

RESEARCH PAPER

The Conservation and Collection of Cocoa Insects Fauna at the Malaysian Cocoa Board

Saripah Bakar*

Malaysian Cocoa Board, 5 – 7th Floor, Wisma SEDCO, Lorong Plaza Wawasan,
Off Coastal Highway, Locked Bag 211, 88999 Kota Kinabalu, Sabah, Malaysia

*Corresponding author: sari@koko.gov.my

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Abstract

The cocoa agroecosystem provides favorable conditions for numerous insect species, with more than 200 species were recorded in Malaysia. Some of the insects are economically important, particularly insects that are associated with cocoa plantation. A collection of insects was built up from 1981, throughout Malaysia via insect samplings and field observations in various landscapes, ranging from monoculture to intercropping planting systems. The sampling technique includes hand-picked, baiting techniques, sweeping for aerial and flying insects, trapping for crawling and ground surface insects as well as light traps for nocturnal insects. At current, more than 10,000 individual insects were collected. Of these, 11 orders of insect from 177 families belonging to more than 600 species were identified, deposited and conserved in the Entomology Laboratory at the Cocoa Research and Development Center Bagan Datuk (CRDC Bagan Datuk) of the Malaysian Cocoa Board (MCB). In order to disseminate information on the biodiversity of insect pests and diseases of cocoa to the target users, the online portal was developed in 2013. The portal, Cocoa Pests and Diseases (CROPED) can be accessed online at the URL of <http://cropped.koko.my>. Until April 2019, 54 articles mainly on the management of pests and diseases of cocoa were uploaded with detail description of 28 species of insects. Conservation of thousands of specimens are properly maintained at the Entomology Laboratory. This information was made available to the public and researchers for further reference.

Keywords: Cocoa; Cocoa agroecosystem; Insects; Entomology; CROPED

INTRODUCTION

Cocoa, *Theobroma cacao* L. (Malvales: Sterculiaceae) is well-known as a shade-loving plant, therefore it usually cultivated with *Gliricidia* sp. as a permanent shade tree. In some areas, cocoa was intercropped with coconut, fruit trees, banana or other economical crops. This intercrop planting system may provide species diversity of flora and fauna. Cocoa is afflicted by a large number of insects, with 123 families of insect pest and natural enemies recorded in Sabah (Conway, 1971). Lee et al., (2013) denoted more than 200 species of insect pests have been recorded in cocoa plantations in Malaysia, and a few species are of economic importance (Lee et al., 2014). Fifteen insects are known as important insect pests (mosquito bug, bee bug, cockchafers beetles, branch borer, mealy bug, bagworms, aphids, grasshopper, shot-hole borer, cocoa white grub, husk borer, shoot borer, cocoa pod borer and thrips) and infested cocoa at different age and part of the tree. Among all species, the Cocoa pod borer (CPB) *Conopomorpha cramerella* Snellen (Lepidoptera: Gracillariidae) is recognized as the major insect pest of cocoa

in Southeast Asia (Alias & Kelvin, 2017). Another economic pest is the mirid, *Helopeltis theivora* (Hemiptera: Miridae) which widely distributed in this region (Saripah et al., 2017). Cocoa stem borer, branch borer, and cocoa husk borer also known infested mature cocoa trees. Other insect pests are less important, but they are still capable of being important pests when there was an outbreak.

Not only cocoa pests become a limiting factor; diseases also contributed to significant yield losses to the cocoa growers. There are several diseases associated with cocoa such as black pod, stem or trunk canker, vascular streak dieback, and root diseases were reported in Malaysia (Lee et al., 2014). Vertebrate pests (monkeys, wild boars, civet cats, rat, and squirrels) also contribute to severe damage, with rodents as the major pests in most cocoa cultivated areas. Combination of insects, diseases and vertebrate pests may become a serious problem to the cocoa growers and inflict to the significant yield loss.

