NANO-EMULSION FORMULATION OF *Isaria fumosorosea* IN CONTROLLING BAGWORM, *Metisa plana* Walker AND POLLINATOR, *Elaeidobius kamerunicus* Faust IN OIL PALM PLANTATION

By

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Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Master of Science

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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The overuse of chemical insecticides to control bagworms in oil palm plantations could have severe repercussions for the environment, ecosystem, and human health. Therefore, the development of myco-insecticide formulation that can effectively control this pest could serve as an option to reduce reliance on chemical insecticides. Myco-insecticide have been proven to have considerable potential for the management of insects while minimizing the adverse effects of insecticides and they have accordingly been used worldwide to control various pests. This study involved the preparation, characterization, and evaluation of oil-based emulsion formulations of *Isaria fumosorosea*. The aim was to determine their efficacy against the larvae of

Metisa plana stage 1 until 4. The isolates were obtained from infected bagworms collected from United Malacca Berhad (UMB) Plantation in Kemayan, Pahang. The specific isolate, coded as BSB01 and identified as *Isaria fumosorosea* (voucher number TSJ772C), was used as the active component in the formulation development. This isolate was then mass produced and formulated through ternary phase diagram consisting of 20% (w/w) surfactant, 40% (w/w) oil and 40% (w/w) water containing 10^7 CFU/mL. Two ternary phase diagram systems were constructed, they were Tween 20/Glycerine/Water and Tween 80/Glycerine/Water. Both selected systems showed large isotropic regions. All formulations were stable under centrifuge, storage at 26±1°C, and under high temperature 54±1°C for two weeks. Both formulations were above >100 nm sizes indicating that the formulations formulated were not in the category of the nano-emulsion. The zeta potential ranged between -29.4 to -36.2 mV, the pH ranged from 6.53 to 7.38, the surface tension ranged from 41 to 51 mN/m, and the viscosity ranged from 300.83 to 384.73 mPas. However, 45 days after treatment the application of all myco-insecticide formulation; Tween 20/Glycerine/Water and Tween 80/Glycerine/Water developed with *I. fumosorosea* as an active ingredient gave an equal efficacy compared to the positive controls and were able to lower the population of *M. plana* at all important stages below the economic threshold level (ETL). All formulated formulations compared, showed no significant increase in mortality of the oil palm pollinator, *Elaeidobius kamerunicus*, suggesting that all were completely harmless despite a dip in the population number week after treatment application. This finding also indicates that abiotic factors such as daily temperature, relative humidity, rainfall amount

and mean wind speed has a direct effect on the efficacy of the formulation's application.

Keywords: Bagworm, entomopathogenic fungi, *Isaria fumosorosea*, nano-emulsion, pollinator

SDG: GOAL 9: INDUSTRY, INNOVATION AND INFRASTRUCTURE

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk Ijazah Master Sains

FORMULASI NANO-EMULSI *Isaria fumosorosea*
DALAM MENGAWAL ULAT BUNGKUS, *Metisa plana* Walker
DAN PENDEBUNGA, *Elaeidobius kamerunicus* Faust
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Kebergantungan yang berlebihan terhadap penggunaan racun serangga kimia untuk kawalan ulat bungkus di ladang kelapa sawit boleh membawa kepada pelbagai kesan kepada ekosistem, alam sekitar dan manusia. Oleh kerana itu, pembangunan formulasi racun serangga miko yang boleh mengawal ulat bungkus serta menjadi alternatif dalam mengurangkan kebergantungan racun serangga kimia. Racun serangga miko telah terbukti mempunyai potensi besar di dalam pengurusan serangga perosak, sambil meminimumkan kesan buruk racun serangga kimia, ia juga telah banyak digunakan di seluruh dunia dalam mengawal pelbagai perosak. Dalam kajian ini, formulasi emulsi *Isaria fumosorosea* berasaskan minyak telah disediakan, dicirikan, dan dinilai

keberkesanannya terhadap larva *Metisa plana* peringkat 1 hingga 4. Strain *I. fumosorosea* (baucar bernombor TSJ772C) berkod BSB01 yang diasingkan daripada ulat bungkus yang dijangkiti dari ladang United Melaka Berhad (UMB) di Kemayan, Pahang telah digunakan sebagai bahan aktif dalam pembangunan formulasi kerana ia merupakan pencilan paling virulen terhadap *Pteroma pendula*. Pencilan ini kemudiannya dihasilkan di dalam kuantiti yang banyak (10^7 CFU/mL), dan diformulasikan melalui rajah fasa ternary yang terdiri daripada 20% (w/w) surfaktan, 40% (w/w) minyak, dan 40% (w/w) air. Pertama, surfaktan dan minyak dinilai keserasiannya dengan konidia dengan menggunakan kaedah pemiringan terus. Dua sistem melalui rajah fasa ternary telah dihasilkan, iaitu Tween 20/glyserin/air dan Tween 80/glyserin/air. Kedua-dua sistem yang dipilih menunjukkan kawan isotropik yang besar. Kesemua formulasi adalah stabil di bawah emparan, penyimpanan pada 26±1°C, dan di bawah suhu setinggi 54±1°C selama dua minggu. Kedua-dua formulasi mempunyai saiz melebihi >100 nm yang menunjukkan formulasi yang dihasilkan bukan dalam kategori emulsi-nano. Potensi zeta formulasi berjulat antara -29.4 hingga -36.2 mV, pH antara 6.53 hingga 7.38, tensi permukaan antara 41 hingga 51 mN/m, dan kelikatan antara 300.83 hingga 384.73 mPas. Namun begitu, selepas 45 hari selepas aplikasi penggunaan formulasi racun serangga miko; Tween 20/glyserin/air and Tween 80/glyserin/air yang dihasilkan menggunakan *I. fumosorosea* sebagai bahan kandungan aktif memberi keberkesanan yang setaraf jika dibandingkan kawalan positif, serta mampu mengurangkan populasi *M. plana* terutamanya pada peringkat yang penting di bawah tahap ambang ekonomi (ETL). Fomulasi – formulasi yang dihasilkan juga tidak menunjukkan sebarang peningkatan ketara terhadap

pendebunga kelapa sawit, *Elaeidobius kamerunicus*. Ini menunjukkan bahawa kesemua formulasi yang dihasilkan tidak berbahaya sama sekali walaupun terdapat penurunan bilangan populasi seminggu selepas rawatan dijalankan. Penemuan ini juga menunjukkan bahawa faktor abiotik seperti suhu harian, kelembapan relatif, jumlah hujan dan min kelajuan angin mempunyai kesan secara terus kepada keberkesanan aplikasi formulasi.

Kata Kunci: Emulsi-nano, *Isaria fumosorosea*, kulat entomopatogenik, pendebunga, ulat bungkus

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TABLE OF CONTENTS

	Page
ABSTRACT	i
ABSTRAK	iv
ACKNOWLEDGEMENT	vii
APPROVAL	viii
DECLARATION	x
LIST OF TABLES	xv
LIST OF FIGURES	xvii
LIST OF ABBREVIATIONS	xix
CHAPTER	
1 INTRODUCTION	1
2 LITERATURE REVIEW	6
2.1 *Elaeis guineensis* Jacq	6
2.2 Bagworms in Malaysia	8
2.2.1 *Metisa plana* Walker	10
2.3 Oil palm pollinating weevil	13
2.4 Entomopathogenic fungi	16
2.4.1 *Isaria fumosorosea* Wize	18
2.5 Pesticide formulation	22
2.5.1 Mycoinsecticide formulation	25
2.6 Component of the formulation	30
2.6.1 Carrier	30
2.6.2 Surfactants	31
2.7 Types of surfactants	32
2.7.1 Anionic surfactants	32
2.7.2 Non-ionic surfactants	32
2.7.3 Cationic surfactants	34
2.7.4 Amphoteric and Zwitterionic surfactants	34
2.8 Formulating and characterization of emulsion formulation	35
2.8.1 Pseudo-ternary phase diagram	35
2.9 Physical characterization and evaluation of nano-emulsion	36
2.9.1 Zeta Potential (ZP)	36
2.9.2 Polydispersity (PDI)	37
2.9.3 Surface tension measurement of emulsion	37
2.9.4 Viscosity measurements of nano-emulsion	38
3 PREPARATION AND CHARACTERIZATION OF NANO-EMULSION FORMULATION OF *Isaria fumosorosea* WIZE	39
3.1 Introduction	39

3.2 Materials and methods 41
3.2.1 Fungal material 41
3.2.2 Ingredients 42
3.2.3 Preparation of oil nano-emulsion formulation 45
3.2.4 Characterization of nano-emulsion formulation 48
3.2.5 Statistical analysis 51
3.3 Results 52
3.3.1 Screening of surfactants through *I. fumosorosea* mycelial viability 52
3.3.2 Effects of oil on *I. fumosorosea* mycelial viability 53
3.3.3 Test for miscibility of the inert components 54
3.3.4 Phase diagram of nano-emulsion using a ternary phase diagram 55
3.3.5 Points of Selection 57
3.3.6 Stability of nano-emulsion formulations under centrifuge 58
3.3.7 Thermostability test of nano-emulsion formulations 59
3.3.8 Particle Size and Zeta Potential (ZP) 59
3.3.9 pH measurements of nano-emulsions 60
3.3.10 Surface tension of nano-emulsions 60
3.3.11 Viscosity Measurement of Nano-emulsions 61
3.4 Discussion 61
3.5 Conclusion 65

4 EFFICACY OF FORMULATED *Isaria fumosorosea* EMULSION ON *Metisa plana* AND ITS SIDE EFFECTS ON *Elaeidobius kamerunicus* 67
4.1 Introduction 67
4.2 Materials and methods 69
4.2.1 Study site for efficacy of *I. fumosorosea* formulations 69
4.2.2 Experimental design 70
4.2.3 Treatment application 71
4.2.4 Pre- and post-census of *Metisa plana* population 74
4.2.5 Study site for side effects of *I. fumosorosea* formulations on *E. kamerunicus* 75
4.2.6 Experimental Design 76
4.2.7 *E. kamerunicus* sample population 76
4.2.8 Treatment application 77
4.2.9 Data analysis 78
4.3 Results 79
4.3.1 Bagworm census 79
4.3.2 Pollinator census 81
4.4 Discussion 84

4.5 Conclusion 88

5 EFFECTS OF TEMPERATURE, RAINFALL, RELATIVE HUMIDITY, AND WIND SPEED ON *M. plana* POPULATIONS AFTER BEING APPLIED WITH *I. fumosorosea* EMULSION FORMULATION 89

5.1 Introduction 89
5.2 Materials and methods 91
5.2.1 Study area for weather variables effects on *I. fumosorosea* formulations 91
5.2.2 Data collection 91
5.2.3 Statistical analysis 92
5.3 Results 93
5.3.1 Weather parameters 93
5.4 Discussion 101
5.5 Conclusion 107

6 SUMMARY, GENERAL CONCLUSION, AND FUTURE RESEARCH RECOMMENDATIONS 109

REFERENCES 113
BIODATA OF STUDENT 142
LIST OF PUBLICATIONS 143

LIST OF TABLES

Table		Page
2.1	Entomopathogenic fungi (EPF) evaluated as biocontrol agents against bagworms	21
2.2	Types of chemical formulations and its application methods	24
3.1	Components for the pseudo-ternary phase diagram study	43
3.2	Surfactants, oil, and water grouped in different combinations for pseudo-ternary phase diagram construction	46
3.3	*I. fumosorosea* mycelial germination in different surfactants concentrations	52
3.4	*I. fumosorosea* mycelial germination in different oils concentrations	53
3.5	Miscibility test between surfactants and oils used based on spontaneous emulsification	55
3.6	Components of the oil nano-emulsion formulations from the homogenous phase	56
3.7	Stability assessment of nano-emulsion formulations following centrifugation at a storage temperature	59
3.8	Mean particle size and Zeta potential of the formulations	60
3.9	Surface tension, pH, and viscosity of formulated nano-emulsions	61
4.1	List of treatments and recommendation rates per hectare	73
4.2	Treatment list and recommendation rates per inflorescences	78
4.3	Mean population of *Metisa plana* days after treatment (DAT) application.	80

4.4	Mean population of EK days after treatment (DAT) application	83
5.1	Weather parameters collected from Malaysia Meteorological Department	92
5.2	Correlation between population of *M. plana* treated *I. fumosorosea* emulsion formulations with weather parameters	98

