

Notes on the Genus *Bactrocera* Fruit Fly species in Mango Orchards in Myanmar

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Abstract: Two surveys were conducted in the dry season and monsoon season by the Japan International Cooperation Agency (JICA) in 2014 to reveal the presence of the *Bactrocera* fruit fly species in Myanmar. In the survey, host fruit sampling and trapping were conducted at four major mango production areas, namely the Yangon, Bago and Mandalay regions and Shan State, and more than seventy thousand *Bactrocera* fruit fly specimens were collected in twenty mango orchards in nine townships. While results of the seasonal occurrence of serious quarantine pest species were previously reported, further analysis was made in this study to determine fruit fly fauna in mango orchards. Based on the morphological research, twenty *Bactrocera* species were identified including major serious fruit flies such as *B. dorsalis*, *B. correcta* and *B. cucurbitae*. Out of the twenty species, nine were new findings and not recorded previously in Myanmar.

Key words: Dacinae, *Bactrocera*, Myanmar, attractant, quarantine, plant protection

Introduction

In recent years, some taxonomists have reported on the Dacinae fruit fly fauna of countries such as India, Bangladesh and China around Myanmar (Kapoor, 1993; Leblanc *et al.*, 2013, 2014; Fericia Kueh Tai Hui *et al.*, 2013; Drew *et al.*, 2007; Hardy, 1973; Liang *et al.*, 1993; Tsuruta and White; 2001, Tsuruta, 1998). According to Drew and Romig (2013), at least fourteen *Bactrocera* species seem to occur in Myanmar, but no significant information has been reported of *Bactrocera* fruit fly fauna in Myanmar. Two types of approaches, i.e. fruit sampling and adult fly trapping, were conducted by the Japan International Cooperation Agency (JICA) in 2014 in order to reveal the distribution of the pest fruit flies in mango orchards in Myanmar. While Nakahara *et al.* (2018) previously reported the seasonal occurrence information of serious plant quarantine pest species such as *B. correcta*, *B. dorsalis* and *B. cucurbitae*, this study summarizes all the species collected in the survey under the view of a fauna of the fruit flies, which is the first comprehensive report of fruit fly species occurring in mango orchards in Myanmar.

Materials and methods

Fruit fly specimens were collected from four major mango production areas, namely the Yangon, Bago and Mandalay regions and Shan State, using two methods, i.e. fruit sampling and adult fly trapping. The methods in detail and geographical data of the locations were described in detail in Nakahara *et al.* (2018). The specimens were kept in a dry state until observation. Morphological identification was made under a stereoscopic microscope. For observation of the terminalia, male abdomens were treated with 10% KOH and transferred to distilled water for dissection as needed. They were placed on double-sided tape and examined under a stereoscopic microscope. Wings were mounted on prepared slides using gum-chloral mounting media and the length was measured under stereoscopic a microscope. Each specimen was identified morphologically in the laboratories of the Plant Protection Division (PPD) in Insein, Yangon, and the Nagoya Plant Protection Station (NPPS) and Yokohama Plant Protection Station (YPPS) in Japan. The main references used for identification were White and Elson-Harris (1992), Drew and Romig (2013) and Drew and Romig (2016), while other papers were referred

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to as needed. Several researchers suggested the elevation of the *Bactrocera* subgenus *Zeugodacus* to full genus level based on phylogenetic data in recent years (De Meyer *et al.*, 2015; Doorenweerd *et al.*, 2018; Krosch *et al.*, 2012; Virgilio *et al.*, 2015). However, Han *et al.* (2017) refers to weak statistical support based on poor sampling data, and that the view has not been accepted by some authors. We considered the status is in the middle of discussion and used the *Bactrocera* subgenus *Zeugodacus* in the study. The specimens examined are deposited in the Research Division of the Yokohama Plant Protection Station, Ministry of Agriculture, Forestry and Fisheries.

Results and discussion

In the fruit sampling, more than two thousand adult flies were detected from mango fruits. As a result of identification, three species were confirmed including *Bactrocera carambolae*, *B. correcta* and *B. dorsalis*. However, *B. zonata*, well known as a species infesting mangoes, was unexpectedly not detected from mango fruits in the survey. *B. latifrons*, not pest of mangoes, were detected from fresh chili (*Capsicum* sp.) cultivated on the premises of the PPD in Insein, Yangon. In the adult fly traps, more than seventy thousand adult males were collected by the trapping survey. As a result of morphological observation, nineteen species were detected as follows: *B. (Asiadacus) apicalis*, *B. (Bactrocera) bhutaniae*, *B. (Bactrocera) carambolae*, *B. (Bactrocera) correcta*, *B. (Bactrocera) dorsalis*, *B. (Bactrocera) nigrifacia*, *B. (Bactrocera) rubigina*, *B. (Bactrocera)* sp. near *lateritaenia*, *B. (Bactrocera) tuberculata*, *B. (Bactrocera) zonata*, *B. (Parasinodacus) cilifera*, *B. (Parasinodacus) incisa*, *B. (Sinodacus) hochii*, *B. (Sinodacus)* sp. near *laterum*, *B. (Zeugodacus) caudata*, *B. (Zeugodacus) cucurbitae*, *B. (Zeugodacus) diversa*, *B. (Zeugodacus) isolata*, *B. (Zeugodacus) tau* (refer to Fig 1, Fig 2, Table 1 and Fruit flies recorded in the present study (described below)).