Other than the pest, beneficial insects also important aspects to the sustenance of cocoa ecosystem, especially pollinators (Saripah & Alias, 2018), and the Cocoa black ant (*Dolichoderus thoracicus*). Most of the observations on the pollinators were from the genus *Forcipomyia* spp. even another three species of ceratopogonids comprised of genus *Dasyhelea* spp., *Brachypogon* spp., and *Atricopogon* spp. were recorded in the Peninsula Malaysia (Azhar & Wahi, 1984). In addition to their previous research, Azhar (1990) listed 17 species of genus *Forcipomyia* as important cocoa pollinators worldwide and seven species was recorded in Perak, Malaysia. Meanwhile, for the Cocoa black ants, numerous research was undertaken, especially on their population distribution (Saripah, 2014a; Abdul Hakim et al., 2017; Nor Aizam et al., 2018) and their function as a biological control agent against the major pest of cocoa (Saripah, 2014b). With a diversity of flora and fauna found in the cocoa ecosystem, therefore access to the wealth of information and technical advisory on this critical aspect must be disseminated among the target users. Information on the pests, beneficial insects and diseases also benefited to the staffs, students and public that associated directly or indirectly with the cocoa industry.

Study Objectives

The objective of the study is to provide information or database on the insect collection and specimen deposited at the Entomology Laboratory CRDC Bagan Datuk from the 1980s, until this recent years. This information, especially on the cocoa pest and disease, later on were disseminated to the public via an online platform, with the establishment of Portal Cocoa Pests and Diseases Information System (CROPED).

Significance of the Study

Diversity of insect presents in the cocoa agroecosystem with different roles and functions (beneficial insects, pests or neutral) is an important element for the sustainability of this commodity. Conservation of insect biodiversity via proper collections and systematic approach can be useful tools as a source of reference in the future. Deposition of important specimens is a necessity in entomological aspect especially when dealing with special condition, for example, outbreak of occasional insect pest. Any information on factors that affected cocoa production, particularly pests and diseases must be disseminated and easily accessible by the target users.

Therefore, development of an online platform which can aid the cocoa farmers to control pests or diseases, or dealing with pest emergence or resurgence was embarked by the MCB. A portal, Cocoa Pests and Diseases Information System (CROPED) is internally developed by MCB's Information Technology and Service Unit in collaboration with the Cocoa Upstream Technology Division. This portal is an open-access platform and can be browsed by the public who have an interest in cocoa pests and diseases.

METHODOLOGY

The initial establishment of insect collection at CRDC Bagan Datuk

The collection of insects was initiated by the former Director General of the MCB cum worldwide expert entomologist, Dato' Dr. Azhar Ismail since 1981 during the pre-MCB 's era which was at the MARDI Research Station, Hilir Perak, Perak. Insects' collection was continued with the establishment of MCB's research center in Cocoa Research and Development Center (CRDC) Bagan Datuk, Perak (formerly known as CRDC Hilir Perak) in the year 2000.

Study sites

Insect collections were carried out at 10 states in Malaysia, which were at Perlis (Chuping, Arau), Selangor (Sungai Bernam, Kuala Selangor), Perak (Hilir Perak, Hutan Melintang, Bagan Datuk, Sitiawan, Teluk Intan, Lumut), Pahang (Tekam, Raub), Melaka (Jasin), Terengganu (Jerangau, Kemaman), Kedah (Changloon), Kelantan (Kota Baharu), Johor (Pontian, Batu Pahat) and Sabah (Tawau). Most of the specimens were collected at Perak state, due to the logistics and frequent insect collection.

Field sampling

Insect collections involve several techniques such as hand-picked, baiting techniques, sweeping for aerial and flying insects, trapping for crawling and ground surface insects as well as light traps for nocturnal insects. Since 1981, insects were collected from various hosts, either on the cocoa trees, coconut, *gliricidia* trees or other associated trees or plant in the cocoa environment.

Species identification

Researchers and staffs in the entomology field cannot be expected to be knowledgeable about all species, hence they must rely on the available species collection. Therefore reference specimens must be kept and preserved in good condition. With the aid of taxonomy key to the species level, this systematic approach will allow relevant parties to procure available information concerning each species. For more accurate identifications, specimens were sent for identification by taxonomists at the Commonwealth Institute of Entomology and British Museum in London in the mid of 1980s (Azhar et al., 2010).

Insect preservation and maintenance of the collection

Insects collected were pinned, labeled or stored (glass bottles, plastic caps, gelatin capsules) and kept in the wooden box for conservation. Some insects, especially at the larval stage were preserved in an alcohol.