LIST OF FIGURES

Figure		Page
2.1	The complete life cycle of *Metisa plana*	13
3.1	Miscibility test result; from left to right (Agnique PG9116/glycerine/water), (Termul 1284/glycerine/water), (Paraffin oil/glycerine/water), (Tween 80/glycerine/water), and (Tween 20/glycerine/water)	54
3.2	Phase diagram of Tween 20 / glycerine / water	56
3.3	Phase diagram of Tween 80 / glycerine / water	57
3.4	Visual observation of nano-emulsion formed from selected points with mycelia and water suspension at 26±1°C	58
4.1	Location of Felda Gunung Besout 2 oil palm plantation	70
4.2	Cifarelli Nuvolla mistblower	72
4.3	Experimental design in RCBD for 12 treatments with 3 replications	74
4.4	Life stages of *Pteroma pendula* and *Metisa plana*	75
4.5	Pneumatic sprayer	77
4.6	Mean population of *Metisa plana* days after treatment	81
4.7	Mean population of EK at each days after treatment	83
5.1	Daily weather parameters during the study; daily minimum, maximum and mean temperature	99
5.2	Daily weather parameters during the study; daily minimum, maximum and mean RH	99
5.3	Daily weather parameters during the study; daily rainfall amount	100

5.4 Daily weather parameters during the study; daily mean wind speed 100

LIST OF ABBREVIATIONS

CFU	Colony-forming unit
ETL	Economic threshold level
WP	Wettable powder
EC	Emulsifiable concentrate
G	Granule
GDP	Gross Domestic Product
EK	*Elaeidobius kamerunicus*
DAT	Day after treatment
SAS	Statistical Analysis System
ANOVA	Analysis of Variance
RCBD	Randomised Complete Block Design
CRD	Completely Randomised Design
SE	Standard error
EPF	Entomopathogenic fungi
USEPA	United State Environmental Protection Agency
ULV	Ultra-low volume
HLB	Hydrophilic-lipophilic balance
RH	Relative humidity
FELDA	Federal Land Development Authority
MPOB	Malaysian Palm Oil Board

CHAPTER 1

INTRODUCTION

Being recognized as a 'Golden Crop' of the country, oil palm has been a crucial commodities crop and a major contributor to the Malaysian economy for the past thirty years. Malaysia has the position of the second largest global producer of palm oil, following Indonesia accounting for around 27% of the total global palm oil production. Both Indonesia and Malaysia play a significant role in the oil palm sector, collectively accounting for over 85% of global oil palm production. Oil palm accounted for 2.7% of Malaysia's Gross Domestic Product (GDP) in the year of 2020 (Ahmad *et al*., 2023). As of the year 2019, the total land area of Malaysia dedicated to oil palm cultivation amounted to 5.9 million hectares, with approximately 46.9% of this land being in Peninsular Malaysia. Sabah and Sarawak exhibited a near parity in terms of their respective land allocations for oil palm cultivation, with Sabah accounting for 26.9% and Sarawak accounting for 26.1% of the total land share (Malaysia Palm Oil Board, 2020).

At present, there exist three prominent species of bagworms that have been identified as the primary pest impacting oil palm plantations. These species include *Metisa plana* Walker, *Pteroma pendula* Joannis, and *Mahasena corbetti* Tams (Lepidoptera: Psychidae) (Cheong and Tey, 2012). Ramlah *et al*., (2007) reported that both *M. plana* and *P. pendula* have caused severe

yield losses ranging from 33 to 47%, with *M. plana* being the most economically significant and crucial defoliator. While *M. corbetti* has a more widespread distribution and has been recorded from Borneo (Sabah and Brunei), Thailand, Indonesia, Solomon Islands, and Samoa (Robinson *et al*., 1994).

According to Wood and Norman, (2019), there has been an increase in the severity of bagworm outbreaks from the 1990s till the present. This has had a significant impact on the oil palm yield, as infestation has been found to be detrimental due to the use of delayed and inappropriate treatment measures (Tey and Cheong, 2013). During an outbreak, the bagworm larvae consumed a substantial quantity of photosynthetic leaf surfaces on oil palm trees (Priwiritama *et al*., 2019), thus impacting the productivity in terms of both the quantity and size of fruit bunches (Ooi and Norman, 2018). According to the Malaysia Act 1967 (Plant Quarantine Act 1967), the Malaysian government officially classified bagworm as a hazardous pest on 15 November 2013 (Norman et al., 2017). Under the provisions of the Plant Quarantine Act 1967, anyone who owns a plantation or is a smallholder and fails to take appropriate measures to control the bagworm infestation may be subject to penalties of up to RM10,000 or imprisonment for a period of two years (Attorney General's Chambers, 2013).

When the bagworm population reaches the economic threshold or when there is an explosion of pests in the field, control measures using chemical insecticides are the main choice. Due to the high intensity of the *M. plana* attack on oil palm plantation, it is a common choice due to the rapid action in reducing the pest population. In contrast to smallholdings, many plantations have increasingly adopted chemical insecticides as the primary method of bagworm outbreak management (Hasber and Noor, 2012). Malaysian Agriculture Digest (2013) has reported that in 2005, the usage of agrichemicals was RM328 million. Meanwhile in 2012, the increment figure of agrichemical usage to RM563 million was reported. The usage of pesticides in Malaysia showed a similar trend where there was a significant increase of about 28% since 2008.

However, overreliance on chemical insecticides in controlling these pests has often led to the development of much other more persistence problems such as resistance of pests to treatment, harmful chemical residues in the environment, and the disruption of beneficial insect populations. Despite the over usage, effective management of this pest in the oil palm industry remain unresolved. Biological control approaches have long been praised for their capacity to play a significant role in pest and disease management. Recent research revealed that biological control can be an effective alternative to chemical control.

To control the pest outbreak, today, pest control management has successful in manipulating living things, including beneficial bacteria. A biopesticide can be defined as a type of pesticide that is created from natural materials and possess the ability to effectively manage pests through unique biological effects or actions (Koul, 2023). Biopesticides have a narrower range of pests that they target compared to chemical pesticides, which means they can lower the risk to other organisms (Thakore, 2006; Glare *et al*., 2012). *Beauveria spp., Isaria spp., Lecanicillium spp*., and *Metarhizium spp*. are types of fungi that naturally occur and have the capacity to infect and kill several insect pests, including different species of herbivores that chew or suck on plants (Sharma *et al*., 2023). These fungi have a high degree of specificity towards their target and are environmentally friendly in comparison to synthetic pesticides that have a wide range of effectiveness. Several studies have shown the ability of various species of entomopathogenic fungi to cause infection in Lepidopterous caterpillars (Loong *et al*., 2013).

Research has shown that the use of oil emulsion or oil in water emulsion improves the efficiency of entomopathogens in controlling a diverse range of insects, regardless of whether the environment is regulated or uncontrolled (Polar *et al*., 2005b). The oil emulsion formulation developed by Kumar *et al*., in 2017 improved the effectiveness of *I. fumosorosea*. The oil formulations are useful in avoiding imbibitional damage of conidia (Xavier-Santos *et al*., 2011) to favour the dispersion and adhesion of conidia on the cuticle of the arthropod (David-Henriet *et al*., 1998). Besides that, the formulation could protect the

conidia against dehydration in low-humidity environments (Bateman *et al*., 1993).

Currently most of the studies done has been on the application of conidia as active ingredient, but little has been done with the usage of mycelium as active ingredient. With some of the studies reported that it can perform equally or even more virulent against several host species compared to conidia alone (Hall, 1981: Bartlett and Jaronski, 1988; Fargues *et al*., 1994; Jackson *et al*., 1997; Burges, 1998; Vandenberg *et al*., 1998; Vega *et al*., 1999). Therefore, this study sets several objectives in expanding the knowledge of *I. fumosorosea*, and the preparation of oil emulsion as a microbial biopesticide.

The objectives for this research were as below:

1. To develop and characterize emulsion formulation of *I. fumosorosea.*
2. To evaluate the efficacy of *I. fumosorosea* emulsion after application against the bagworms, *M. plana* and its side effects on oil palm pollinator, *Elaeidobius kamerunicus*.
3. To investigate the effects of temperature, rainfall, relative humidity, and wind speed on *M. plana* populations after being applied with *I. fumosorosea* emulsion formulation.

REFERENCES

Ahmad, M. J., Ismail, R. and Ghani, F. A. (2023). Review on socioeconomic and sustainability of oil palm plantations among rural communities in Malaysia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1208, No 1, p. 012054). IOP Publishing.

Abdullah, F., Sabri, M. S. M., Sina, I., Fauzee, F. and Isa, S. M. (2012). Response of the male bagworm moth (*Metisa plana* Walker, Lepidoptera: Psychidae) towards female bagworm pheromone lure in wind tunnel bioassays. *Asia Life Sci., 21(2)*: 375-389.

Adaigbe, V. C., Odebiyi, J. A., Omoloye, A. A., Aisagbonhi, C. I. and Iyare, O. (2011). Host location and ovipositional preference of *Elaeidobius kamerunicus* on four host palm species. *Journal of Horticulture and Forestry*, *3*(5), 163-166.

Aisagbonhi, C. I., Norman, K., Okwuagwu, C. O., Wahid, M. B., Jackson, T. and Adaigbe, V. (2004). Preliminary observations on a field population of the oil palm-pollinating weevil *Elaeidobius kamerunicus* in Benin City, Nigeria. *International Journal of Tropical Insect Science*, 24(3), 255-259.

Ali, S. R. A., Najib, M. A., Mazmira, M., Masri, M. and Basri, M. W. (2012). Field Efficacy of MPOB Ecobac (EC) for controlling Bagworm, *Pteroma pendula* (Lepidoptera: Psychidae) Outbreak in Oil Palm Plantation. In *UMT 11th International Annual Symposium on Sustainability Science and Management 09th-11th July*.

Ali, S., Huang, Z. and Ren, S. (2010). Production of cuticle degrading enzymes by *Isaria fumosorosea* and their evaluation as a biocontrol agent against diamondback moth. J. Pest Sci. 83, 361-370.10.1007/s10340-010-0305-6.

Albernaz, D. A. S., Tai, M. H. H. and Luz, C. (2009). Enhanced ovicidal activity of an oil formulation of the fungus *Metarhizium anisopliae* on the mosquito *Aedes aegypti*. Med. Vet. Entomol, 23:141-147.

Alvez, S. B., Pereira, R. M., Stimac, J. L. and Viera, S. A. (1996). Delayed germination of *Beauveria bassiana* conidia after prolonged storage at low, above-freezing temperatures. *Biocontrol Science and Technology*, 6, 575-581.

Alvez, R. T., Bateman, R. P., Prior, C. and Leather, S. R. (1998). Effects of simulated solar radiation on conidial germination of *Metarhizium anisopliae* in different formulations. Crop. Prot. 17(8), 675-679.

Alvez, R., Bateman, R., Gunn, J., Prior, C. and Leather, S. (2002). Effects of different formulations on viability and medium-term storage of *Metarhizium anisopliae* conidia. *Neotropical Entomology*, 31, 91-99.

Amsellem, Z., Sharon, A., Gressel, J. and Quimby. P. C. (1990). Complete abolition of high inoculum threshold of two mycoherbicides (*Alternaria cassia* and *A. crassa*) when applied in invert emulsion. *Phytopathology*, 80: 925-929.

Araújo, F. A., Kelmann, R. G., Araújo, B. V., Finatto, R. B., Teixeira, H. F. and Koester, L. S. (2011). Development and characterization of parenteral nanoemulsions containing thalidomide. *European Journal of Pharmaceutical Sciences*, *42*(3), 238-245.

Arias-Estevez, M., Lopez-Periago, E., Martinez-Carballo, E., Simal-Gandara, J., Mejuto, J-C. and Garcia-Rio, L. (2008). The mobility and degradation of pesticides in soils and the pollution of groundwater resources. *Agric. Ecosyst. Environ*. 123(4): 247-260.

Arnosti, A., Delalibera, I., Conceschi, M. R., D'Alessandro, C. P., Travaglini, R. V. and Camargo-Mathias, M. I. (2019). Interactions of adjuvants on adhesion and germination of *Isaria fumosorosea* on adults of *Diaphorina citrii*. *Scientia Agricola, 76*, 487-493.

Assadpour, E., Maghsoudlou, Y., Jafari, S. M., Ghorbani, M. and Aalami, M. (2016a). Optimization of folic acid nano-emulsification and encapsulation by maltodextrin-whey protein double emulsions. *Int. J. Biol. Macromol. 86*, 197-207.

Assadpour, E., Maghsoudlou, Y., Jafari, S. M., Ghorbani, M. and Aalami, M. (2016b). Evaluation of folic acid nano-encapsulation by double emulsions. *Food. Bioprocess. Technol. 9*, 2024-2032.

Attorney General's Chambers (2013). Declaration of dangerous pest 2013. Federal Government Gazette. PU(B) 468.

Auffray, T., Frerot, B., Poveda, R., Louise, C. and Beaudoin-Olivier (2017). Diel patterns of activity for insect pollinators of two oil palm species (Arecales: Arecacea). *J. Insect Sci., 17*(2):45.