According to previous reports, fourteen *Bactrocera* species are occurring in Myanmar (CABI, 2017; Drew and Romig, 2013). Out of these species, nine species were confirmed in our survey, and the other five species (data not shown) were not detected. In addition to those nine species, eleven other species were detected in our survey. Among the species, two species, *B.* sp. near *lateritaenia* and *B.* sp. near *laterum*, could not be identified exactly because there were few samples and a sufficient analysis could not be conducted. Although not described in detail in this paper, another *B.* sp. was also recorded in addition to the two species. Further investigation is necessary about the three species using more specimens. For the other nine species, namely *B. apicalis*, *B. bhutaniae*, *B. carambolae*, *B. cilifera*, *B. diversa*, *B. hochii*, *B. isolate*, *B. nigrifacia* and *B. rubigina*, it would be the first time for a scientific journal to report their distribution in Myanmar.

Seven species, namely *B. carambolae*, *B. correcta*, *B. dorsalis*, *B. tuberculata*, *B. zonata*, *B. cilifera* and *B. cucurbitae*, were detected in all research area regardless of altitude, suggesting widespread distri-

bution in mango cultivation areas. Five species, namely *B. apicalis*, *B. diversa*, *B. hochii*, *B.* sp. near *lateritaenia* and *B.* sp. near *laterum*, were detected in the Yangon and/or Bago regions only. Three species, namely *B. incisa*, *B. isolata* and *B. bhutaniae*, were detected in Mandalay and Shan State only respectively. In addition, three species, namely *B. caudate*, *B. rubigina* and *B. tau*, were not detected in Shan State. A probable reason is that their habitat depends on host plants and the surrounding environment of mango orchards. This survey was carried out largely in mango orchards and the surrounding area. However, twenty species were found despite the limited research area, suggesting a diversity of fruit fly fauna in Myanmar. This survey should contribute to advancing studies on fruit flies because there is little information on fruit flies in Myanmar.

Fruit flies recorded in the present study

Bactrocera (Asiadacus) apicalis (de Meijere) (Fig 1: 1)

Distribution: Brunei, China, Malaysia, Thailand, Vietnam and Indonesia (Drew and Romig, 2013). Attractant: cue-lure. Host: *Trichosanthes wawraei* flowers (Cucurbitaceae) (Allwood *et al.*, 1999). This is probably the first record in Myanmar.

Bactrocera (Bactrocera) bhutaniae (Fig 1: 2)

Distribution: Bhutan, India, Bangladesh, Vietnam, Thailand and Taiwan (Doorenweerd *et al.*, 2018; Drew and Romig, 2013). Attractant: cue-lure. Host: *Xylosma brachystachys* (Flacortiaceae) (Drew and Romig, 2013). Doorenweerd *et al.* (2019) doubts the plant name based on the fact that it is unresolved in Theplantlist.org (2017). This is probably the first record in Myanmar.

Bactrocera (Bactrocera) carambolae Drew & Hancock (Fig 1: 3)

Distribution: India, Indonesia, Malaysia, Thailand, and Vietnam. Introduced into French Guiana, Guyana and Suriname (Drew and Romig, 2013). Attractant: methyl eugenol. Host: The species is a major pest of edible and rainforest fruits (Allwood *et al.*, 1999; CABI, 2017). The distribution has been suggested in previous surveys, however this is probably the first published record in Myanmar.

Bactrocera (Bactrocera) correcta (Bezzi) (Fig 1: 4)

Distribution: Bhutan, China, India, Malaysia, Myanmar, Nepal, Pakistan, Sri Lanka, Thailand and Vietnam (Drew and Romig, 2013). Attractant: methyl eugenol. Host: The species is a major pest of commercial edible fruits and wild fruits (Allwood *et al.*, 1999; CABI, 2017; Drew and Romig, 2013; Tsuruta and White, 1997).