Establishment of Portal Cocoa Pests and Diseases Information System (CROPED)

Even though numerous information was published in the recent decade, the lack of efficient methods for information retrieval will let pests and disease problems worsen. The control of pest and diseases has been relatively more difficult if the information is insufficient or hardly accessible by the public. Most of the information was available in hardcopies printable version and the English language. Hence an information disseminating system that is simple and easy to be accessed by the target users must be developed. Appropriate information on pest and diseases must be easily retrieved, and this will open the door to the creation of knowledge-based portal or any kind of informative database. Therefore, the establishment of Portal Cocoa Pests and Diseases Information System (CROPED) was embarked by the MCB in the year 2013.

RESULTS

From the year 1980 through 1988, there were only 744 specimens, belonging to approximately 100 insect families deposited in the Entomology Laboratory. Since then, collection of specimens were continuously undertaken throughout the years, and in 2019 more than 10,000 specimens were deposited in this laboratory. There are 623 insect species belonging from 177 families, and 11 orders were maintained and can be a source of reference for cocoa insects. The highest order was collected on the cocoa leaf with eight orders from Diptera, Hymenoptera, Hemiptera, Coleoptera, Lepidoptera, Homoptera, Odonata and Neuroptera (Figure 1). Other trees associated with cocoa recorded seven orders from Hymenoptera, Hemiptera, Homoptera, Coleoptera, Lepidoptera, Homoptera, Odonata and Orthoptera. Coconut leaf, gliricidia leaf, and tree and grass recorded six orders. Four orders were collected at the nursery, cocoa pod and from a coconut yellow dwarf. Out of 177 families of insect, the highest number was recorded from Coleoptera with 45 families (Figure 2), followed by Lepidoptera (32), Hymenoptera (31), Diptera (28), Hemiptera (18) and Homoptera (14). Less than five families were collected from Orthoptera, Neuroptera, Dictyoptera, Isoptera and Odonata orders.

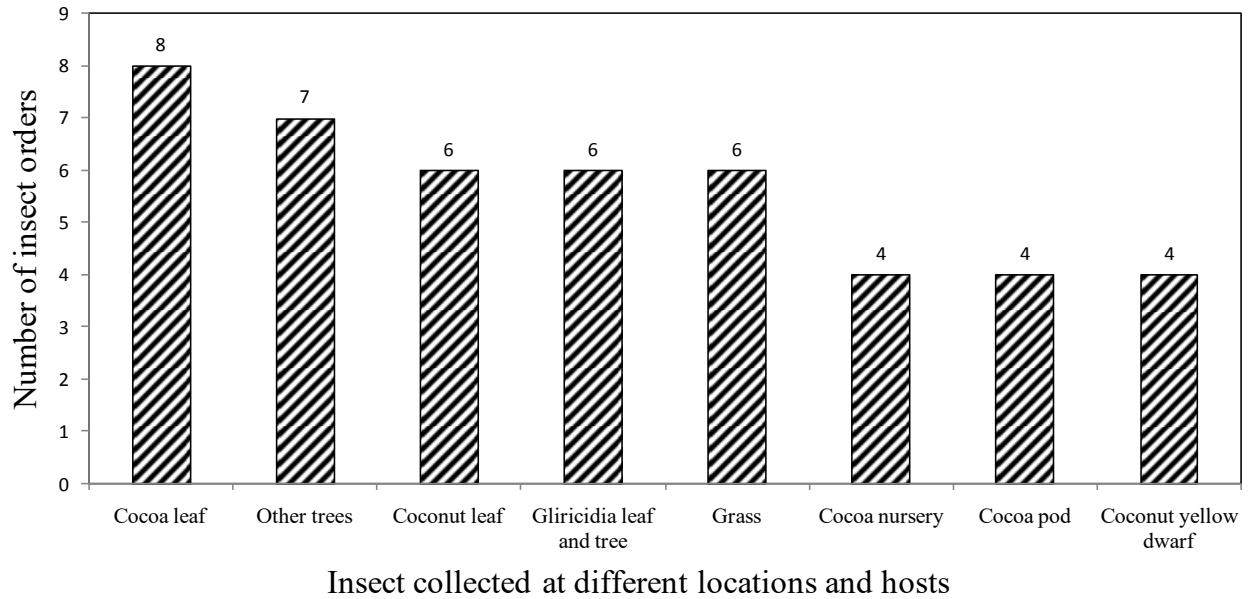


Figure 1. The number of insect orders collected from different locations and hosts