Avery, P. B., Wekesa, V. W., Hunter, W. B., Hall, D. G., McKenzie, C. L. and Osborne, L. S. (2011). Effects of the fungus *Isaria fumosorosea* (Hypocreales: Cordycipitaceae) on reduced feeding and mortality of the Asian citrus psyllid, *Diaphorina citrii* (Hemiptera: Psyllidae). *Biocontrol Sci. Technol*. 21, 1065-1078. 10.1080/09583157.2011.596927

Avery, P. B., N. M. F. Abou-Ghadir, M. A. K. Nasser and M. R. Metwaly (2015). Compatibility of Isaria fumosorosea (Hypocreales: Cordycipitaceae) blastospores with agricultural chemicals used for management of the Asian citrus psyllid, Diaphorina citrii (Hemiptera: Liviidae). Insects, 4: 694-711.

Awalludin, M. F., Othman, S., Rokiah, H., Wan, N. A. and Wan, N. (2015). An overview of the oil palm industry in Malaysia and its waste utilization

through thermochemical conversion, specifically via liquefaction. Renew. Sustain. Energy Rev. 50, 1469-1484.

Ayuningsih, M. (2013). Frekuensi kunjungan Elaeidobius kamerunicus Faust pada bunga betina dan efektivitasnya terhadap pembentukan buah kelapa sawit. Tesis, Institut Pertanian Bogor, Bogor.

Azeem, A., Rizwan, M., Ahmad, F. J., Iqbal, Z., Khar, R. K., Aqil, M. and Telegaonkar, S. (2009). Nanoemulsion components screening and selection: a technical note. *AapsPharmscitech*, 10(1), 69-76.

Baboota, S. Shakeel, F., Ahuja, A., Ali, J. and Shafiq, S (2007). Design, development and evaluation of novel nanoemulsion formulations for transdermal potential of Celecoxib. *Acta Pharm*, 57; 315-332.

Bartlett, M. C., & Jaronski, S. T. (1988). Mass production of entomogenous fungi for biological control of insects. Fungi in Biological Control Systems, 61-85.

Barcelos, E., Rios, S. D. A., Cunha, R. N., Lopes, R., Motoike, S. Y., Babiychuk, E., Skirycz, A. and Kushnir, S. (2015). Oil palm natural diversity and the potential for yield improvement. *Front. Plant. Sci*. 2015, 6, 190.

Barlow, H. S. (1982). An introduction to the Moths of Southeast Asia. Art Printing Work Sdn Bhd. Kuala Lumpur. p. 305.

Barreto, L. P., Luz, C., Mascarin, G. M., Roberts, D. W., Arruda, W. and Fernandes, E. K. K. (2016). Effect of heat stress and oil formulation on conidial germination of *Metarhizium anisopliae* s.s. on tick cuticle and artificial medium. Jour. Inver. Path. 138(2016), pp: 94-103.

Basiron, Y. (2007). Palm oil production through sustainable plantations. Eur. J. Lipid Sci. Technol. 109. 289-295.

Basri, M., Halim, A. and Hitam, A. (1983). “Current status of *Elaeidobius kamerunicus* Faust and its effect on the oil palm industry in Malaysia, PORIM Occ”.

Basri, M. W., Hassan, A. H. and Zulkefli, M (1988). Bagworms (Lepidoptera: Psychidae) of oil palm in Malaysia, *PORIM Occasional Paper* No. 23:37 pp.

Basri, M. W. (1993). Life history, ecology and economic impact of the bagworm, *Metisa plana* Walker (Lepidoptera: Psychidae), on the oil palm. *Elaeis guineensis* Jacquin (Palmae). Phd thesis. University of Guelph.

Basri, M. and Kevan, P. G. (1995). Life history and feeding behavior of the oil palm bagworm, *Metisa plana* Walker (Lepidoptera: Psychidae).

Bakeri, S. A., Ali, S. R. A., Tajuddin, N. S. and Kamaruzzaman, N. E. (2009). Efficacy of Entomopathogenic Fungi, *Paecilomyces* spp., In Controlling the Oil Palm Bagworm, *Pteroma pendula* (Joannis). *Journal of Oil Palm Research* Vol. 21 December 2009 p. 693-699.

Basiron, Y. (2007). Palm oil production through sustainable plantations. *Eur. J. Lipid Sci. Technol*. 109(2007), 289-295. DOI: 10.1002/ejlt.200600223

Bateman, R. (1993). Simple, Standardized Methods for Recording Droplet Measurements and Estimation of Deposits from Controlled Droplet Applications. *Crop Protection, 12*(3), 201-206.

Bateman, R. P., Carey, M., Moore, D. and Prior, C. (1993). The enhanced infectivity of *Metarhizium flavoviride* in oil formulations to desert locusts at low humidities. *Ann. Appl. Biol. 122*, 145-152.

Bateman, R. (1994). Physical properties and atomization of ULV formulations of mycoinsecticides. In: Smits, P. H. (Ed.), Microbial Control of Pests, 4th European Meeting, IOBC WPRS Bulletin, 17, pp.189-192.

Bateman, R. P. (1997). Methods of application of microbial pesticides formulations for the control of grasshoppers and locust. *Memoirs of the Entomological Society of Canada*, 171:67-79.

Bateman, R. P. and Alves, R. T. (2000). Delivery systems for mycoinsecticide using oil-based formulations, Aspects *Appl. Biol. 57*, 163-170.

Batta, Y. A. (2003). Production and testing of novel formulations of the entomopathogenic fungus *Metarhizium anisopliae* (Metschinkoff) Sorokin (Deuteromycotina: Hyphomycetes). *Crop Protection, 22*, 415-422.

Beirnaert, A. and Vanderweyen, R. (1941). Contribution a l'etude genetique et biometrique des varieties d'*Elaeis guineensis*, Jacq. *Publication INEAC*, Serie Scientifique 27.

Behie, S. W. and Bidochka, M. J. (2014). Ubiquity of insect-derived nitrogen transfer to plants by endophytiv insect-pathogenic fungi: an additional branch of the soil nitrogen cycle. *Appl Environ Microbiol* 80:1553-1560.

Bhanu Prakash, G., Ravi Sankar, U. and Padmaja, V. (2015). Development and testing of mycopesticide formulations of *Metarhizium anisopliae* (Metschinkoff) for shelf life and field application against *Spodoptera litura* (Feb) larvae. International Journal of Bioassays, 4, 4284-4289.

Boutin, C., Strandberg, B., Carpenter, D., Mathiassen, S. K. and Thomas, P. J. (2014). Herbicide impact on non-target plant reproduction: what are the toxicological and ecological implications? *Environ. Pollut*. 185:295-306.

Bouchemal, K., Briancon, S., Perrier, E. and Fessi, H. (2004). Nano-emulsion formulation using spontaneous emulsification: solvent, oil and surfactant optimization. *International Journal of Pharmaceutics*, 280(1-2), 241-251.

Burges, H. D. (1998). Formulation of Mycoinsecticides. In *Formulation of Microbial Biopesticides*; Burges, H. D., Ed.; Kluwer Academic Publisher: Dordrecht, The Netherlands, 1998; pp. 131-185.

Brigante, M., and Avena, M. (2014). Synthesis, characterization and application of a hexagonal mesoporous silica for pesticide removal from aqueous solution. *Micropor. Mesopor. Mater*. 191: 1-9.

Brunner-Mendoza, C., Navarro-Barranco, H., Leon-Mancilla, B., Perez-Torres, A. and Toriello, C. (2017). Biosafety of an entomopathogenic fungus *Isaria fumosorosea* in an acute dermal test in rabbits. *Cutan. Ocul. Toxicol*. 2017, 36, 12-18.

Brownbridge, M., Townsend, R. J., O'Callaghan, M., Bell, N. L., Mander, C. and Jackson, T. A. (2008). Developing opportunities for entomopathogenic microbes and nematodes in crop protection. Future Challenges in Crop Protection: Repositioning New Zealand's Primary Industries for the future, New Zealand Plant Protection Society Inc. (2008), pp. 129-142

Caenn, R. and Chillingar, G. V. (1996). Drilling fluids: state of the arts. *Journal Petroleum Science Engineer. 14*: 221-230.

Caudwell, R. W., Hunt, D., Reid, A. and Mensah, B. A. (2003). Insect pollination of oil palm – an evaluation of the long-term viability and sustainability of *Elaeidobius kamerunicus*. *The Planter*, 79(923), 75-91.

Cardona Jaramillo, J. E. C., Carrillo Bautista, M. P., Alvarez Solano, O. A., Achenie, L. E. K. and Gonzalez Barrios, A. F. (2019). Impact of the mode of extraction on the lipidomic profile of oils obtained from selected Amazonian fruits. *Biomolecules, 9*(2019), p. 329.

Castro, M. J. L., Ojeda, C. and Cirelli, A. F. (2014). Advances in surfactants for agrochemicals. *Environmental chemistry letters*, 12(1), 85-95.

Charnley, A. K. and Collins, S. A. (2007). Entomopathogenic fungi and their role in pest control. Kubicek, C. P., Druzhinina, I. S. (Eds). Environmental and Microbial Relationships: The Mycota IV (2nd Ed.), Springer-Verlag, Berlin (2007), pp. 159-187.

Chappat, M. (1994). Some applications of emulsions, Colloids Surf, A: Physicochemical Engineer. *Aspects 91*: 57-77.

Chapple A. C., Taylor R. A. J., Hall, F. R. and Downer, R. A. (1994). Understanding the dose transfer process as a prerequisite to a more lab-to-field performance correlation. In: Comparing Laboratory and Field

Pesticide Performance II. BCPC Monograph No. 59. H. G. Hewitt. J Casely. L. G. Copping, B. T. Grayson and D. Tyson (eds.): 267-272.

Cheong, Y. L., Sajap, A. S., Hafidzi, M. N., Omar, D. and Abood, F. (2010). Outbreaks of bagworms and their natural enemies in an oil palm, *Elaeis guineensis*, plantation, at Hutan Melintang, Perak, Malaysia, *Journal of Entomology, 7*(3), 141-151.

Cheong, Y. L. and Tey, C. C. Understanding pest biology and behavior for effective control of oil palm bagworms. *The Planter*, 8(1039) (2012), pp. 699-715.

Chelico, L. and Khachatourians, G. G. (2008). Isolation and characterization of nucleotide excision repair deficient mutants of the entomopathogenic fungus, *Beauveria bassiana, Journal of Invertebrate Patholgy. 98*: 93-100.

Chelico, L., Haughian, J. L. and Khachatourian, G. G. (2006). Nucleotide excision repair and photoreactivation in the entomopathogenic fungi *Beauveria bassiana, Beauveria brongniartii, Beauveria nivea, Metarhizium anisopliae, Paecilomyces farinosus* and *Verticillium lecanii, Journal of Application Microbiology. 100*: 964-972.

Chet, I. (1987). *Trichoderma* application, mode of action and potential as biocontrol agent of soil borne plant pathogenic fungi. *Innovative Approaches Plant Disease Control*. Pp. 137-160, John Wiley & Sons, New York, NY, USA, 1987.

Chet, T., Schicler, H., Haran, S. and Appenheim, A. B. (1993). Cloned chitinase and their role in biological control of plant pathogenic fungi. *Proceeding of the International Symposium on Chitin Enzymology*, pp. 47-48, Senigalia, Italy, 1993.

Chiu, S. B., Khoo, K. C. and Hussein, M. Y. (1986). A method of estimating the natural population of the pollinating weevil *Elaeidobius kamerunicus* Faust, of oil palm (*Elaeis guineensis*). In *1. Regional Symposium on Biological Control, Serdang, Selangor (Malaysia), 4-6 Sep 1985*. Penerbit Universiti Pertanian Malaysia.

Chin, C. P., Wu, H. S. and Wang, S. S. (2011). New approach to pesticide delivery using nanosuspensions: research and applications. *Ind. Eng. Chem. Res*. 50(12):7637-7643.

Chirila, E., Carazeanu, I. and Dobrinas, S. (2000). Spectrometric studies about some dyes – anionic surfactant interactions in aqueous solutions. Talanta. 53(1), pp. 271-275.

Cito, A., Barzanti, G. P., Strangi, A., Francardi, V., Zanfini, A. and Dreassi, E. (2016). Cuticle-degrading proteases and toxins as virulence markers of *Beauveria bassiana* (Balsamo) Vuillemin. *Journal of Basic Microbiology, 56*(9), 941-948.

Cizauskaite, U., Marksiene, R., Viliene, V., Gruzauskas, R. and Bernatoniene, J. (2017). New strategy of multiple emulsion formation based on the interactions between polymeric emulsifier and natural ingredients. Colloids. Surf. A. Physicochem Eng. Asp, 515(2017), pp. 22-33.

Clerk, G. C. and Madehn, M. F. (1965). The longevity of conidia of three insect-parasitizing hyphomycetes.*Trans. Br. Myco. Soc*. 48, 193-209.

