**196**	**266**	**20**
	Frequency of infection/ damage			
Butt rot	5(8%)	27(14%)	56(21%)	9(45%)
Trunk rot	3(5%)	33(17%)	66(25%)	12(60%)
Root rot	2(3%)	8(4%)	19(7%)	2(10%)
Twiners and stranglers	25(40%)	89(45%)	93(35%)	13(65%)
Leaf Skeletonizer	9(15%)	42(21%)	36(14%)	7(35%)
Leaf Spot	1(2%)	8(4%)	3(1%)	3(15%)
Shootholes	17(27%)	79(40%)	112(42%)	12(60%)
Broken/damaged stem	2(3%)	36(18%)	43(16%)	4(20%)
Uprooted	1(2%)	2(1%)	8(3%)	3(15%)
with Slashed on stem	2(3%)	36(18%)	43(16%)	4(20%)
Harvested	1(2%)	8(4%)	40(15%)	0(0%)

as the age and diameter of the trees increases.

Likewise, prevalence of leaf diseases leaf diseases and skeletonizers are higher among larger diameter classes. Standards has highest remaining infection from rainy season to the unset of the summer with 15% of 20 individual surveyed were still parasitized. This was significantly higher that the three remaining classes: wildlings, sapling, and pole with 1.61%, 4.08%, and 1.13% respectively. It was also observed that larger diameter classes have also higher foliage volume which took longer to shed off. As a result, they were observed to have much remaining foliage which is still good source of food for the leaf skeletonizer and infection courts for pathogens as compared to trees of smaller diameter class. Wind damages like broken branches and blown down trees were also higher for pole and standard than in wildlings and saplings. Damages from this natural factors together with anthropogenic impact produce wounds which serves as infection court or entry points for pores carried by mobile insects and other arthropods (*Eusebio 1998*).

Among the potential anthropogenic threats pointed out by *Madulid and Agoo* (*1990*) and *Caringal and Castillo* (*2002*), utilization of Philippine teak for charcoal and pole was observed in the field having the poles to be the most exploited with 15% as shown in table 3. Similarly, larger diameter classes were also the most affected by other human activities inside the Philippine teak forest resulted to 16% of poles and 20% of standard found to have stem damages like slashed and cut. The effects of seasonal defoliation have been observed to be fatal now among the regenerants because of the intense heat and drought. Wildlings are the most reactive to drought and heat with more than half defoliated follow by saplings with 50% while larger diameter trees are more resistant to drought due to deeper root system that can tapped the deeper soil moisture.

Notes on Arthropods and macrofungi diversity in Philippine teak forest

Aside from the leaf skeletonizer, a number of insects and other arthropods was encountered and documented (**Figure 8**). These organisms were not regarded as pest because almost all of them were not feeding from the tree or posting any harm on it. Majority of the insects and other arthropods are found in the rigid flaky bark of Philippine teak which served as a very good shelter against predators, extreme temperature, and unfavorable weather conditions. Among the insect found are (several species for each order): silverfish (Order *Thysanura*), ants (Order *Hymenoptera*), crickets (Order *Orthoptera*), cockroaches (Order *Blattodea*), moths (Order *Lepidoptera*), praying mantis (Order *Mantodea*), stick insects (Order *Phasmatodea*), termites (Order *Isoptera*), beetles (Order Coleoptera), and Scorpio flies (Order Mecoptera) (**Figure 8**). Other arthropods encountered are from the classes of Arachnida which includes spiders (Order *Aranae*) and scorpion (Order *Scorpiones*), Diplopoda which include cylinder millipedes (*Julus* sp.) and flat backed-millipedes (Polydesmus species), and Chilopoda (Order *Scolopendrida*). Other invertebrate such as forest snail (Gastropods) was also found hibernating from the intense summer under the bark. These arthropods are performing