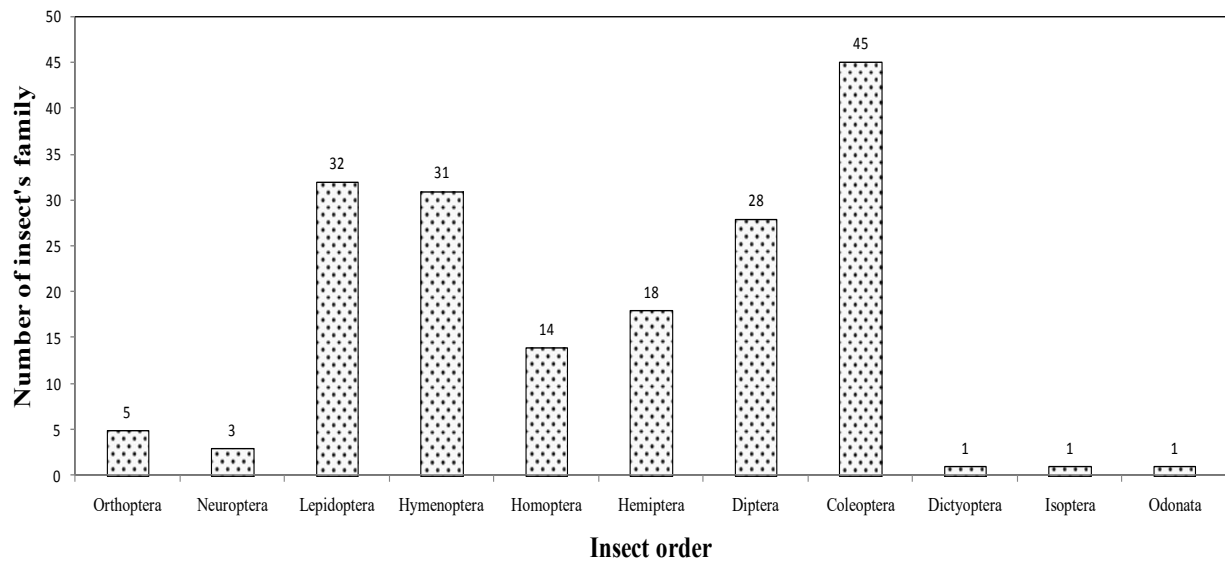


Figure 2. The number of insect family recorded from different insect order

Insects were collected from different locations and hosts, and the percentage is shown in Figure 3. Cocoa trees harbored the highest number of insects, with 36.70 % among all the deposited specimens. This was followed by other trees (10.30 %), ground (9.33 %) and coconut tree (8.80%). The focus was also given to insects that directly associated with cocoa trees, and the highest number of insects were recorded found on the cocoa leaf (53.13 %), followed by decaying and rotten cocoa pods (12.22 %); and either inside or outside the cocoa pods (Figure 4).