Cliquet, S. and Jackson, M. A. (2005). Impact of carbon and nitrogen nutrition on the quality, yield and composition of blastospores of the bioinsecticidal fungus *Paecilomyces fumosoroseus*. *J. Ind. Microbiol. Biotechnol*., 32(2005), pp. 204-210.

Corley, R. H. V. and Lee. C. H. (1992). The physiological bases for genetic improvement of oil palm in Malaysia. *Euphytica*, 60: 179-184.

Corley, R. H. V. and Tinker, P. B. (2003). The oil palm. Wiley Blackwell, London.

Corley, R. H. V. (2009). How much palm oil do we need? *Environ. Sci. Policy, 12*: 134-139.

Corley, R. H. V. and Tinker, P. B. (2015). The oil palm. Wiley Blackwell, London.

Connick, W. J., Lewis, J. A. and Quimby, P. C. (1990). Formulation of biocontrol agents for use in plant pathology, in: UCLA Symposium in Molecular and Cell Biology, 345-372.

Daoust, R. A. and Roberts, D. W. (1983). Studies on the prolonged storage of *Metarhizium anisopliae* conidia: Effect of temperature and relative humidity on conidial viability and virulence against mosquitoes. *Invertebr. Pathol* 41, 143-150.

Das, S., Lee, S. H., Chia, V. D., Chow, P. S., Macbeath, C., Liu, Y. and Shliout, G. (2020). Development of microemulsion based topical ivermectin formulations: pre-formulation and formulation studies. *Colloids and Surfaces B: Biointerfaces*, 189, 1-8.

David-Henriet A. I., Pye, B. J. and Butt, T. M. (1998). Formulations and application of the entomopathogenic fungus *Metarhizium anisopliae* for the control of crucifer pests in Europe. Insect Pathogens and Insect Parasitic Nematodes. IUBC/WPRS BUII 21: 89-90.

da Silva Delabona, P., Lima, D. J., Robl, D., Rabelo, S. C., Farinas, C. S. and da Cruz Pradell, J. G. (2016). Enhanced cellulose production by *Trichoderma harzianum* by cultivation on glycerol followed by induction on cellulosic substrates. *Journal of Industrial Microbiology and Biotechnology*, 43(5), 617-626

de Azevedo Ribeiro, R. C., Barreto, S. M. A. G., Otrosky, E. A., da Rocha-Filho, P. A., Verissimo, L., M. and Ferrari, M. (2015). Production and Characterization of Cosmetic Nanoemulsions Containing *Opuntia ficus-indica* (L.) Mill Extract as Moisturizing Agent. Molecules, 20, 2492-2509.

Deshpande, M. V. (1999). Mycopesticide production by fermentation: Potential and challenges. Crit. Rev. Microbio. 1999, 25, 229-243.

Derakhshan, A., Rabindra, R. J. and Ramanujam, B. (2007). Efficacy of different isolates of entomopathogenic fungi against *Brevicoryne brassicae* (Linnaeus) at different temperatures and humidities. *J. Biol. Control. 21*(1): 65-72.

Domsch, K. H., Gams, W. and Anderson, T. H. (1980). Compendium of soil fungi. Volume 2. Academic Press (London) Ltd.

Ekenta, C. M., Ajala, M. K., Akinola, M. O. and Oseni, Y. (2017). Abandoned Nigerian economic resources: the case of oil palm. J. Agric. Ext. Rural. Dev. 4:1-16.

Encyclopedia of Emulsion Technology: Volume 4, in: P. Becher (Ed.) Marcel Dekker, Inc., New York, 1996. pp xi (ISBN 0-8247-9380-3), *J. Dispers. Sci. Technol. 18* (1997) 459-460.

Enting, C. E. and Latip, S. N. H. M. (2021). Life Cycle of Oil Palm Bagworm, *Metisa plana* Walker (Lepidoptera: Psychidae) at Different Temperatures Under Controlled Environment. *Serangga, 26*(2): 151-165.

Fages, J. (1990). An optimized process for manufacturing an *Azospirillum* inoculant for crops. *Appl. Microbiol. Biotechnol. 32*:473-478.

Fargues, J., Maniania, N. K. & Delmas, J. C. (1994). Infectivity of Propagules of *Paecilomyces fumosoroseus* During In Vitro Development to *Spodoptera frugiperda*. Journal of Invertebrate Pathology, 64(3), 173-178.

Faria, M. R. d. and Wraight, S. P. (2007). Mycoinsecticide and Mycoacaricides: A comprehensive list with worldwide coverage and international classification of formulation types, Biological Control, Vol. 43, Issue 3, 2007, pp 237-256, ISSN 1049-9644.

Faria, M., Hotchkiss, J. H., Hajek, A. E. and Wraight, S. P. (2010). Debilitation in conidia of the entomopathogenic fungi *Beauveria bassiana* and *Metarhizium anisopliae* and implication with respect to viability determinations and mycopesticide quality assessments. *Journal of Invertebrate Pathology, 105*, 74-83.

FAO. (2021). Pesticides use. Global, regional and country trends, 1990-2018. FAOSTAT. Analytical Brief Series. No. 16. Rome.

Feng, M. G., Khachatourians, G. G. and Poprawski, T. J. (1994). Production, Formulation and Application of the Entomopathogenic Fungus *Beauveria bassiana* for Insect Control: Current Status. *Biocontrol Sci. Technol*. 1994, 4, 3-34.

Fernandez C., A., Ojeda, C., Castro, M. J. L. and Salgot, M. (2008). Surfactants in sludge- amended agricultural soils. A review. *Environmental Chemical Letter*, 6: 135-148.

Fernandez-Bravo, M., Flores-Leon, A., Calero-Lopez, S., Gutierrez-Sanchez, F., Valverde Garcia, P. and Quesada-Moraga, E. (2017). UV-B radiation-related effects on conidial inactivation and virulence against *Ceratitis capitata* (Wiedemann) (Diptera: Tephritidae) of phylloplane and soil *Metarhizium* sp. strains. *Journal of Invertebrate Pathology. 148*: 142-151.

Fernandes, E. K. K., Rangel, D. E. N., Braga, G. U. L. and Roberts, D. W. (2015). Tolerance of entomopathogenic fungi to ultraviolet radiation: a review on screening of strains and their formulation. *Curr. Genet. 61*: 427-440.

Field, R. J. and Dastgheib, F. (1996). Enhancing uptake and translocation of systemic active ingredients, p. 241-296. In C. L. Foy & D. W. Pritchard (eds.), Pesticide formulation and adjuvants technology. Boca Raton, Florida, CRC Press, p. 363.

Fryd, M. M. and Mason, T. G. (2012). Nanoinclusions in cryogenically quenched nanoemulsions, Langmuir. 28(2012), 12015-12021

Gams, W., Hodge, K. T., Samson, R. A., Korf, R. P. and Seifert, K. A. (2005). '(1684) Proposal to Conserve the Name *Isaria* (anamorphic fungi) with a Conserved Type'. *Taxon*, 54, 537.

Gautam, U. K., Hlavkova, D., Shaik, H. A., Karaca, I., Karaca, G., Sezen, K. and Kodrik, D. (2020). Adipokinetic Hormones Enhance the Efficacy of the Entomopathogenic Fungus *Isaria fumosorosea* in Model and Pest Insects. Pathogen 2020, 9, 801.

Girard, N., Tadros, T. F. and Bailey, A. I. (1997). Original contribution styrene and methylmethacrylate oil-in-water microemulsions. Colloid Polym. Sci. 275 (7), 698-704.

Glare, T., J. Caradus, W. Gelernter, T. Jackson and N. Keyhani (2012). Have biopesticides come of age? *Trends Biotechnology 30*: 250-258.

Goodarzi, F. and Zendehboudi, S. (2019). Comprehensive Review on Emulsions and Emulsion Stability in Chemical and Energy Industries. *Can. J. Chem. Eng*. 2019, 97, 281-309.

Grijalba, E. P., Espinel, C., Cuartas, P. E., Chaparro, M. L. and Villamizar, L. F. (2018). *Metarhizium rileyi* biopesticide to control *Spodoptera frugiperda*:

Stability and insecticidal activity under glasshouse conditions. *Fungal biology*, 122, 1069-1076.

Griffin, W. C. (1949). Classification of surface-active agents by “HLB”. *Journal of the Society of Cosmetic Chemists*. 1, 311-326.

Griffin, W. C. (1954). Calculation of HLB values of non-ionic surfactants. *Journal of the Society of Cosmetic Chemists*. 5, 249-256.

Gupta, A., Eral, H. B., Hatton, T. A. and Doyle, P. S. (2016). Nanoemulsions: Formulation, properties and applications, *Soft Matter. 12*(2016). 2826-2841.

Hasber, S. and H. H. Noor (2012). Evaluation of several chemical control approaches against bagworm, *Metisa plana Walker* (Lepidoptera: Psychidae) in FELDA oil palm plantations. *Planter*, 2012. 88(1040): P. 785-799.

Hall, R. A. (1981). Fungus *Verticillium lecanii* as a microbial insecticide against aphids and scales. Microbial Control of Pests and Plant Diseases, 1970-1980.

Haran, J. M., Beaudoin-Olliver, L., Benoit, L., Kuschel, G. and Valdenar (2020). Revision of the palm-pollinating weevil genus *Elaeidobius* Kuschel, 1952 (Curculionidae, Curculioninae, Derelomini) with descriptions of two new species. Plazi.org taxonomic treatments database. Checklist dataset https://doi.org/10.5852/ejt.2020.684 accessed via GBIF.org on 2022-04-21.

Hajek, A., and St Leger (1994). Interactions between fungal pathogens and insect hots. *Annu. Rev. Entomol*. 39, 293-322. 10.1146/aanurev.en.39.010194.001453.

Hawerd, V. E. and Warr, G. G. (2000). Cation selectivity at air/anionic surfactant solution interfaces. *Langmuir. 16*(1), pp. 157-160.

Herlianda, S., Pujiastuti, Y., Adam, T. and Thalib, R. (2006). Life cycle of pollinator beetle (*Elaeidobius kamerunicus* Faust) (Curculionidae: Coleoptera) on male flower of oil palm (*Elaeis guineensis* Jacq.) in the laboratory. *Agria*, 3(1), 10-12.

Herzfeld, D. (2011). Private pesticide applicator’s training manual, 19th edn. University of Minnesota Extension. http://www.extension.umn.edu/agriculture/pesticide-safety/ppat_manual/Intro.pdf. Accessed Dec 2015.

Higley, L. G. and Pedigo, L. P. (1996). The EIL Concept. In: L. G. Higley and L. P. Pedigo (Eds.) Economic Thresholds for Integrated Pest Management, Lincoln: University of Nebraska Press. pp. 9-21.

Hoong, H. W. and Hoh, C. K. Y. (1992). Major pests of oil palm and their occurrence in Sabah. *The Planter, 68(793)*: 193-210.

Ho, C. T. (2002). Ecological studies on *Pteroma pendula* Joannis and *Metisa plana* Walker (Lepidoptera: Psychidae) towards improved integrated management on infestation in oil palm (pp. 560). Ph.D. thesis, Universiti Putra Malaysia.

Hodge, K. T., Gams, W., Samson, R. A., Korf, R. P. and Seifert, K. A. (2005). 'Lectotypification and Status of *Isaria* Pers.: Fr.', *Taxon*, 54, 485-489.

Hofstein, R. and Chapple, A. (1998). Commercial development of biofungicides. In *Biopesticides: Use and Delivery* Eds. F. R. Hall & J. J. Menn. Humana Press. Totowa, NJ, USA, Ch. 6:77-102.

Huang, Z., Ali. S., Ren, S. X. and Wu, J. H. (2010). Effect of *Isaria fumosoreus* on mortality and fecundity of *Bemisia tabaci* and *Plutella xylostella*. Insect Sci. 17, 140-148. 10.1111/j.1744-7917.2009. 01299.x

Humber, R. A. (1998). Entomopathogenic fungal identification. APS/ESA Workshop: Joint Annual Meeting. Las Vegas, NV.

Hussein, M. Y., Lajis, N. H. and Ali, J. H. (1990). Biological and chemical factors associated with the successful introduction of *Elaeidobius kamerunicus* Faust, the oil palm pollinator in Malaysia. In *VI International Symposium on Pollination 288* (pp. 81-87)

Hussein, R. H., Ezzat, S. M. and Nabil, H. A. (2014). Effects of some abiotic factors on mycelial growth rates of *Isaria fumosorosea Wize* and laboratory evaluation against *Planococcus citri* (Risso). *Journal of Entomology, 11*(6), 338-344.

Ho, C. T. (2002). Ecological studies on *Pteroma pendula* Joannis and *Metisa plana* Walker (Lepidoptera: Psychidae) towards improved integrated management of infestations in oil palm. Doctor of Philosophy Thesis. Universiti Putra Malaysia.