Bactrocera (Bactrocera) dorsalis (Hendel) (Fig 1: 5, Fig 2)

Distribution: Asian countries such as Bhutan, Cambodia, Hong Kong, India, Laos, Myanmar, Nepal, Thailand, China, Sri Lanka, Taiwan and Vietnam (CABI, 2017; Drew and Romig, 2013). African countries including Angola, Benin and Congo. Oceania countries

Table 1. Summary of fruit fly species collected

Species	Lure	Collection site *	The report referring to distribution in Myanmar
<i>B. (Asiadacus) apicalis</i>	Cue-lure	Hlegu (Y), Pegu (B) and Patheingyi (M)	
<i>B. (Bactrocera) bhutaniiae</i>	Cue-lure	Taunggyi (S) and Nyaung Shwe (S)	
<i>B. (Bactrocera) carambolae</i>	Methyl eugenol	Hlegu (Y), Pegu (B), Sintgaing (M), Kalaw (S), Taunggyi (S) and Nyaung Shwe (S)	
<i>B. (Bactrocera) correcta</i>	Methyl eugenol	Hlegu (Y), Pegu (B), Amarapura (M), Sintgaing (M), Patheingyi (M), Kalaw (S), Taunggyi (S) and Nyaung Shwe (S)	Drew and Romig (2013) CABI (2017)
<i>B. (Bactrocera) dorsalis</i>	Methyl eugenol	Hlegu (Y), Pegu (B), Amarapura (M), Sintgaing (M), Patheingyi (M), Kalaw (S), Taunggyi (S) and Nyaung Shwe (S)	Drew and Romig (2013) CABI (2017)
<i>B. (Bactrocera) latifrons</i>	—	Insein (Y)	Carroll <i>et al.</i> (2002) McQuate <i>et al.</i> (2013)
<i>B. (Bactrocera) nigrifacia</i>	Cue-lure	Pegu (B), Amarapura (M), Patheingyi (M) and Sintgaing (M)	
<i>B. (Bactrocera) rubigina</i>	Cue-lure	Hlegu (Y), Pegu (B) and Sintgaing (M)	
<i>B. (Bactrocera) sp. near lateritaenia</i>	Cue-lure	Hlegu (Y)	
<i>B. (Bactrocera) tuberculata</i>	Methyl eugenol	Hlegu (Y), Pegu (B), Amarapura (M), Patheingyi (M), Sintgaing (M), Kalaw (S), Taunggyi (S) and Nyaung Shwe (S)	Drew and Romig (2013) CABI (2017)
<i>B. (Bactrocera) zonata</i>	Methyl eugenol	Hlegu (Y), Pegu (B), Amarapura (M), Patheingyi (M), Sintgaing (M), Kalaw (S), Taunggyi (S) and Nyaung Shwe (S)	Drew and Romig (2013) (wide spread across South-East Asia), CABI (2017)
<i>B. (Parasinodacus) cilifera</i>	Cue-lure	Hlegu (Y), Pegu (B), Amarapura (M), Patheingyi (M), Sintgaing (M), Kalaw (S), Taunggyi (S) and Nyaung Shwe (S)	
<i>B. (Parasinodacus) incisa</i>	Cue-lure	unknown (M)	Drew and Romig (2013)
<i>B. (Sinodacus) hochii</i>	Cue-lure	Hlegu (Y)	
<i>B. (Sinodacus) sp. near laterum</i>	Cue-lure	Pegu (B)	
<i>B. (Zeugodacus) caudata</i>	Cue-lure	Hlegu (Y), Pegu (B), Amarapura (M), Patheingyi (M) and Sintgaing (M)	Drew and Romig (2013) CABI (2017)
<i>B. (Zeugodacus) cucurbitae</i>	Cue-lure	Hlegu (Y), Pegu (B), Amarapura (M), Patheingyi (M), Sintgaing (M), Taunggyi (S) and Nyaung Shwe (S)	Drew and Romig (2013) CABI (2017)
<i>B. (Zeugodacus) diversa</i>	Methyl eugenol	Hlegu (Y)	
<i>B. (Zeugodacus) isolata</i>	Cue-lure	Amarapura (M) and Patheingyi (M)	
<i>B. (Zeugodacus) tau</i>	Cue-lure	Hlegu (Y), Pegu (B), Amarapura (M), Patheingyi (M) and Sintgaing (M)	Drew and Romig (2013) (mentioned as synonym of <i>B. zahadi</i>), CABI (2017)

* Collection site indicates township and first letter of the production area: Yangon Region (Y), Bago Region (B), Mandalay Region (M) and Shan State (S).