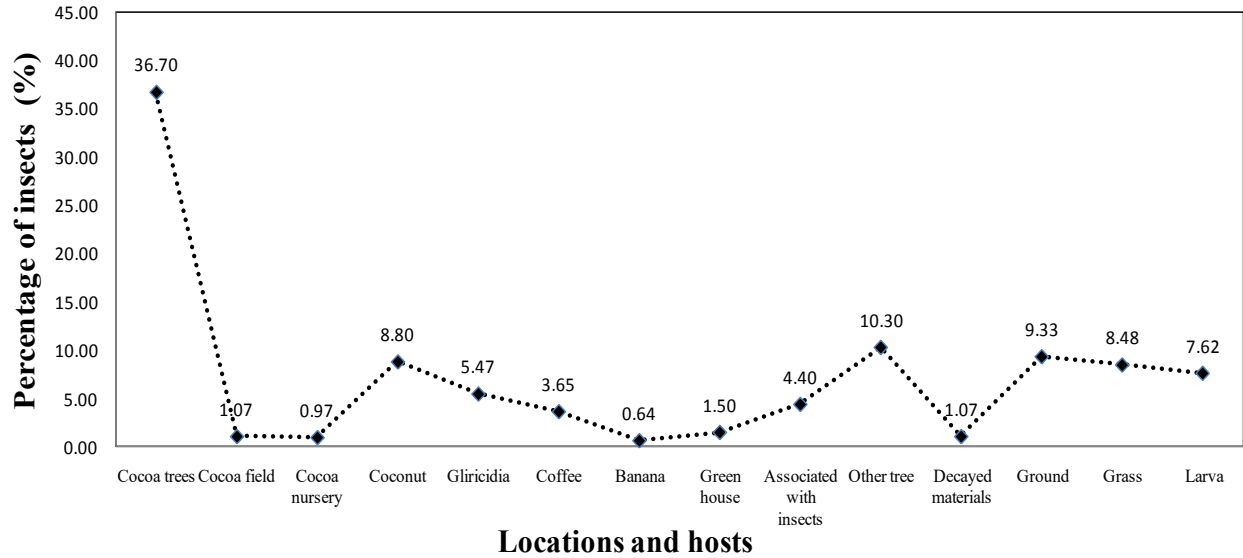
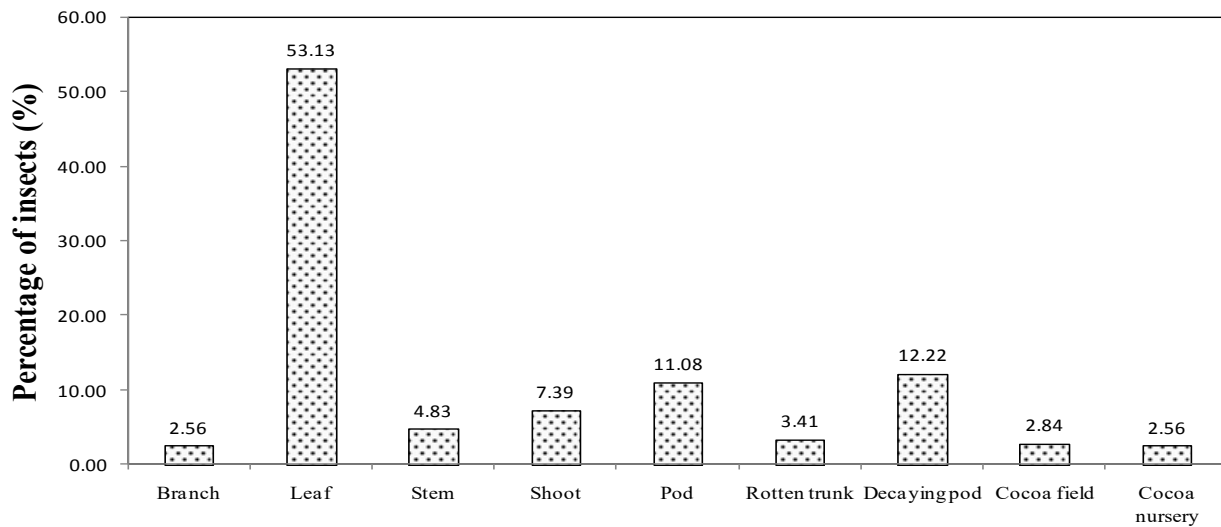


Figure 3. Insect specimens recorded from various hosts



Insect collected at different parts of cocoa trees and locations

Figure 4. Insect specimens recorded associated with cocoa trees

Application of an online platform in disseminating information is proven very effective, and regards to this, the MCB developed a portal which focused on pest and diseases in the cocoa ecosystem. The portal Cocoa Pests and Diseases Information System (CROPED) or Portal Perosak dan Penyakit Koko was officially launched by the Honorable Minister of Malaysian Plantation and Commodities Malaysia in October 2013. The portal was available online at <http://cropped.koko.my>. Portal or database can be more extensive than hardcopy printable version, and yet they are much more effectively searched. They can also be networked, and the internet

allows actual or potentially both shared access to live datasets and, increasingly, added value through interoperability across distributed datasets (Scoble, 2002). Until April 2019, 54 research articles on the pest and diseases of cocoa by the MCB's officers were uploaded, and 45 articles on the cocoa research in general. The number of registers users until April 2019 is 1,134 as compared to 18 users in November 2013 shortly after the first month launched of this portal (Figure 5). The number of hits was steadily increased after it was launched from 3,716 hits in November 2013 to 23,944 hits (November 2014), 83,563 (November 2015), 137,892 (November 2016), 181,700 (November 2017) and 227,493 viewers in April 2019.