Hsieh, L. S., Tzean, S. S. and Wu, W. J. (1997). The Genus Akanthomyces on Spiders from Taiwan, Mycologia, 89:2, 319-324.

Ibrahim, L., Butt, T., Beckett, A. and Clark, S. (1999). The germination of oil-formulated conidia of the insect pathogen, *Metarhizium anisopliae. Mycological Research*, 103(07), 901-907.

Inglis, D. D., Goettal, M. S. and Johnson, D. L. (1993). Persistence of the entomopathogenic fungus, *Beauveria bassiana*, on phylloplanes of crested wheatgrass and alfalfa. Biol. Control. 1993, 3, 258-270.

Inglis, G. D., Johnson D. L. and Goettel, M. S. (1997). Effects of temperature and sunlight on mycosis (*Beauveria bassiana*) of grasshoppers under field conditions. *Environ Entomol 26*:400-409.

Inglis, G. D., Goettal, M., Butt, T. and Strasser, H. Use of hyphomycetous fungi for managing insect pests. In: Butt, T. M; Jackson, C. W. and Magan, N. (Eds.) Fungi as biocontrol agents: progress, problems and potentials. CABI Publishing, Wallingford, United Kingdom, 2001, 23-70.

Imoulan, A., Alaoui, A. and El Meziane, A. (2011). Natural occurrence of soil-borne entomopathogenic fungi in the Moroccan Endemic Forest of *Argania spinosa* and their pathogenicity to *Ceratitis capitata*. *World J. Microbio. Biotechnol. 27*:2619-2628.

Isman, M. B. (2006). Botanical insecticides, deterrents, and repellants in modern agriculture and an increasingly regulated world. *Annu. Rev. Entomol*. 51:45-66.

Ismail, I., Kazemzadeh, Y., Sharifi, M., Riazi, M., Malayeri, M. R. and Cortes, F. (2020). Formation and stability W/O emulsions in presence of asphaltene at reservoir thermodynamic conditions. *J. Mol. Liq*. 2020, 299, 112-115.

Jackson, M. A., McGuire, M. R., Lacey, L. A. & Wraight, S. P. (1997). Liquid Culture Production of Desiccation Tolerant Blastospores of the Bioinsecticidal Fungus *Paecilomyces fumosoroseus*. *Mycology Research, 101*(1), 35-41.

Jackson, M. A., Payne, A. R. and Odelson, D. A. (2004). Liquid-culture production of blastospores of the bioinsecticidal fungus *Paecilomyces fumosoroseus* using portable fermentation equipment. *J. Ind. Microbiol. Biotechnol*. 2004, 31, 149-154.

Jackson, M. A. (2007). The biotechnology of producing and stabilizing living, microbial living, microbial biological control agents for insect and weed.

Jackson, M. A. and Jaronski, S. T. (2009). Production of Microsclerotia of the Fungal Entomopathogen *Metarhizium anisopliae* and their Potential for use as a Biocontrol Agent for Soil-Inhabiting Insects. *Mycological Research, 113*(Pt 8), 842-50.

Jackson, M. A., Dunlap, C. A. and Jaronski, S. T. (2010). Ecological considerations in producing and formulating fungal entomopathogens for use in insect biocontrol. *Biocontrol, 55*(2010), pp. 129-145.

Jaronski, S. T. (2010). Ecological factors in the inundative use of fungal entomopathogens. *Biocontrol 55*:159-185.

Jaronski, S. T. and Jackson M. A. (2012). Mass production of entomopathogenic Hypocreales. Lacey, L. A. (Ed.), Manual of Techniques

in Invertebrate Pathology, Academic Press, San Diego (2012), pp. 257-286.

Jain, K., Kumar, R. S., Sood, S. and Gowthamarajan, K. (2013). Enhanced oral bioavailability of atorvastatin via oil-in-water nanoemulsion using aqueous titration method. *Journal of Pharmaceutical Sciences and Research, 5*(1), 18.

Jafari, S. M., He, Y. and Bhandari, B. (2007a). Production of sub-micron emulsions by ultrasound and microfluidization techniques. *J. Food. Eng. 82*, 478-488.

Jafari, S. M., He, Y. and Bhandari, B. (2007b). Optimization of nano-emulsions production by microfluidization. *Eur. Food Res. Technol. 225*, 733-741.

Jafari, S. M., Assadpour, E., He, Y. and Bhandari, B. (2008). Re-coalescence of emulsion droplets during high-energy emulsification. *Food Hydrocoll. 22*, 1191-1202.

Jessica, J. J., Peng, T. L., Sajap, A. S., Lee, S. H. and Syazwan, S. A. (2018). Evaluation of the virulence of entomopathogenic fungus, *Isaria fumosorosea* isolates against subterranean termites *Coptotermes* spp. (Isoptera: Rhinotermitidae). *J. For. Res*. (*Harbin, China*) 2018.

Jones, F. M. (1927). The mating of the Psychidae. *Trans. Am. Entomol*. Soc. 53: 293-312.

Jones, F. M. and Parks, H. B. (1928). The bagworms of Texas. *Bull. Tex. Agric. Exp. Stn*. 382: 4-36.

Kachhawa, D. (2017). Microorganisms as a biopesticides. Journal of Entomology and Zoology Studies. 2017; 5(3): 468-473.

Kaczmarek, A., Bogus, M. I., Wloka, E., Wronska, A., Krawiel, M., Kazek, K., Zalewska, K., Klocinska-Bialy, M., Sobocinka, A., Gliniewicz, E., Mikulak, M. and Matlawska (2020). The interaction between cuticle free fatty acids (FFA) of the cockroaches *Blattella germanica* and *Blatta orientalis* and hydrolases produced by the entomopathogenic fungus *Conidiobolus coronatus*. PloS One, 15(2020), 10.1371/journal.

Norman, K., H. J., Robinson, G. S. and Mohd Basri, W (1994). Bagworm (Lepidoptera: Psychidae) infestation in the centennial of the Malaysian oil palm industry – A review of causes and control. *J. Oil Palm Res, 31*(3), 364-380.

Norman, K., Ali, S. R. A., Masri, M. M. M., Ahmad, M. N., Manan, C. and Norman, K. (2017). Controlling *Metisa plana* Walker (Lepidoptera: Psychidae) outbreak using *Bacillus thuringiensis* at an oil palm plantation in Slim River, Perak, Malaysia. *J. Oil Palm Res*., 29: 47-54.

Kawakami, K. and Mikuna, T. (1965). Effects of relative humidity and temperature on the viability of conidia of some muscardines. *Actu. Serzcol. 56*, 42-46.

Kaya, G. P. and Hassan, S. (2000). Entomogenous fungi as promising biopesticides for tick control. *Exp. Appl. Acarol. 24*:913-926.

Keck, C. M., Kovacevic, A., Muller, R. H., Savic, S., Vuleta, G. and Milic, J. (2014). Formulation of solid lipid nanoparticles (SLN): The value of different alkyl polyglucosides surfactants. *Int. J. Pharm, 474*, 33-41.

Kepler, R. M., Luangsa-ard, J. J. and Hywel-Jones, N. L. (2017). A phylogenetically based nomenclature for *Cordycipitaceae* (Hypocreales). *IMA Fungus 8*, 335-353.

Kim, J. S., Je, Y. H., Skinner, M. and Parker, B. L. (2013). An oil-based formulation of *Isaria fumosorosea* blastospores for management of greenhouse whitefly *Trialeurodes vaporariorum* (Homoptera: Aleyrodidae). *Pest. Manage. Sci. Vol. 69*(5), p: 576-581.

Kurniawan, Y. (2010). Demografi dan populasi kumbang *Elaeidobius kamerunicus* Faust (Coleoptera: Curculionidae) sebagai penyerbuk kelapa sawit (*Elaeis guineensis* Jacq). Tesis, Institut Pertanian Bogor, Bogor.

Kushairi, A. (2009). Role of oil palm breeding in wealth creation and quality of life. Proceedings of the 8th Malaysia Congress on Genetics, Genting Highlands, Malaysia, 4-6 August 2009.

Kushairi, A., Singh, R. and Ong-Abdullah, M. (2017). The oil palm industry in Malaysia: thriving with transformative technologies. *J Oil Palm Res*. 29(4), 431-439.

Kumar, V., Avery, P. B., Ahmed, J., Cave, R. D., Mckenzie, C. L. and Osborne, L. S. (2017). Compatibility and Efficacy of *Isaria fumosorosea* with Horticultural Oils for Mitigation of the Asian Citrus Psyllid, *Diaphorina citrii* (Hemiptera: Liviidae). *Insects* 2017, 8, 119.

Kok, C. C., Eng, O., Razak, A. R., & Arshad, A. M. (2011). Microstructure and life cycle of *Metisa plana* Walker (Lepidoptera: Psychidae). *Journal of Sustainability Science and Management*, *6*(1), 51-59.

Kouakou, M., Hala, N. K., Akpa, A., Akpesse, M., Tuo, Y., Dagnogo, M., Konan, K. E. and Koua, H. K. (2014). Comparative efficacy of *Elaeidobius kamerunicus, E. plagiatus, E. subvittatus* (Coleoptera: Curculionidae) and *Microporum spp.* (Coleoptera: Nitidulidae) in the pollination of oil palm (*Elaeis guineensis*). *J. Exp. Biol. Agric. Sci., 2*:538-545.

Kouakou, M., Tuo, Y., Hala, A. K., Douan, B. G., Dagnogo, M. and Koua, H. K. (2018). Influence of the number of inflorescences and some climatic

factors on the abundance of *Elaeidobius kamerunicus* (Coleoptera: Curculionidae), main pollinator of the oil palm in Cote d'Ivoire. *International Journal of Biological and Chemical Sciences, 12*(4), 1571-1582.

Koul, O. (2023). Biopesticides: commercial opportunities and challenges. *Development and Commercialization of Biopesticides*, 1-23

Kreuter, J. (1994). *Colloidal drug delivery systems* (Vol. 66). CRC Press.

Lacey, L. A. (Ed.) (2016). *Microbial control of insect and mite pests: from theory to practice*. Academic Press.

Lawrence, M. J. and Rees, G. D. (2000). Microemulsion-based media as novel drug delivery systems, *Advanced Drug Delivery Reviews*, 45(1), 89-121.

Lei, C. J., Halim, N. A., Asib, N., Zakaria, A. and Azmi, W. A. (2022). Conidial Emulsion Formulation and Thermal Storability of *Metarhizium anisopliae* against Red Palm Weevil, *Rhynchophorus ferrugineus* Olivier (Coleoptera: Dryopthoridae), Microorganisms, 10, 1460.

Leng, P., Zhang, Z., Li, Q., Zhao, M. and Pan, G. (2014). Microemulsion formulation of carbendazim and its *in vitro* antifungal activities evaluation. Plos One: e109580.

Li, J., Yao, J., Li, Y. and Shao, Y. (2012). Controlled release and retarded leaching of pesticides by encapsulating in carboxymethyl chitosan/bentonite composite gel. *J. Environ. Sci. Health. B*. 47(8):795-803.

Li, P., Ma, K., Thomas, R. K. and Penfold, J. (2016). Analysis of the asymmetric synergy in the adsorption of zwitterionic-ionic surfactant mixtures at the air-water interface below and above the critical micelle concentration. The Journal of Physical Chemistry B, 120(5), 3677-3691.

Li, K., Tscharntke, T., Saintes, B., Buchori, D. and Grass, I. (2019). Critical factors limiting pollination success in oil palm: a systematic review. *Agriculture, ecosystems & environment, 280*, 152-160.

Litwin, A., Nowak, M. and Rozalska, S. (2020). Entomopathogenic fungi: unconventional applications. *Reviews in Environmental Science and Bio/Technology, 19*(1), 23-42.

Liu, W., Sun, D., Li, C., Liu, Q. and Xu, J. (2006). Formation and stability of paraffin oil-in-water nano-emulsions prepared by the emulsion inversion point method. *Journal of colloid and interface science, 303*(2), 557-563.

Loong, C. Y., A. S. Sajap, H. M. Noor, D. Omar and F. Abood (2013). Effects of UV-B and solar radiation on the efficacy of *Isaria fumosorosea* and *Metarhizium anisopliae* (Deuteromycetes: Hyphomycetes) for controlling

bagworm, *Pteroma pendula* (Lepidoptera: Psychidae). *J. Entomol., 10*(2): 53-65.

Lord, J. C., Anderson, S. and Stanley, D. W. (2002). Eicosanoids mediate *Manduca sexta* cellular response to the fungal pathogen *Beauveria bassiana*: A role for the lipoxygenase pathway. *Arch. Insect Biochem. Physiol*. 2002, 51, 46-54.

Luangsa-ard, J. J., Hywel-Jones, N. L., and Samson, R. A. (2004). 'The Polyphyletic Nature of *Paecilomyces* Sensu Lato Based on 18S-generated rDNA phylogeny', *Mycologia*, 96, 773-780.

