Biodiversity of the genus *Bactrocera* (Diptera: Tephritidae) in guava *Psidium guajava* L. orchards in different agro-forested locations of southern Thailand

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***Abstract*—** Biodiversity of the genus *Bactrocera* was investigated in guava orchards and it surroundings in southern Thailand for a year (March 2012 - March 2013). Sampling of fruit flies was conducted in four provinces with the aid of parapheromones; methyl eugenol and torula yeast placed in Steiner and Ball traps, respectively. One commercial guava orchard located in agro-forested area was selected at each province. Each of the trap was replicated twice on the orchards and it surroundings. From the genus *Bactrocera*, thirty-one species were identified comprising of 14 new records. Apart from 8 species that were common to all study sites, *B. papayae* and *B. carambolae* were the most abundant species at all sites. Study site in Songkhla province was higher than any other site in species number followed by Narathiwat, while Trang and Surathani provinces were not different in species number.

***Keywords*—** southern Thailand, guava, ball trap, Steiner trap, *Bactrocera.*

I. Introduction

THE production of fruit and vegetables in Thailand generate important sources of income. These crops provide required nutritional essentials for the populace. The importance of horticultural sector was noticed by the government and subsequently it development was included in the National, Social and Economic Development Plan since 1981 (Plan V) [1]. Due to increase in population and urbanization levels, there is also increase in the demand for fruits and vegetables. For several tropical fruits, the production is mainly by smallholder producers largely intended for local consumption in the rapidly expanding local-urban green market (*Thalad kaset*). However, reliable markets for fruits can be secured only when a country is able to produce high quality fruits free from pests and diseases. Production of high quality fruits and vegetables worldwide is hampered by insect pests, especially fruit fly (Diptera: Tephritidae) [2].

The Tephritid flies especially those in the sub-family Dacinae are well distributed in south-east Asian countries. Apart from the clearly distinct few species of this sub-family, it is known that a complex of sibling species exists in this region and much of these complex members are of serious economic importance to agriculture because of damage caused to commercial fruits and vegetables. The damage, if uncontrolled, may result in a total loss of the crop in question [3]. The cost of losses due to infestation of fruit flies can be surprisingly high, there are examples where losses have been up to 100% in cucurbit species, caused by Melon fly (*Bactrocera cucurbitae*) [4]. Crop losses in mango (12-60%), guava (40-90%) and papaya (12-60%) have also been recorded as in [5]. Species in the *B. dorsalis* complex are certainly the most significant fruit fly pest species in south-east Asia [6]. Reference [7] revised the family tephritidae and proposed two distinct genera, *Bactrocera* and *Dacus*, for the tribe Dacini (Sub-family Dacinae). *Bactrocera* is a large genus consisting of 629 described species out of 880 in the tribe Dacini [8], and contains most of the fruit fly pests in the tropical and subtropical countries.

Thailand fauna is rich in biodiversity, but few diversity studies were known to be carried out on the tephritid flies. Examples of such studies include the survey as in [9] of the fauna of Thailand and neighboring countries which treated 211 species of fruit flies. Most recent study was the identification of the *B. dorsalis* complex of fruit flies in Asia [6]. Their study identified 14 members of this complex to be prevalence in Thailand. Except for the extensive survey carried out on fruit flies of bamboo shoot [10], [11], [12], most pronounced studies were on biology and ecological studies [13], [14], [15], [16], [17].

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The family Myrtaceae, is the family of one of the most consumed fruits family in Thailand and the most popular fruit of this family is the *P. guajava*. Fruit flies biodiversity have not been sufficiently studied on many members of this family. Therefore, this research aimed at identifying those fruit flies that subsist in guava orchards and it surrounding environments. The alpha and beta diversity at different sites will be presented. These biodiversity studies will enhance pest advisors with the ideas about what fruit flies were localize and or prevalence, and how to develop friendly ecological control schemes for these pests.

II. Study Site

The study was conducted from March 2012 to March 2013. Four provinces were selected for sample collections; these were Narathiwat, Songkhla, Trang and SuraThani (Fig. I). The sample collections were based specifically in guava orchards and their surrounding environments. Guava orchards were selected because some *Bactrocera* spp were found to be in close association with the *P. guajava* fruits from the preliminary survey of this study. Commercial orchards were used and were mainly located within agro-forested areas of which most vegetation were extended rubber plantations except for the few vegetable garden and fruit orchards that were patchy spot among the rubber plantations. Apart from the great distances among the sites, also were different geographical features and physical factors which distinctly distinguished each site.