Figure 8. Other insect species found in the Philippine teak: (a) snout beetle (*Curculionidae*), (b) Tenebrionid beetle, (c) predatory ground beetle (*Carabidae*), (d) mealybugs with ants (*Pseudococcidae*), (e) silverfish (*Thysanura*), (f) walkingstick (*Phasmida*) (g) Scorpio flies (*Mecoptera*), (h) termites (*Isoptera*), (i) tussock moth (Lymantriidae), (j) unkown specie (k) cockroaches (Blattodea), (l) cricket (*Gryllidae*), (m) tropical green ant (*Oecoplylla smaragdina*), (n) white ants (*hymenoptera*), (o) brown moth (*Pyralidae*), (p) black ant (*Dolichoderus*), and (q) mantis (*Phasmatodea*).

specifics ecological functions which contribute to maintenance of functioning forest ecosystem . Even though documentation about this is not one of the main objectives of this study, it is worth mentioning that Philippine teak houses high diversity of invertebrates particularly arthropods.

A number of macro fungi was also found in Philippine teak forest (**Figure 9**). The class of fungi which responsible for almost all of wood rotting diseases are belongs to Basidiomycetes which was notable for their fruiting bodies. They are sometimes regarded as macroscopic fungi because of their conspicuous and large fruiting bodies. Among the wood rotting fungi found to have fruiting bodies in the natural stand of Philippine teak were *Auricularia mesenterica* (Dicks.) Pres, *Auricularia auricula*, *Cantharellus infundibuliformis*, *Daedalea palisoti*, *Fomes* sp., *Ganoderam lucidum*, H*exagonia apiaria*, *Lenzites betulina*, *Panus rudis*, *Polyporus abieta* and *Polyporus* sp. (**Figure 9**). These fungi were suspected to cause the butt rot, heart rot and root rot of the Philippine teak. With their presence, it is also worth mentioning that there is a high diversity of fungi in the natural stand of Philippine teak.

CONCLUSION AND RECOMMENDATIONS

Despite recent conservation and protection efforts of the local government, there are notable anthropogenic threats to *T. philippinensis* including illegal harvesting for domestic poles and lumber even for charcoal production. These disturbances together with wind damages increase the risk to wood rotting diseases like butt rot, heart rot and root rot which are already prevalent within the stand. There were observed defoliator and leaf diseases in the stand with lesser threat to its survival. Variation on the extent and frequency for both leaf and wood diseases across altitudinal habitat range and across diameter class. Upper diameter classes (pole and standard) at lower habitat range (<100 m asl) are most threatened both