Luangsa-ard, J. J., Hywel-Jones, N. L., Manoch, L. and Samson, R. A. (2005). On the Relationships of *Paecilomyces* sect. *Isarioidea* species', *Mycological Research*, 109, 581-589.

Luz, C. and Batagin, I. (2005). Potential of oil-based formulations of *Beauveria bassiana* to control *Triatoma infestans*. *Mycopathologia. 160*, 51-62.

Ma, K., Li, P., Wang, Z., Chen, Y., Campana, M., Doutch, J., Dalgliesh, R., Maestro, A., Thomas, R. K. and Penfold, J. (2022). Strong synergistic interactions in zwitterionic-anionic surfactant mixtures at the air-water interface and in micells: The role of steric and electrostatic interactions. Journal of Colloid and Interface Science. 613, pp. 297-310.

Maina, U. M., Galadima, I. B., Gambo F. M. and Zakaria, D. (2018). A review on the use of entomopathogenic fungi in the management of insect pests of field crops. *Journal of Entomology and Zoology Studies, 6*(1): 27-32.

Mains, E. B. (1950). Entomogenous species of Akanthomyces, Hymenostilbe and Insecticola in North America. *Mycologia* 42: 566-589.

Majeed, M. Z., Fiaz, M., Ma, C. S. and Afzal, M. (2017). Entomopathogenicity of three muscardine fungi, *Beauveria bassiana*, *Isaria fumosorosea* and *Metarhizium anisopliae*, against the Asian citrus psyllid, *Diaphorina citrii* (Kuwayama) (Hemiptera: Psyllidae). Egypt. *J. Biol. Pest Control. 27*, 211-215.

Mahdi, E. S., Sakeena, M. H. F., Abdulkarim, M. F., Abdullah, G. Z., Sattar, M. A. and Noor, A. M. (2011). Effect of surfactant and surfactant blends on pseudoternary phase diagram behavior of newly synthesized palm kernel oil esters. Drug Design, Development and Therapy, 5, pp. 311-323.

MALAYSIAN AGRICULTURAL DIGEST. (2013). Chapter 16: Agricultural chemicals. Malaysian Agricultural Digest. P. 155-163.

Malaysian Palm Oil Council (2018). Malaysian Palm Oil Council Official website. https://www.mpoc.org.my, accessed on 14 August 2018.

Malusa, E. and Vassilev, N. (2014). A contribution to set a legal framework for biofertilisers. *Applied Microbiology and Biotechnology, 98*(15). 6599-6607.

Mason, T. G., Graves, S. M., Wilking, J. N. and Lin, M. Y. (2006). Extreme emulsification: Formation and structure of nanoemulsions, 9(2006), 193-199.

Mascarin, G. M., Jackson, M. A., Kobori, N. N., Behle, R. W. and Junior, I. D. (2015). Liquid culture fermentation for rapid production of desiccation tolerant blastospores of *Beauveria bassiana* and *Isaria fumosorosea* strains. *Journal of Invertebrate Pathology*, 127, 11-20.

Mathieu, C., Duval, R., Xu, X., Rodrigues-Lima, F. and Dupret, J-M. (2015). Effects of pesticide chemicals on the activity of metabolic enzymes: focus on thiocarbamates. *Expert. Opin. Drug. Metab. Toxicol*. 11(1): 81-94.

Manan, C. A. H. C., Latip, S. N. H. M., Razali, A. B. C., Mohamed, S. M. S. and Abidin, C. M. R. Z. (2021). Evaluation of Bacillus thuringiensis and flubendiamide for controlling Metisa plana via aerial spraying in oil palm plantaion. *Serangga, 26*, 202-215.

Mannino, M. C., Huarte-Bonnet, C., Davyt-Colo, B. and Pedrini, N. (2019). Is the insect cuticle the only entry gate for fungal infection? Insights into alternative modes of action of entomopathogenic fungi. *Journal of fungi, 5*(2), 33.

McClatchie, G. V., Moore, D., Bateman, R. P. and Prior, C. (1994). Effects of temperature on the viability of the conidia of *Metarhizium flavoviride* in oil formulations. Mycol. Res. 98(7), 749-756.

McClements, D. J. and Gumus, C. E. (2016). Natural emulsifiers – biosurfactants, phospholipids, biopolymers, and colloidal particles: molecular and physicochemical basis of functional performance. *Adv. Colloid. Interface. Sco, 234* (2016), pp. 3-26.

McClements, D. J., Bai. L. and Chung, C. (2017). Recent advances in the utilization of natural emulsifiers to form and stabilize emulsions. *Annu. Rev. Food. Sci. Technol, 8*(2017), pp. 205-236.

Meliala, R. A. S. (2008). Studi biologi serangga penyerbuk kelapa sawit *Elaeidobius kamerunicus* Faust (Coleoptera: Curculionidae) *Elaeis guineensis* Jacq. di Laboratorium. Tesis. Universitas Sumatera Utara, Medan.

Meleson, K., Graves, S. and Mason T. G. (2004). Formation of concentrated nanoemulsions by extreme shear, Soft Mater. 2(2004, 109-203

Malaysian Palm Oil Board (2016). *Standard Operating Procedures (SOP) Guidelines for Bagworm Control*. Malaysia.

Mishra, S., Kumar, P. and Malik, A. (2015). Effect of temperature and humidity on pathogenicity of native *Beauveria bassiana* isolate against *Musca domestica* L. *Journal of parasitic diseases*, 39, 697-704.

Mills, I., Cvitas, T., Homann, K., Kallay, N., Kuchitsu, K. (1993). IUPAC Quantities, Units and Symbols in Physical Chemistry, Second ed. Blackwell, Oxford.

Malaysian Palm Oil Board (2020). Malaysian Oil Palm Statistics 2019. 39th edition. MPOB, Bangi. 289 pp.

Mudalige, T., Qu, H., Van Haute, D., Ansar, S. M., Paredes, A. and Ingle, T. (2019). Characterization of nanomaterials: Tools and challenges. *Nanomaterials for food applications*, 313-353.

Mulqueen, P. (2003). Recent advances in agrochemical formulation. *Advances in colloid and interface science, 106*(1), 83-107.

Muller, R. H. (1996). Zeta-potential and particle charge in the laboratory practice – Introduction to theory, practical and data interpretation (pp. 104-108). Stuttgart; Wissenschaftliche Verlagsgesellschaft.

Munthali, D. C. and Wyatt, I. J. (1986). Factors affecting the biological efficiency of small pesticide droplets against *Tetranychus urticae* eggs. *Pesticide Science, 17*: 155-164

Mohamad, S. A., Syarif, M. N. Y., Ahmad, S. N., Masri, M. M. M., Hung, K. J. and Kamarudin, N. (2021). Population density of *Elaeidobius kamerunicus* Faust in different spikelet position at anthesising male inflorescence of *Elaeis guineensis* Jacq. In Sabah and Sarawak, Malaysia. *Journal of Oil Palm Research, 33*(1), 21-36.

Moore, D., Bridge, P, D., Higgins, P. M. and Bateman, R. P. (1993). Ultra-violet radiation damage to *Metarhizium flavoviride* conidia and the protection given by vegetable and mineral oils and chemical sunscreens. *Annu. Appl. Biol. 122*, 605-616.

Mola, F. L. and Afkari, R. (2012). Effects of different vegetable oils formulations on temperature tolerance and storage duration of *Beauveria bassiana* conidia. *African Journal of Microbiology Research. 6*(22), pp. 4707-4711.

Moldoveanu, S. and David, V. (2021). Chapter 6 – Solvent extraction. Modern Sample Preparation for Chromatography, Second ed., Elsevier, 191-279.

Morwanti, D. (2006). (Skripsi), Bogor, Institusi Pertanian Bogor.

Morales, D., Gutierrez, J. M., Garcia-Celma, M. J. and Solans, Y. C. (2003). A study of the relation between bicontinuous microemulsions and oil/water nano-emulsion formulations. *Langmuir*, 19(18), 7196-7200.

Narang, A. S., Delmarre, D. and Gao, D. (2007). Stable drug encapsulation in micelles and microemulsions. *International journal of pharmaceutics, 345*(1-2), 9-25.

Nascimento, E., Da Silva, S. H., Dos Reis Marques, E., Roberts, D. W. and Braga, G. U. L (2010). Quantification of cyclobutane pyrimidine dimers induced by UVB radiation in conidia of the fungi *Aspergillus robertsii*, *Photochem. Photobiol. 86*: 1259-1266.

Nasir, D. M., Hazmi, I. R., Luqman, M., Azhari, H., Mohamad, S. A., Nurul, M. Y. S., Pau, S. S. N. and Nasir, N. M. (2023). Life cycle and Development Periods of Oil Palm Pollinating Weevil, *Elaeidobius kamerunicus* Faust, 1878 (Coleoptera: Curculionidae) from Oil Palm Plantations in Malaysia. *The Planters, Kuala Lumpur, 99* (1170): 579-589.

Nasir, A. A., Syarif, N. Y., Omar, D. and Asib, N. (2023). Effectiveness of *Cordyceps fumosorosea* Wettable Powder Formulation against *Metisa plana* (Walker) and Its Side Effects on *Elaeidobius kamerunicus* in Oil Palm Plantation. *Journal of Pesticide Science, 48*(2), 54-60.

Nithya, P. R. and Reji Rani, O. P. (2017). Evaluation of carrier materials for formulating entomopathogenic fungus *Lecanicilium Lecanii* (Zimmermann) Zare and Gams. *Journal of Biological Control, 31*(1): 50-55.

Norman, H. K., Robinson, G. S. and Basri, M. W. (1994). Common bagworm pests (Lepidoptera: Psychidae) of oil palm, with notes on related South-East Asian species. *Malayan Nature Journal*, 48, 93-123.

Norman, H. K. and Basri, M. W. (2007). Status of common oil palm insect pests in relation to technology adoption. *Planter, 83*(975), 371-385.

Ooi, P. and Norman, K. (2018). The Importance of Sustainable Management for Common Oil Palm Insect Pests. Oil Palm Bulletin 77: 14-18.

Ortiz-Urquiza, A. and Keyhani, N. O. (2013). Action on the Surface: Entomopathogenic Fungi versus the Insect Cuticle. *Insects. 4*:357-374.

Parveez, A., Elina, A., Loh, S., Meilina, O., Kamalrudin, M., Izuddin, M. N., Sundram, S., Zafarizal, A. A. H. and Zainab, I. (2020). Oil palm economic performance in Malaysia and R&D progress in 2019. *J. Oil. Palm. Res. 32*: 159-190.

Pan, Z., Cui, B., Zeng, Z., Feng, L., Liu, G., Cui, H. and Pan, H. (2015). Lambda-cyhalothrin nanosuspension prepared by the melt emulsification-high pressure homogenization method. Journal of *Nanomaterials, 2015*, 1-8.

Pal, R. (2016). Modelling the viscosity of concentrated nanoemulsions and nanosuspensions. *Fluids, 1*(2), 11.

Perdana Rozziansha, T. A., Sudharto, A. S., Chenon, R. D. de., Prasetyo, A. E. and Susanto, A. (2011). Organisme Pengganggu Tanaman *Pteroma pendula* Joannis. Inf PT, H – 0008.

Pell, J. K., Eilenberg, J., Hajek, A. E. and Steinkraus, D. C. (2001). Biology, ecology and pest management potential of Entomophthorales. In: Butt, M. T., Jackson, C., Maga, N. (Eds) *Fungi as Biocontrol Agents*, CAB International, UK, 2001, 71-115.

Poinar, J. G. O., Jackson, T. A., Bell, N. L. and Wahid, M. B. (2002). *Elaeolenchus parthenonema* n.g.n.sp. (Nematoda: Sphaerularioidae: anandranematidae n. fam.) parasitic in the palm pollinating weevil *Elaeidobius kamerunicus* Faust, with a phylogenetic synopsis of the Sphaerularioidae Lubbock, 1981. *Systemic Parasitology*, 52, 219-225.

Polar, P., Muro M. A., Kairo M. T., Moore, D., Pegram, R., John, S. A., Roach-Benn, C. (2005a). Thermal characteristic of *Metarhizium anisopliae* isolates important for the development.

Polar, P., Kairo, M. T., Moore, D., Pegram, R. and John A. S. (2005b). Comparison of water, oils and emulsifiable adjuvant oils as formulating agents for *Metarhizium anisopliae* for use in control of *Boophilus microplus*. Mycopathol. 160:151-157.

Prathiba, J. and Pal, S. (2021). Influence of temperature and humidity on conidial germination and colony growth of entomopathogenic fungi. *Journal of Entomology and Zoology Studies, 9*(4), 201-206.

Preetz, C., Hauser, A., Hause, G., Kramer, A. and Mader, K. (2010). Application of atomic force microscopy and ultrasonic resonator technology on nanoscale: Distinction of nanoemulsions from nanocapsules. *European Journal of Pharmaceutical Sciences*, 39(1-3), 141-151.