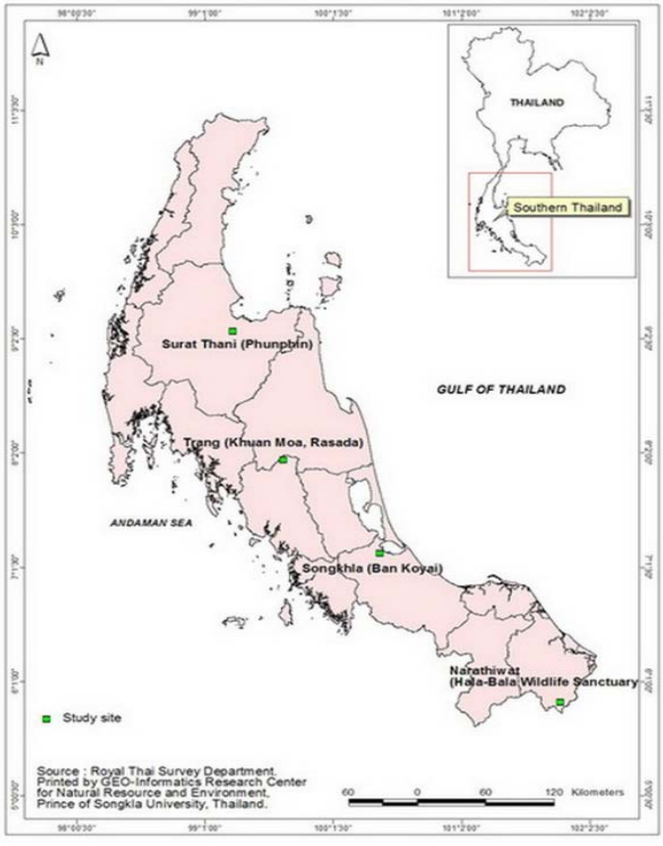

Fig. I Location of agro-forested sites studied in southern Thailand for fruit fly biodiversity.

III. Trapping

Consecutive trapping of fruit flies was conducted for a year. The focus was on fruit infesting species of the genus *Bactrocera* and most significantly the *B. dorsalis* complex members associated with *P. guajava*.

Two types of traps were implored for this research; Steiner trap [18] (Thailand modification) and Ball trap AR934 (ISCA Technologies, modified McPhail trap, USA). Methyl eugenol (Benzene,1,2,-dimethoxy-4-(2-propenyl) (Thailand) and torula yeast (ISCA Technologies, USA) were the two parapheromones (attractants) used. For the Steiner trap, methyl eugenol was mixed with Pyrethriod (Changzhou Kangmei Chemical Industry, China) at the rate of 63ml pyrethroid / 1000ml methyl eugenol, 1ml of the mixture was used to impreginate cotton wool placed in the trap. The Ball trap AR934 was baited with torula yeast pellets dissolved in water (3 pellets to 1½ litres) as recommended by ISCA Technologies, USA. Methyl eugenol is relatively specific and was used to attract the members of the genus *Bactrocera* and mostly the *B. dorsalis* complex members. The torula yeast is less specific and was used to attract other fruit flies.

At each site two replicates of each type of traps were set up in orchard and around the orchard (2 Steiner traps and 2 ball traps) given a total of four traps each on and around the orchards. In guava orchards, the traps were hung and suspended between the ranged of 1.3 - 1.5m height. But 1.5 - 2.3m height was maintained around the guava orchards where traps were hung on bamboo trunk (*Bambusa arundinacea* Willd.), rubber, (*Hevea brasiliensis* Müll.Arg), sapodilla (*Manilkara zapota* L.), and biter bean (*Parkia speciosa* Hassk.) trees. Traps were inspected and trapped flies were collected once a week only in Songkhla province and all baits were changed every month. Flies were collected at other sites once in a month and baits replaced accordingly. Traps were rotated anticlockwise after each clearance.