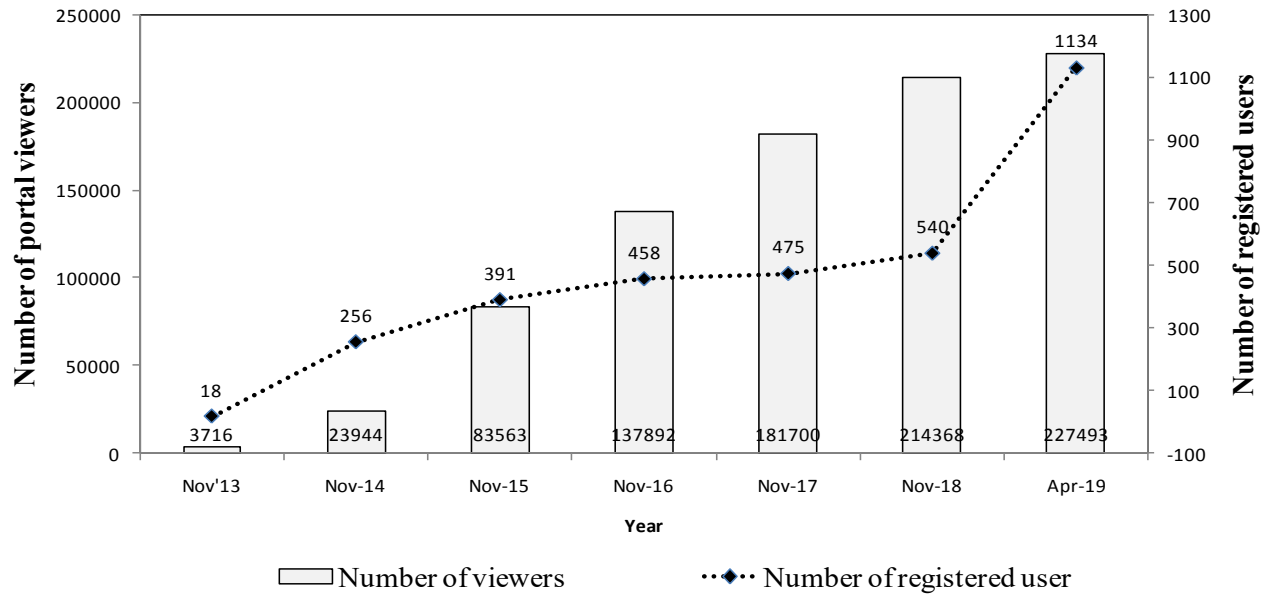


Figure 5. The number of viewers and registered users from November 2013 through April 2019

DISCUSSIONS

Massive cocoa cultivation and gradual expansion of the host-ranges of indigenous insect species were believed to be one of the factors contributing to the species richness and composition in cocoa. Lee et al., (2013) recorded more than 200 insect species are associated with cocoa plantation which can be divided into two categories based on roles and functions, i.e. herbivores including the defoliators, stem borers, fruit borers; and carnivores especially the natural enemies (Azhar, 1995). With the vision to be the world renown, reputable and leading institution for sustainable development of the cocoa industry, the MCB accounting every single aspect that has a linkage with cocoa including this entomological field. With the diversity of insects and their specific roles posses by different species, insect collections become one of the priorities for researchers and staffs of Entomology Unit. The establishment of insect collection in the MCB is neither a short-term collection nor a simple project. This includes involvements of experienced manpower, the diversion or creation of monetary recourses and the most important is a continuous program of insect collections. With tremendous and continuous efforts in collecting,

preserving and maintaining good conditions of the specimens, this Entomology Unit is successfully established and become a referral for cocoa insect pests in Malaysia.