Prior, C., Jollands, P. and Le Patourel, G. (1987). Infectivity of oil and water formulations of *Beauveria bassiana* (Deuteromycotina: Hyphomycetes) to the cocoa weevil pest *Pantorhytes plutus* (Coleoptera: Curculionidae). *Journal of Invertebrate Pathology*. 52: 66-72.

Prior, C., Jollands, P. and Patourel, G. L. (1988). Pathogenicity test of *Beauveria bassiana* (Balsamo) against oil palm bagworm (*Metisa plana* Walker). *Elaeis*, 5(2): 92-101

Priwiratama, H., Rozziansha, T. A., Susanto, A. and Prasetyo, A. E. (2019). Effect of Bagworm *Pteroma pendula* Joannis Attack on the Decrease in Oil Palm Productivity. *Jurnal Hama dan Penyakit Hutan Tropika* 19(2): 101-108.

Ramlah, A. A. S., Norman, K., Basri, M.W., Najib, M. A., Mohd Mazmira, M. M. and Kushairi, A. (2007). *Manual Pengurusan Bersepadu Ulat Bungkus di Ladang Sawit*. MPOB, Bangi. 15 pp.

Ramanujam, B., Rangeshwaran, R., Sivakumar, G., Mohan, M. and Yandigeri, M. S. (2014). Management of Insect Pests by Microorganisms. Proceedings of Indian National Science Academy. 2014; 80(2): 455-471.

Rang, M. J. and Miller, C. A. (1999). J. Colloid Interface Sci. 209(1999) 179.

Rahate, A. R. and Nagarkar, J. M. (2007). Emulsification of vegetable oils using a blend of nonionic surfactants for cosmetic applications. *Journal of dispersion science and technology, 28*(7), 1077-1080.

Rajanaidu, N., Kushairi, A. and Mohd Din, A. (2017). Monograph Oil Palm Genetic Resources. MPOB, Bangi. 289 pp.

Raikos, V. and Ranawana, V. (2017). Designing emulsion droplets of foods and beverages to enhance delivery of lipophilic bioactive components – a review of recent advances. *Int. J. Food. Sci. Technol, 52* (2017). Pp. 68-80.

Rao, J. J. and McClements, D. J. (2011). Formation of flavor oil microemulsions, nanoemulsions and emulsions: influence of composition and preparation method. *J. Agric. Food. Chem. 59*, 5026-5035.

Relyea, R. A. and Edwards, K. (2010). What doesn't kill you makes you sluggish: how sublethal pesticides alter predator-prey interactions. Copeia 4:558-567.

Rhainds, M., Gries, G. and Chinchilla, C. (1996). Development of a sampling method for first instar *Oiketicus kirbyi* (Lepidoptera: Psychidae) in oil palm plantations. *Journal of Economic Entomology, 89*(2): 396-401.

Rhainds, M. (2000). A review of recent sampling and ecological studies on bagworms (Lepidoptera: Psychidae) in commercial plantation of oil palm. *The Planter* 76(886): 9-14.

Rhainds, M., Gries, G., Ho, C. T. and Chew, P. S. (2002). Dispersal by bagworm larvae, *Metisa plana*: Effects of population density, larval sex, and host plant attributes. *Ecol. Entomol., 27(2)*: 204-212.

Rhainds, M., Davis, D. R. and Price, P. W. (2009). Bionomics of Bagworms (Lepidoptera: Psychidae). Annual Review of Entomology, 54, 209-26.

Rhainds, M. and Sadof, C. (2009). Control of bagworms (Lepidoptera: Psychidae) using contact and soil-applied systemic insecticides. *Journal of Economic Entomology 102*(3): 1164-1169.

Robinson, G. S., K. R. Tuck & M. Shaffer, 1994. A Field Guide to the Smaller Moths of South-East Asia. Natural History Museum, London. 309 pp.

Robins, M. M., Watson, A. D. and Wilde, P. J. (2002). Emulsions-creaming and rheology. Curr. Opin. *Colloid Interface Sci. 7*, 419-425.

Robins, M. and Fillery-Travis, A. (1992). Colloidal dispersions, in: W. B. Russel, D. A. Saville, W. R. Schowalter (Eds.), Cambridge University Press, Cambridge, UK. *J. Chem. Technol. Biotechnol. 54*, 201-202.

Roberts, D. W. and Hajek, A. E. (1992). Entomopathogenic fungi as bioinsecticides. *Frontiers in Industrial Mycology*, p. 144-159.

Rojas, L. (2012). International pesticide market and regulatory. http://wcropchemicals.com/pesticide_regulatory_profile/. Accessed Dec 2015.

Roland, I., Piel, G., Delattre, L. and Evrard, B. (2003). Systematic characterization of oil-in-water emulsions for formulation design. *International Journal of Pharmaceutics*, 263(1), 85-94.

Rywinska, A. and Rymowicz. W. (2010). High-yield production of citric acid by Yarrowia lipolytica on glycerol in repeated-batch bioreactors. *Journal of Industrial Microbiology and Biotechnology*, 37(5), 431-435.

Sajap, A. S. and Siburat, S. (1992). Incidence of entomogenous fungi in the bagworm, *Pteroma pendula* (Lepidoptera: Psychidae), a pest of *Acacia mangium*. *J Plant Proc in the Tropics. 9*:105-110.

Sajap, A. S., Rozihawati, Z., Omar, D. and Lau, W. H. (2014). *Isaria fumosorosea* and *Metarhizium anisopliae* for Controlling *Atteva sciodoxa* (Lepidoptera: Yponomeutidae), a Pest of *Eurycoma longifolia*. *Journal of Tropical Forest Science 26*(1): 84-91.

Sakamoto, K., Lochhead, R. Y., Maibach, H. I., Yamashita, Y. and Ifuku, O. (2017). Botanical Ingredients, *Cosmet. Sci. Technol (2017)*, pp. 305-320.

Saldarriaga Ausique, J. J., D'Alessandro, C. P., Conceschi, M. R., Mascarin, G. M. and Delalibera Junior, I. (2017). Efficacy of entomopathogenic fungi against adult *Diaphorina citri* from laboratory to field applications. *Journal of Pest Science, 90*, 947-960.

Sambathkumar, S. and Ranjith, A. M. (2011). Insect pollinators of oil palm in Kerala with special reference to African weevil, *Elaeidobius kamerunicus* Faust, *Pest Management in Horticultural Ecosystems, 17*(1), 14-18.

Samson, R. A. (1974). *Paecilomyces* and some allied Hyphomycetes. Stud. Mycol. 6, 1-119.

Samson, R. A. and Evans, H. C. (1974). Notes on Entomogenous Fungi from Ghana: II. The Genus Akanthomyces. *Acta Botanica Neerlandica*, 23(1), 28-35.

Sankaran, T (1970). The oil palm bagworms of Sabah and the possibilities of their biological control. *PANS, 16*:43-55.

Sani, I., Ismail, S. I., Abdullah, S., Jalinas, J., Jamian, S. and Saad, N. (2020). A review of the biology and control of whitefly, *Bemisia tabaci* (Hemiptera: Aleyrodidae), with special reference to biological control using entomopathogenic fungi. *Insects, 11*(9), 619.

Saxena, S. and Pandey, A. K. (2001). Microbial metabolites as eco-friendly agrochemicals for the next millennium. *Appl. Microbiol. Biotechnol.* 55(4): 395-403.

Savardekar, P and Bajaj, A. (2016). Nanoemulsion – a review. *International Journal of Research in Pharmacy and Chemistry*, 6, 312-322.

Setya, S., Talegaonkar, S. and Razdan, B. K. (2014). Nanoemulsions: formulation methods and stability aspects. *World J. Pharm. Sci*, 3(2), 2214-2228.

Shahid, A. A., Rao, Q. A., Bakhsh, A. and Husnain, T. (2012). *Arch. Biol. Sci*. 2012, 64, 21-42.

Sharma , N., Madan, P. and Lin, S. (2016). Effect of process and formulation variables on the preparation of parental paclitaxel-loaded biodegradable polymeric nanoparticles: A co-surfactant study. *Asian Journal of Pharmaceutical Sciences, 11*(3), 404-416.

Sharma, A., Sharma, S. and Yadav, P. K. (2023). Entomopathogenic fungi and their relevance in sustainable agriculture: A review. *Cogent Food & Agriculture, 9*(1), 2180857.

Sheikh, A. A., Rehman, N. Z. and Kumar, R. (2017). Diverse adaptation in insects. A Review. *Journal of Entomology and Zoology Studies 5*(2): 343-350.

Shim, S. M., Lee, K. R., Kim, S. H., Im, K. H. and Kim, J. W. (2003b). The optimal culture conditions affecting the mycelial growth and fruiting body formation of *Paecilomyces fumosoroseus. Mycobiology, 31*: 214-220.

Shinoda, K. and Kunieda, H. I. R. O. N. O. B. U. (1983). Phase properties of emulsions: PIT and HLB. Encyclopedia of emulsion technology, 1, 337-367.

Shrivastava, A. (2018). Introduction to plastics engineering. William Andrew.

Silva, W. O. B., Mitidieri, S., Schrank, A. and Vainstein, M. H. (2005). Production and extraction of an extracellular lipase from the entomopathogenic fungus *Metarhizium anisopliae*. *Process Biochemistry, 40*(1), 321-326.

Siti Ramlah, A. A., Norman, K., Basri, W, M., Najib, A. M. and Kushairi, A. (2007). Sistem Pengurusan Perosak Bersepadu bagi Kawalan Ulat Bungkus di Ladang Sawit. MPOB Press.

Sivasankaran, P., Eswaramoorthy, S. and David, H. (1998). Influence of temperature and relative humidity on the growth, sporulation and pathogenicity of *Beauveria bassiana. J. Biol. Control., 12*, 71-75.

Skinner, M., Parker, B. L. and Kim, J. S. (2014). Role of Entomopathogenic Fungi in Integrated Pest Management. Current Concepts and Ecological Perspective. 2014, pp. 169-191.

Smulek, W., Burlaga, N., Hricovini, M., Medvedova, A., Kaczorek, E. and Hricoviniova, Z. (2021). Evaluation of surface active and antimicrobial properties of alkyl D-lyxosides and alkyl L-rhamnosides as green surfactants. *Chemosphere, 271*, 129818

Soberon-Chavez, G. (Ed.) (2010). Biosurfactants: from genes to application (Vol. 20). Springer Science & Business Media.

Staples, E., Penfold, J. and Tucker, I. (2000). Adsorption of mixed surfactants at the oil-water interface. *Journal of Physical Chemistry B*. 104(3), pp. 606-614.

Stern, V. M., Smith, R. F., van den Bosch, R. and Hagen, K. S. (1959). The integrated control concepts. Hilgardia, 29: 81-101.

Sudarsono, H., Purnomo, P. and Hariri, A. M. (2011). Population assessment and appropriate spraying technique to control the bagworm (*Metisa plana* Walker) in North Sumatra and Lampung. *AGRIVITA Journal of Agricultural Science* 33(2): 188-198.

Suhail, M., Janakiraman, A. K., Khan, A., Naeem, A. and Badshah, S. F. (2019). Surfactants and their Role in Pharmaceutical Product Development: An overview. Journal of Pharmacy and Pharmaceutics. 6, 72-82.

Sung, G. H., Hywel-Jones, N. L., Sung, J. M., Luangsa-ard, J. J., Shrestha, B. and Spatafora, J. W. (2007). Phylogenetic Classification of *Cordyceps* and Clavipitaceous Fungi, *Studies in Mycology*, 57, 5-59.

Syed, R. A. (1980). Pollinating insects of oil palm, 1977-1980. *Commonwealth Institute of Biological Control Report*.

Syed, R. A. (1981). Insect pollination of oil palm: feasibility of introducing *Elaeidobius* spp. Into Malaysia. *Oil Palm News* 25, 2-16.

Syed, R. A., Law, I. H. and Corley, R. H. V. (1982). Insect pollination of oil palm: introduction, establishment and pollinating efficiency of *Elaeidobius kamerunicus* in Malaysia. *The Planter*, 58, 547-561.

Syed, H. K. and Peh, K. K. (2014). Identification of Phases of Various Oil, Surfactant/Co-surfactants and Water System by Ternary Phase Diagram. *Acta Pol Pharm*. 71(2), pp. 301-309.

Syed Mohamed, S. M. (2018). Efficacy of Five Insecticides against Bagworm, *Metisa plana* Walker and their Side Effects on Oil Palm Pollinator, *Elaeidobius kamerunicus* Faust. Master of Science Thesis. Universiti Putra Malaysia.

Syarif, M. N. Y. (2018). Formulation and Laboratory Efficacy of *Isaria fumosorosea* against Bagworms (*Metisa plana* Walker and *Pteroma pendula* Joannis) (Lepidoptera: Psychidae). Master of Science Thesis. Universiti Putra Malaysia.