IV. Characteristics Of The Site Where The Biodiversity Study Was Carried Out

The orchards in Songkhla (Ban Koyai 4.45ha) and Trang (Khuan Mao 3.23ha) sites were located in extensive *H. brasiliensis* plantation. But the Narathiwat (Halabala Wildlife Santuary 1.21ha) site was surrounded by forest comprising of different vegetation. SuraThani (Phunphin 2.42ha) site was located in an extensive palm (*Elaeis guineensis* Jacq.) plantation. Other economic fruits which occur within the range of the study sites that were similar, include; rose apple (*Syzygium samarangense* Merrill & Perry), banana (*Musa* spp. L.), mango (*Mangifera indica* L.), pawpaw (*Carica papaya* L.), Citrus (*Citrus sinensis* L.), santol (*Sandoricum koetjape* Merr.) malabar almond (*Terminalia catappa* L.) and bamboo (*B. arundinacea*). But rambutan (*Nephelium lappaceum* L.), mangosteen (*Garcinia mangostana* L.), sapodilla (*M. zapota*), Star fruit (*Averrhoa carambola* L.), bread fruit (*Artocarpus altilis* (Parkinson) Fosberg), jackfruit (*Artocarpus heterophyllus* Lam.), bitter bean (*P. speciosa*), durian (*Durio*

zibethinus L.), tamarind (*Tamarindus indica* L.), coconut (*Cocos nucifera* L.), palmyra palm (*Borassus flabellifer* L.), palm (*Livistona speciosa* Kurz.), langsat (*Lansium domesticum* Corrêa.) were common to Ban Koyai, Khuan Mao and Hala-Bala Wildlife sanctuary. The vegetables and legumes that were sited at Ban Koyai and Khuan Mao were; cucumber (*Cucumis sativus* L.), bitter gourd (*Momordica charantia* Descourt.), chilli pepper (*Capsicum annum* L.), eggplant (*Solanum melongena* L.) and lentils (*Vigna unguiculata* Verdc.). Roots and tubers found at Ban Koyai were; sweet potato (*Ipomoea batatas* Lam.) and cassava (*Manihot. esculenta* Crantz.). The economic grasses were sited at Ban Koyai and SuraThani and these were; sugar cane (*Saccharum officinarum* L.), rice (*Oryza sativa* L.).

V. Identification

The sampled specimens were sorted on the basis of morphological characters detailed in [6], [9], [19], [20], [21] with the aid of stereo microscope. Further confirmations were done by Assoc. Prof. Dr. Surakrai Permkam of the Faculty of Natural Resourses, Prince of Songkla University, Hat Yai. Voucher specimens were kept at the Entomology Research Unit of the Department of Biology and Princess Maha chakri Sirindhorn Natural History Museum, Prince of Songkla University, Hat Yai, Thailand.

VI. Data Analysis

Alpha diversity (species richness or within habitat) and Beta diversity (differentiation diversity or between habitats diversity) at the different locations and on guava orchards and around the guava orchards were analyzed and compared to determine which site is more in species or diverse. Qualitative Sorenson similarity index (QS) were calculated to determine extent of similarity among sites by using the formulae described by Magurran [22].

$$QS = 2C / A + B$$

Where; QS = Quotient of similarity (0-1), C = Number of species shared by the two sites and A + B = Sum of species in site A and B.

The attractant were also compared by pooling the data for each parpheromone type together. Only the presence and absence data are used, since the differences in attractiveness of the different attractants used do not allow the use of quantitative data. Analysis was conducted on DIVERSITY statistical package.

VII. RESULT

VIII. Alpha diversity

Species composition and abundance

The sum of 226,658 fly specimens was collected during the field sampling period of one year at all sites. From the total specimens collected, 75.6973% and 22.7735% represents *B. papayae* and *B. carambolae*, respectively (Table I.). These two species constituted 98.4708%. Others species represent very low percentage of 1.5292%. The Ban Koyai site revealed the highest species number of 30. The Hala-Bala Wildlife Sanctuary present 19 species, while 10 species each were observed at Khuan Mao and Phunphin sites. The total species number for all sites was 31 species. All the species collected so far belong to the genus *Bactrocera*. Among the 31 species collected at all sites, 20 species belong to the *Bactrocera dorsalis* complex (*) and 11 species were other *Bactrocera*. Out of the 31 species, 8 were common to all sites, these were; *B. albistrigata*, *B. carambolae*, *B. cucurbitae*, *B. irvingiae*, *B. osbeckiae*, *B. papayae*, *B. propingua*, *B. umbrosa*. But *B. kinabalu* was only found at Hala-Bala Wildlife Sanctuary and likewise, *B. sp1* was common to Ban Koyai site only.