With enormous specimens deposited in this Entomology Laboratory, an identification which is a process of finding the taxon to which specimen belongs is very important. A method such as using conventional identification keys and interactive keys are available for aiding the identification process (Pankhurst, 1991). The implementation of systematic entomology in the ranking and classifying insect with the highest level of diversification is essential in the management of insect specimens. Systematic is the basic component in entomology, and preservation of insect specimens requires major and continuous effort to ensure the specimens will be kept in a good condition for further reference in the future. The benefit of having insects identified quickly and accurately will be evident to the entomologist. Proper identification of existing specimens to the key species is an important aid, especially to the junior entomologist, students or relevant parties that has less experience in the insect taxonomy. Having a systematic collection of insects will help in the identification process and later on will be an important aspect in the development of excellent insect reference center (Azhar, 1984; Zack & Azhar, 1988). All specimens deposited at the Entomology Laboratory were very well preserved, and maintenance was carried out regularly in order to ensure good conditions of the specimen. More than 2,500 specimens that deposited from the year 1981 through 1985 are still in good condition due to proper maintenance that was taken at regular. These specimens, including pests of cocoa, pests of other economic plants, beneficial insects such as pollinators, parasites of other insect species, predator as well as non-economical insects can be a good reference for current research on the biodiversity of the insect in cocoa agroecosystems.

There are many references for the cocoa insects were published in a book, manual, pamphlet, flyers and other elements of printable versions. Most of the references were written in English and more focus on the insect pests of cocoa (Entwistle, 1972; 1985). The details on every aspect were discussed, including the biology, taxonomy and control approach in managing specific pests. Many of these insect pests of cocoa also been briefly described in several books (Yusof, 2012; Khoo et al., 1991; Ooi, 1994; Yusof & Khoo, 1989). The management of the Cocoa pod borer was described in detail in Ooi et al., (1987). Other important pests of cocoa were also described in a book chapter published by the MCB (Azhar et al., 2009; Lee et al., 2013). As most of the cocoa smallholders preferred information in the Malay language, therefore, several publications were published by the MCB in book chapters (Lee et al., 2013 & 2014, Sapiyah et al., 2009a & 2009b). Information on the cocoa pests also disseminated to the cocoa growers in a manual form, namely flyers, pamphlet, calendars and posters.

The pests and diseases of cocoa were introduced with pictures of insects or diseases, as well as damage symptoms. The symptoms are a relevant criterion in the diagnosis and identification of the insects, as most symptoms are species or taxon-specific (Azhar, 1988). Details information on the infestation symptoms and their associated insects were presented with several color photographs for each species. Recommendations on controlling pests and diseases based on information derived from previous research and recent trials were explained and suggested to cocoa growers in CROPED. There are 54 articles on pest and diseases were uploaded in the Content with 34 international web linkages that associated with cocoa pests and diseases. The portal contents consisted of the Home, Introduction, Pests, Diseases, Search, Gallery, Frequently Ask Questions and Linkage. The public can access information on services and available facilities of five P&D Laboratory in the MCB, including laboratories at the CRDC

Bagan Datuk, Perak and two at the CRDC Tawau, Sabah. Recently, there are 30 articles on insects was available with seven articles of pests that infested cocoa pods, 14 articles of pests of cocoa leaf and shoots, seven articles on cocoa bark and trunk borers and one article on the beneficial insect. Other than cocoa pest information, articles for mammalian pests (4) and rodent pests (2) were also uploaded. The public also can browse seven articles on diseases, including root disease (1), stem and branch (3), cocoa pod (2) and one article for leaf disease. The Photo Gallery menu was uploaded with more than 300 pictures that will help the public in understanding symptoms, biology, and information of every species. The publication menu was uploaded with more than 99 publications related to the pests and diseases researches at the MCB.

CONCLUSIONS

Conservation of insect biodiversity in the cocoa ecosystem will be very important as a further reference in the future. Good maintenance of all specimens must be prioritized, and sampling of insects must be carried out as a source of specimen enrichment. With more than 200 species of insects that potentially become a pest, information on how to manage insect pests, as well as diseases and vertebrate must be disseminated to the cocoa smallholders. Information in the CROPED portal can be assessable anywhere and everywhere, and hopefully, it will help the cocoa growers in managing cocoa plantation at their best.

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