Tabibiazar, M. and Hamishehkar, H. (2015). Formulation of a Food Grade Water-In-Oil Nanoemulsion: Factors Affecting on Stability. *Pharm. Sci*. 2015, 21, 220-224.

Tadros, T. F., Vandamme, A, Levecke, B., Booten, K. and Stevens, C. V. (2004). Stabilization of emulsions using polymeric surfactants based on inulin. Adv. Colloid Interf. Sci. 108/109, 207-226.

Tadros, T., Izquierdo, P., Esquena, J. and Solans, C. (2004). Formation and stability of nano-emulsions. Adv. Colloid Interface Sci. 108-109.

Tajudin, N. S. A., Ali, S. R. A., Bakeri, S. A. and Kamaruzzaman, N. E. (2010). Effect of *Beauveria brongniartii* and *Beauveria bassiana* on oil palm bagworm, *Pteroma pendula* (Joannis). *Journal of Oil Palm Research, 22*(1), 729-735.

Tan, S. Y., Ibrahim, Y. and Omar, D. (2008). Efficacy of *Bacillus thuringiensis* Berliner Subspecies kurstaki and aizawai against the Bagworm, Metisa plana Walker on oil palm. Journal of Bioscience 19(1): 103-114.

Tan, S. F., Masoumi, H. R. F., Karjiban, R. A., Stanslas, J., Kirby, B. P., Basri, M. and Basri, H. B. (2016). Ultrasonic emulsification of parenteral valproic acid-loaded nanoemulsion with response surface methodology and evaluation of its stability. *Ultrasonics sonochemistry*, 29, 299-308.

Tang, K. H. D. and Al Qahtani, H. M. S. (2019). Sustainability of oil palm plantations in Malaysia. Environment, Development and Sustainability, 22(6), 4999-5023. DOI: 10.1007/s10668-019-00458-6.

Tey, C. C. and Cheong. Y. L. (2013). Challenges in integrated pest management (IPM). Proc. Of 10th NATSEM 2013 – Confronting Management Challenges in the Oil Palm Industry. Incorporated Society of Planter, Kuala Lumpur. P. 117-127.

Thakore, Y. (2006). The biopesticide market for global agricultural use. Ind. Biotechnol., 2: 194-208. DOI: 10.1089/ind.2006.2.194.

Tian, J., Liang, L., Hao, C. and Ma, R. (2013). The study on the acute toxicity and dermal sensitization of *Isaria fumosorosea*. *J. Shanxi Agric. Univ*. (*Nat. Sci. Ed*.) 2013, 33, 144-146.

Tomomasa, S. Kochi, M. and Nakajima, H. (1988). Microemulsion Formation in Two Phase Region Preparation Method and Stability. *Journal of Japan Oil Chemists' Society, 37*, 1012-1017.

Turner, S. F., Clarke, S. M., Rennie, P. N., Thirtle, D. J., Cooke, Z. X. and Thomas, R. K. (1999). Adsorption of sodium dodecyl sulfate to a polystyrene/water interface studied by neutron reflection and attenuated total reflection infrared spectroscopy. *Langmuir. 15*(4), pp 1017-1023.

Turner, P. D. and Gilbanks, R. A. (2003). *Oil Palm Cultivation and Management*. Second Edition. Kuala Lumpur. The Incorporated of Planters.

Tuo, Y., Koua, H. K. and Hala, N. (2011). Biology of *Elaeidobius kamerunicus* and *Elaeidobius plagiatus* (Coleoptera: Curculionidae), main pollinators of oil palm in West Africa. *European Journal of Scientific Research, 49*(3), 426-432.

Tominack, R. L. and Tominack, R. (2000). Herbicide formulations. *Journal of Toxicology: Clinical Toxicology*, 38(2), 129-135.

United States Environmental Protection Agency (USEPA) (2015). What are biopesticides. http://www.epa.gov/ingredients-used-pesticide-products/what-are-biopesticides. Accessed Dec 2015.

Ushikubo, F. Y. and Cunha, R. L. (2014). Stability mechanisms of liquid water-in-oil emulsions. *Food Hydrocolloids, 34*(2014), pp. 145-153.

Valent Bioscience Corporation (2014). Dipel ES Biological Insecticide; Arial Application in Oil Palm (Brochure). Australia.

Vandenberg, J. D., Ramos, M. & Altre, J. A. (1998). Dose-Response and Age- and Temperature-Related Susceptibility of the Diamondback Moth (Lepidoptera: Plutellidae) to Two Isolates of *Beauveria bassiana* (Hyphomycetes: Moniliaceae). *Environmental Entomology, 27*(4), 1017-1021.

Vandergheynst, J., Scher, H., Guo, H. and Schultz, D. (2007). Water-in-oil emulsions that improve the storage and delivery of the biolarvicide *Lagenidium giganteum*, *BioControl 52*: 207-229.

Vey, A., Hoagland, E. E. and Butt, T. M. (2009). Fungi as biocontrol Agents: Progress, Problems and Potential. CABI.

Vega, F. E., Jackson, M. A. & Mcguire, M. R. (1999a). Germination of Conidia and Blastospores of *Paecilomyces fumosoroseus* on the Cuticle of the Silverleaf Whitefly, *Bemisia argentifolii. Mycopathologia, 147*, 33-35.

Vega, F. E., Jackson, M. A. & Mcguire, M. R. (1999b). Germination of Conidia and Blastospores of *Paecilomyces fumosoroseus* on the Cuticle of the Silverleaf Whitefly, *Bemisia argentifolii. Mycopathologia, 147*, 33-35.

Von B., H. Boettcher, C., Quart, A., Regenbrecht, M., Akari, S., Keiderling, U., Schnablegger, H., Daehne, S. and Kirstein, S. (2000). Surfactant-induced changes of morphology of J-aggregates: superhelix-to-tube transformation. *Langmuir, 16*, 14, pp 5908-5916.

Wahid, M. B., Masijan, Z., Hassan, A. H. and Dolmat, M. T. (1988). The population census and the pollination efficiency of the weevil Elaeidobius kamerunicus in Malaysia-A status report 1983-1986. In *International Oil Palm/Palm Oil Conferences-Progress and Prospects 1987-Conference 1: Agriculture, Kuala Lumpur, 23-26 Jun 1988*. IPMKSM.

Wahid, M. B. and Kamarudin, N. H. (1997). Role and effectiveness of *Elaeidobius kamerunicus*, *Thrips hawaiiensis* and *Pyroderces* sp. in pollination of mature oil palm in Peninsular Malaysia. *Elaeis* 9(1): 1-16.

Wang, C., Tai, X., Du, Z. and Liu, X. (2017). Formulation and physicochemical properties of promising avermectin microemulsion with biodegradable surfactant and oil. *J. Dispers. Sci. Technol. 38*:409-415.

Wehrle, P., Magenheim, B. and Benita, S. (1995). The influence of process parameters on the PLA nanoparticle size distribution, evaluated by means of factorial design. *Eur. J. Pharm, Bio-pharmcol. 41*, 19-26.

White, T., Burns, T., Lee, S. and Taylor, J. (1990). Amplification and Direct Sequencing of Fungal Ribosomal RNA Genes for Phylogenetics. In: PCR Protocols: a guide to methods and applications. Academic Press, 64, 315-322.

Wize, M. C. (1904). Die durch Pilze hervorgerufenen Krankheiten des Rubenrusselkafers (*Cleonus punctiventris* Germ.) mit besondere Breruksichtigung neuer Arten. *Bulletin International de l'Academie des Sciences de Cracovie, Classe des Sciences Mathematique et Naturelles*, 713-727.

Wraight, S. P., Carruthers, R. I., Franklin, R. H. and Julius, J. M. (1999). Production, delivery, and use of mycoinsecticides for control of insect pests on field crops, in Biopesticides: use and Delivery. Springer, 233-269.

Wraight, S. P., Jackson, M. A. and De Kock, S. L. (2001). Formulation of Fungal Biocontrol Agents. Fungi as *Biocontrol Agents: Progress Problems and Potential*, 253.

Wood, B. J. (1968). Pest of Oil Palms in Malaysia and their Control. Incorporated Society of Planters, Kuala Lumpur. 204 pp.

Wood, B. J. (1971). Development of integrated control programmes for pests of tropical perennial crops in Malaysia. Biological Control (Huffaker, C. B. ed.) Plenum Press, New York, USA. p. 422-457.

Wood, B. J., Corley, R. H. V. and Goh. K. H. (1973). Studies on the effect of pest damage on oil palm yield. Communication, Chemara Research Station. Incorporated Society of Planters.

Wood, B. J. and Norman, K. (2019). Bagworm (Lepidoptera: Psychidae) infestation in the centennial of the Malaysia oil palm industry – A review of causes and control. *J. Oil Palm Res*, 31: 364-380.

Wraight, S. P., Carruthers, R. I., Jaronski, S. T., Bradley, C. A., Garza, C. J. and Galaini-Wraight, S. (2000). Evaluation of the entomopathogenic fungi *Beauveria bassiana* and *Paecilomyces fumosoroseus* for microbial control of the silverleaf whitefly, *Bemisia argentifolii*. *Biological control, 17*(3), 203-217.

Wraight, S. P., Jackson, M. A. and de Kock, S. L. (2001). Production, stabilization and formulation of fungal biocontrol agents. Butt, T., Jackson, C., Magan, N. (Eds), Fungi as Biocontrol Agents – Progress, Problems and Potential, CABI Press, Wallingford, UK, pp. 253-287.

Wydro, P. and Paluch, M. (2005). A study of the interaction of dodecyl sulfobetaine with anionic and cationic surfactants in mixed micelles and monolayers at the air-water interface. *Journal of Colloid and Interface Science*. 286(1), 387-391.

Wylie, F. R. and Speight, M. R. (2012). *Insect pests in tropical forestry*. CABI.

Xavier-Santos, S., Lopes, R. B. and Faria, M. (2011). Emulsifiable oils protect *Metarhizium pingshaense* conidia from imbibitional damage. Biol. Control, 59 (2011), pp. 261-267.

Xiao, J. X., Sivar, U. and Tjerneld, F. (2000). Phase behavior and protein partitioning in aqueous two-phase systems of cationic-anionic surfactant mixtures. Journal of Chromatography B: *Biomedical Sciences and Applications. 743*(1-2), pp. 327-338

Yaap, B., Struebig, M.J., Paoli, G. and Koh, L. P. (2010). Mitigating the biodiversity impacts of oil palm development, CAB Rev. 5, 1-11 (2010).

Yap, T. H. (2000). The intelligent management of Lepidoptera leaf-eaters in mature oil palm by trunk injection (A review of principles). *The Planter 76*(887): 99-107

Yamashita, Y. Miyahara, R. and Sakamoto, K. (2017). Emulsion and emulsification technology. *Cosmet. Sci. Technol. Theor. Princ. Appl*, pp. 489-506.

Yamaguchi, Y., Inaba, Y., Uchiyama, H. and Kunieda, H. (1999). Anomalous phase behavior polyelectrolyte and oppositely charged surfactants. *Colloids Polymer Science.* 277(1999), pp. 1117-1124.

Yaqin, M. N. Y. (2017). Formulation and laboratory efficacy of *Isaria fumosorosea* against bagworms (*Metisa plana* Walker and *Pteroma pendula* Joannis) (Lepidoptera: Psychidae). Master thesis, Universiti Putra Malaysia.

Yeo, H., Pell, J. K., Alderson, P. G., Clark, S. J. and Pye, B. J. (2003). Laboratory Evaluation of Temperature Effects on the Germination and Growth of Entompathogenic Fungi and on their pathogenicity to Two Aphid Species. *Pest Management Science*, 59, 156-165.

Yue, J., Yan, Z., Bai, C., Chen, Z., Lin, W. and Jiao, F. (2015). Pollination activity of *Elaeidobius kamerunicus* (Coleoptera: Curculionidae) on oil palm on Hainan Island. *Florida Entomologist, 98*(2), 499-505.

Yunus, A. and Ho, T. H. (1980). List of economic pests, host plants, parasites, and predators in West Malaysia (1920-1978). Bulletin, Ministry of Agriculture, Malaysia, pp 153.

Zheng, Y., Lu, X., Lai, L., Yu, L., Zheng, H. and Dai, C. (2020). The micelle thermodynamics and mixed properties of sulfobetaine-type zwitterionic Gemini surfactant with nonionic and anionic surfactants. *Journal of Molecular Liquids, 299*, 112108.

Zimmermann, G. (2008). The entomopathogenic fungi *Isaria farinosa* (formerly *Paecilomyces farinosus*) and the *Isaria fumosorosea* species complex (formerly *Paecilomyces fumosoreus*): Biology, ecology and use in biological control. *Biocontrol Sci. Technol*. 2008, 18, 865-901.