TABLE I
SPECIES AND POPULATION TRAPPED AMONG THE FOUR SITES IN SOUTHERN THAILAND.

Species	Narathiwat	Songkhla	Trang	Surathani	Total	%
B. albistrigata	2	10	1	1	14	0.0062
*B. atrifemur**	0	5	0	0	5	0.0022
*B. bimaculata**	0	27	0	0	27	0.0119
*B. caramabolae**	3091	38552	7196	2778	51617	22.7735
*B. caryae**	0	3	0	0	3	0.0013
B. caudatus	3	349	0	0	352	0.1553
B. correcta	5	204	0	0	209	0.0922
B. cucurbitae	2	16	7	2	27	0.0119
B. diversa	8	460	0	0	468	0.2065
*B. floresiae**	1	5	0	0	6	0.0026
*B. holtimanni**	10	43	0	0	53	0.0234
*B. irvingiae**	7	66	23	10	106	0.0468
*B. kandiensis**	0	3	0	0	3	0.0013
*B. kinabalu**	1	0	0	0	1	0.0004
B. latifrons	1	8	1	0	10	0.0044
*B. lombokensis**	4	15	0	0	19	0.0084
*B. malaysiensis**	2	24	0	0	26	0.0115
*B. melastomatos**	0	17	0	0	17	0.0075
B. musae	0	5	2	2	9	0.0039
*B. neocognata**	0	3	0	0	3	0.0013
*B. neopropingua**	0	2	0	0	2	0.0009
*B. osbeckiae**	13	78	33	21	145	0.064
*B. papayae**	7936	132596	20034	11005	171571	75.6973
*B. philippinensis**	0	32	0	0	32	0.0141
*B. propingua**	2	7	2	1	12	0.0053
*B. quasipropingua**	0	8	0	0	8	0.0035
*B. raiensis**	1	2	0	0	3	0.0013
B. tau	1	6	0	1	8	0.0035
B. umbrosa	3	1569	253	13	1838	0.8109
B. zonata	0	60	0	0	60	0.0265
B. Sp1	0	1	0	0	1	0.0004
Total	**11093**	**174176**	**27552**	**13834**	**226654**	
Species richness	**19**	**30**	**10**	**10**	**31**	

**B. dorsalis* complex members

Apart from the *Dacus* spp. which is not within the scope of this present work, thirteen new records were observed all belonging to the *B. dorsalis* complex previously revised in [6]. Except for a taxa tagged *B. sp1* whose identity is still unclear, all other *Bactrocera* have been previously identified and described by other tephritid scientists. The total number of

flies collected belonging to the new records was 188 specimens from the four sites. Out of this, *B. holtimanni* was the highest with 28.1915%, followed by *B. philippinensis* with 17.0213% and *B. bimaculata* 14.3617% (Table II).

TABLE II
NEW RECORDS OF B. DORSALIS COMPLEX IN SOUTHERN THAILAND

Species	Narathiwat	Songkhla	Trang	Surathani	Total	%
B. atrifemur	0	5	0	0	5	2.6596
B. bimaculata	0	27	0	0	27	14.3617
B. caryae	0	3	0	0	3	1.5957
B. floresiae	1	5	0	0	6	3.1915
B. holtimanni	10	43	0	0	53	28.1915
B. kandiensis	0	3	0	0	3	1.5957
B. kinabalu	1	0	0	0	1	0.5319
B. lombokensis	4	15	0	0	19	10.1063
B. malaysiensis	2	24	0	0	26	13.8298
B. neocognata	0	3	0	0	3	1.5957
B. neopropingua	0	2	0	0	2	1.0638
B. philippinensis	0	32	0	0	32	17.0213
B. quasipropingua	0	8	0	0	8	4.2553
B. Sp1	0	1	0	0	1	0.5319
Total	**18**	**171**	**0**	**0**	**188**	
Species richness	**5**	**13**	**0**	**0**	**14**	

Only the sites in Narathiwat and Songkhla provinces were found to have shared these new records in the order of 5 and 13 species, respectively. Only four species among the new records were common to both sites, these were; *B. floresiae*, *B. holtimanni*, *B. lombokensis* and *B. malaysiensis*.