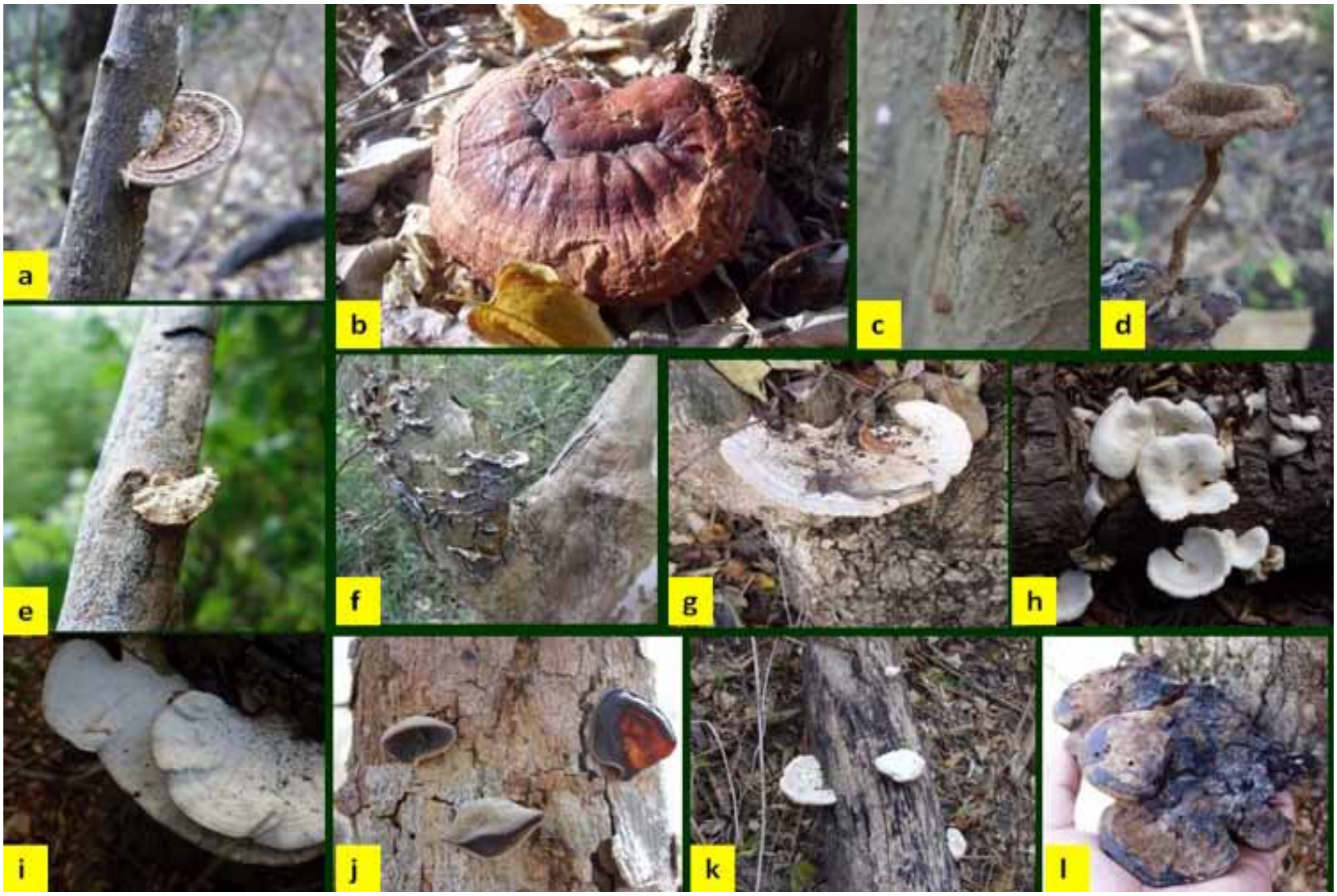

Figure 9. Different wood rotting fungi which can cause heart rot diseases on the natural stand of Philippine teak: (a) *Polyporus* sp., (b) *Ganoderma lucidum*, (c) *Polyporus abietina*, (d) *Cantharellus infundibuliformis*, (e) *Hexagonia apiaria* (Pers.) Fr. (f) *Auricularia mesenterica* (Dicks.) Pers., (g) *Daedalea palisoti*, Fr., (h) *Panus rudis*, (i) *Lenzites betulina*, (j) *Auricularia auricula*, (k) *Fomes* sp., and (l) *Ganoderma applanatum*.

naturally and anthropogenically. Philippine teak was also directly affected with the impacts of climate change. Increasing intensity of heat and drought during summer was also a major challenge to the survival of the regenerants. Ex-situ propagation of teaklets to assist natural regeneration can be good intervention to ensure continuous survival. Philippine teak also serves as an important function for a number of insects and other species of arthropods sheltering under its bark. Moreover, a number of species of macrofungi was also documented within the natural stand. This observation adds to its existing ecological importance. However, these insects are also the most probable vectors for the spread wood rotting diseases as they may carry pores from tree to tree. A deeper studies on the species riches and movement can be done to validate this assumption and formulate appropriate management interventions. To ensure long-term survival, continuous and innovative IEC (information and education campaign) about the ecological, historical and cultural importance must be done. Existing protection and conservation policies must be reiterated to the local community especially those residing at close proximity. Furthermore, Philippine teak can be included on priority species for reforestation/ afforestation programs such as National Greening Program (NGP). Regular inventory and other monitoring mechanisms must be initiated and institutionalized to tract status. Comprehensive studies on biology of pests and diseases, arthropods and macrofungi diversity, and climate change sensitivity must be done to provide more basis in ensuring its survival.

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