In general, 11 species were trapped from guava orchards viz; *B. albistrigata*, *B. carambolae*, *B. caudatus*, *B. correcta*, *B. cucurbitae*, *B. diversa*, *B. holtimanni*, *B. irvingiae*, *B. papayae*, *B. tau*, *B. umbrosa*, and *B. zonata.* The remaining 20 species were trapped from around the guava orchards.

IX. BETA DIVERSITY

Differentiation diversity

The QS Index for this study (Table III) revealed high similarity between Trang and SuraThani sites. Also high similarity was observed between Narathiwat and Songkhla sites. Except for low similarity observed between Narathiwat and Trang sites, all other comparisons revealed low-medium similarities.

TABLE III.
DIVERSITY INDICES OF THE FRUIT FLY SPECIES AT DIFFERENT AGRO-FORESTED LOCATION IN SOUTHERN THAILAND.

Site	Trang	Surathani	Narathiwat
Songkhla	0.500	0.500	0.735
Trang	-	0.900	0.462
Surathani	-	-	0.513

QS indices

X. ATTRACTANT RESPONSE

The methyl eugenol and torula yeast were they two para-pheromones used as attractants for this study. Though methyl eugenol was known for its specificity and limited species attraction, but it was revealed from this study that it attracted more species of *Bactrocera* fruit flies than the torula yeast which has broad spectrum of attracting more species (Table IV). This scenario was more pronounced in Narathiwat and Songkhla where 19 and 26 species were attracted by methyl eugenol and 3 and 7 species were attracted by torula yeast, respectively. Methyl eugenol attracted mostly the *B. dorsalis complex* members while torula yeast attracted more of the cucurbit species (*B. cucurbitae*, *B. caudatus*, *B. latifrons* etc) and very few individuals of *B. carambolae* and *B. papayae* as well as other *Dacus* species and some bamboo shoot genus outside the scope of this study.

TABLE IV
RESPONSE OF FRUIT FLY SPECIES TO ATTRACTANTS

Species	NT/ME	NT/TY	SG/ME	SG/TY	TR/ME	TR/TY	ST/ME	ST/TY
B. albistrigata	2	0	0	10	0	1	1	0
B. atrifemur	0	0	5	0	0	0	0	0
B. bimaculata	0	0	27	0	0	0	0	0
B. caramabolae	2526	565	20999	17553	6797	399	2290	488
B. caryae	0	0	3	0	0	0	0	0
B. caudatus	3	0	224	125	0	0	0	0
B. correcta	5	0	204	0	0	0	0	0
B. cucurbitae	2	0	0	16	0	7	0	2
B. diversa	8	0	460	0	0	0	0	0
B. floresiae	1	0	5	0	0	0	0	0
B. holtimanni	10	0	43	0	0	0	0	0
B. irvingiae	7	0	66	0	23	0	10	0
B. kandiensis	0	0	3	0	0	0	0	0
B. kinabalu	1	0	0	0	0	0	0	0
B. latifrons	1	0	0	8	0	1	0	0
B. lombokensis	4	0	15	0	0	0	0	0
B. malaysiensis	2	0	24	0	0	0	0	0
B. melastomatos	0	0	17	0	0	0	0	0
B. musae	0	0	5	0	2	0	2	0
B. neocognata	0	0	3	0	0	0	0	0
B. neopropingua	0	0	2	0	0	0	0	0
B. osbeckiae	13	0	78	0	33	0	21	0
B. papayae	7053	883	89071	43525	16100	3934	9592	1413
B. philippinensis	0	0	32	0	0	0	0	0
B. propingua	2	0	7	0	2	0	1	0
B. quasipropingua	0	0	8	0	0	0	0	0
B. raiensis	1	0	2	0	0	0	0	0
B. tau	0	1	0	6	0	0	0	1
B. umbrosa	3	0	1569	0	237	16	11	2
B. zonata	0	0	60	0	0	0	0	0
B. Sp1	0	0	1	0	0	0	0	0
Total	**9644**	**1449**	**112933**	**61243**	**23194**	**4358**	**11928**	**1906**
Species richness	**18**	**3**	**26**	**7**	**7**	**6**	**8**	**5**

*ME=Methyl eugenol, TY=Torula yeast, NT=Narathiwat, SG=Songkhla TR=Trang and ST=SuraThani

XI. DISCUSSION

The genus *Bactrocera* contains over 500 described species of fruit flies. It is the most predominant genus of fruit fly in the Asia and Pacific regions [21], [8]. Within this genus, the *B. dorsalis* complex contained 75 species which is a group of monophyletic group of species of relatively recent evolutionary origin [23]. From the present study, eight species were found to be common to all sites of which five of them belong to the *B. dorsalis* complex. *B. carambolae* and *B.*

papayae were found to be the most abundant and predominating at all agro-forested locations in southern Thailand. Though classified as sympatric sibling species, but their relatedness was recently distinguished [24]. These species were reported by several researchers [6], [17] to have predominated over other species assuming a notorious status posing high threat to fleshy fruits. Although the two species were prevalence at all locations, *B. papayae* was more predominating and abundant at all locations. The occurrence of these two species can be attributed to having wide range of host plants among wild and cultivated species. This were evidenced from some tephritid workers reports [6], [25], [26], [27], their work had resulted into 75 and 193 hosts for *B. carambolae* and *B. papayae*, respectively. Other members of the *B. dorsalis* complex common to all sites were *B.irvingiae*, *B. osbeckiae* and *B. propingua*. The remaining fifteen were recorded in 1 – 3 location(s). These were relatively small in number, may be due to fewer available hosts, less colonization ability and their phytophagous status [28], [29]. *B. umbrosa* was common to all locations and it was the third most abundant species after *B. carambolae* and *B. papayae*. It was not surprising to record this species at all locations as it is not a pest of guava. But it got attracted to methyl eugenol [20], also their host; *A. altilis* and *A. heterophyllus* are widely cultivated at three locations. Though in small number, *B. albistrigata* were also recorded at all locations within guava orchards only as the have affinity for fruit plants in the family myrtaceae and rarely respond to methyl eugenol. *B. cucurbitae* was also common to all locations. This is oligophagous species recorded on cucurbitae, there occurrence on guava orchards was due to the presence of their hosts (*C. sativus* and *M. charantia*) on and around the orchards.

Other species trapped at 1 - 3 locations of significant pest status were *B. diversa*, *B. caudatus* and *B. correcta*. Apart from the first two species which have their host range among the cucurbitae plants, *B. correcta* has been reported to be pest of guava. *B. diversa* though not a pest of guava, but have been reported to form winter swarms and congregate at the underside of guava leaves [30]. The three species were trapped only from guava orchards inter-planted with the plants from cucurbitae family.

The other species found were usually present in very low numbers, often represented by 1-5 specimens (e.g, *B. atrifemur*, *B. caryae*, *B. floresiae*, *B. kandiensis*, *B. kinabalu*, *B. neocognata*, *B. neopropingua*, *B. raiensis* and *B.sp1*). All of them were trapped among the guava orchard surrounding vegetation. These species might be of low economic importance due to fewer hosts and or newly introduced to such areas.

The new records were fourteen species of which thirteen belong to the *B. dorsalis* complex and *B.sp1* which could not be described due to it representation by single specimen. These species were very few in numbers of individuals trapped. All of them except *B.sp1* were found to be introduced from adjacent countries. This phenomenon is similar to the report of [31] that South East Asia (Thailand, Penisular Malaysia, Indonesia and Borneo Island consisting of East Malaysia, Brunei Darussalam, and Kalimantan) appears to share many fruit fly species. Hence cross infestation is common to most of these countries. But there are some species too from as far as India / Sri Lanka (*B. caryae* and *B. kandiensis*) and Philippine (*B. neopropingua*, *B. philippinensis* and *B. quasipropingua*) which were found in Thailand in this present study.

Songkhla site (Ban Koyai) was the most diverse with reference to species richness and available hosts. Thirty-one species were observed. Related to this site is the Hala-Bala Wildlife Sanctuary in Narathiwat which recorded 19 species. This site is rich in wild and some economically important host fruits. The Trang (Khuan Mao) and SuraThani (Phunphin) sites were not different in the number of species recorded and less diverse compared to the other two sites mentioned before. This may be due to the fact that, these sites were relatively less in the number host plants. Therefore, species richness and abundance is directly proportional to the available hosts.

XII. Beta Diversity

High fauna similarities existed between the sites in Trang and Surathani, and between Narathiwat and Songkhla. Other similarity comparisons fall in low-medium status. This is most likely caused by the different range of fruits at each agro-forested location and most significantly the impact of weather such as temperature, rainfall and relative humidity. The Ban koyai agro-forest location in Songkhla had 31 species and the richest in species, richer than Hala-Bala Wildlife Santuary in Narathiwat by 12 species and richer than Khuan Mao in Trang and Phunphin in Surathani by 21 species. Out of the 14 new records of species, 13 were observed at Ban Koyai and 5 at Hala-Bala Wild life Sanctuary agro-forest locations. Khuan Mao and Phunphin agro-forested locations had none. The disparity may be due to weekly sampling at Ban Koyai compared to monthly sampling at other locations. The distribution of species therefore, should be referenced with caution until more intensive sampling is carried out in other areas. It is also worth mentioning that Ban Koyai and Hala-Bala Wildlife Sanctuary present a more conducive environment for fruit fly to thrive. These agro-forested locations, apart from heavy rubber plant cover which present a cool environment and subsequently moderate temperature; there are several varieties of fruit producing plants coupled with reasonable distance between guava orchards and human settlement areas. But Khuan Mao and Phunphin agro-forested

locations do not have such vegetation covers and are relatively close to human settlement areas. Out of the 8 common species, *B. carambolae* and *B. papayae* were the most abundant in reasonable number above economic threshold. These notorious species have significantly dominated over other species causing damages to fleshy fruits in southern Thailand.

XIII. Attractants Response

The attractants correspond to published records for different species. Methyl eugenol is known to be very potent and attract some species of the genus *Bactrocera* especially the *B. dorsalis* complex members [6]. The *B. carambolae* and *B. papayae* have been long known to respond immensely to methyl eugenol. Hence, it is not surprising having them in large number at all locations. The torula yeast is known to attract fly from most sub-family of tephritidae (Blepharoneurinae, Dacinae, Phytalmiinae, Tachiniscinae, Tephritinae and Trypetinae). But because the scope of this present work is limited to dacinae (genus *Bactrocera*) makes it look less potent. Furthermore, torula yeast is actually an attractant that do not operate as parapheromones but as food substances required for proper development of eggs (attract mostly female and any male attracted was accidental). Hence, less specific than the specific parapheromones attractants. There captures reflect more the proportional presence of different fruit flies in particular environment. Also the radius of attraction is less compared to parapheromones and therefore presents better the fruit fly fauna immediately surrounding trap location, rather than a wide area as common to parapheromones.

The Steiner traps captured large number of flies from all locations than the ball traps. But most cucurbit feeders (*B. cucurbitae*, *B. caudatus*, *B. tau* and *B. latifrons*) were captured by the ball traps because the responded significantly to torula yeast than methyl eugenol. Accidental trapping was rarely recorded, only for a *B. latifrons* and some *B. cucurbitae* that were found in methyl eugenol trap which is very uncommon. However, this does not reflect a true parapheromone response

XIV. Impact Of B. Carambolae And B. Papayae On Other Fruit Fly Diversity

The present work revealed 31 species of the genus *Bactrocera* to be present in southern Thailand of which 14 were new records. Therefore, 17 species were present before now attacking fleshy fruits in this region. The relative abundance of other species seems to be affected by the present of *B. carambolae* and *B. papayae*. It seems as if this two notorious species are outcompeting and displacing many other species. This phenomenon has also been observed with *B. invadens* in Kenya [2] and *B. tryoni* in Australia [32]. The two species have been found to co-subsist on guava fruits which lead to intergeneric competition [33] that might have limited other species (*B. correcta*) to other hosts. The abiotic factors at various environments may be well adapted to by these species as they subsist very well over a wide range of temperature. Other factor could be the nature of various agro-forest locations and their life history strategies. It seems that *B. papayae* multiply rapidly and subsequently has the ability to colonise new areas faster than other species. *B. carambolae* and *B. papayae* should be considered as a serious pest that could threaten the growth of horticultural industry and have an immense impact on the fruit fly fauna in southern Thailand.

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