Fig. 1. External morphological characteristics of twenty fruit fly species (1)

1. *Bactrocera (Asiadacus) apicalis*, 2. *Bactrocera (Bactrocera) bhutaniae*, 3. *Bactrocera (Bactrocera) carambolae*, 4. *Bactrocera (Bactrocera) correcta*, 5. *Bactrocera (Bactrocera) dorsalis*, 6. *Bactrocera (Bactrocera) latifrons*, 7. *Bactrocera (Bactrocera) nigrifacia*, 8. *Bactrocera (Bactrocera) rubigina*, 9. *Bactrocera (Bactrocera) sp. near lateritaenia*, 10. *Bactrocera (Bactrocera) tuberculata*



Fig. 1. External morphological characteristics of twenty fruit fly species (2)

11. *Bactrocera (Bactrocera) zonata*, 12. *Bactrocera (Parasinodacus) cilifera*, 13. *Bactrocera (Parasinodacus) incisa*, 14. *Bactrocera (Sinodacus) hochii*, 15. *Bactrocera (Sinodacus) sp. near laterum*, 16. *Bactrocera (Zeugodacus) caudata*, 17. *Bactrocera (Zeugodacus) cucurbitae*, 18. *Bactrocera (Zeugodacus) diversa*, 19. *Bactrocera (Zeugodacus) isolata*, 20. *Bactrocera (Zeugodacus) tau*, a. Male adult (Female adult: *B. latifrons*) in dorsal view, b. Lateral view, c. Wing, d. face, e. Abdomen.

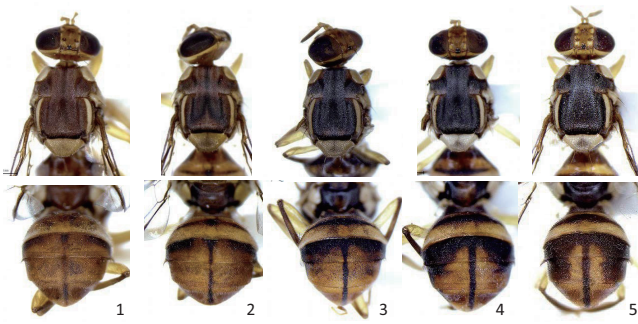


Fig. 2. Color variation patterns on scutum and abdomen of *Bactrocera dorsalis*.

1,3-5; ♂, Sintgaing Township, Mandalay Region, 10-11. II. 2014, coll., 2; ♂, Taunggyi Township, Shan State, 4. VI. 2014, coll.

such as French Polynesia, Palau and Papua New Guinea. Introduced into Hawaii and Mariana Islands. Eradicated from Ryukyu and Ogasawara Islands in Japan (CABI, 2017). Attractant: methyl eugenol. Host: The species is a major pest of commercial edible fruits and wild fruits (Allwood *et al.*, 1999; CABI, 2017; Drew and Romig, 2013; Tsuruta and White, 1997).

Scutum color pattern was highly variable, from almost entirely black to entirely orange brown (Fig 2) in Myanmar. These color variations were found in populations in which *B. dorsalis* are recorded to occur, i.e. Pakistan (Schutze *et al.*, 2014), India (David and Ramani, 2011; Schutze *et al.*, 2014) and Bangladesh (Leblanc *et al.*, 2013).

Drew and Romig (2013) doubted the distribution of *B. dorsalis* in India and Sri Lanka. In addition, Schutze *et al.* (2014) reorganized the classification of a part species including *B. dorsalis* and several sibling species in the latest research. In the future, there is a possibility that the classification and distribution area will be reorganized even further.

***Bactrocera (Bactrocera) latifrons (Hendel)* (Fig 1: 6)**

Distribution: Asian countries including Indonesia, Thailand, Taiwan and Vietnam, and introduced into Hawaii (Carroll *et al.*, 2002; Drew and Romig, 2013). Attractant: No record. Host: Solanaceae and nine other plant families (Allwood *et al.*, 1999; CABI, 2017, McQuate and Liquido, 2013). The specimens have been bred from fresh chili (*Capsicum frutescens*) in Yangon.

***Bactrocera (Bactrocera) nigrifacia Zhang, Ji & Chen* (Fig 1: 7)**

Distribution: Bangladesh, China, Thailand and Taiwan (Lanyu Is.) (Doorenweerd *et al.*, 2019; Drew and Romig, 2013; Zhang *et al.*, 2011). Attractant: cue-lure. Host: Verbenaceae, Capparaceae, Cucurbitaceae, Euphorbiaceae (Drew and Romig, 2013). This is probably the first record in Myanmar.

***Bactrocera (Bactrocera) rubigina (Wang & Zhao)* (Fig 1: 8)**

Distribution: Bangladesh, Bhutan, China, Thailand, Northern Vietnam and Taiwan (Doorenweerd *et al.*, 2019; Drew and Romig, 2013).

Attractant: cue-lure. Host: *Litsea verticillata* (Lauraceae)(Liang *et al.*, 1993). This is probably the first record in Myanmar.

***Bactrocera (Bactrocera) sp. near lateritaenia Drew & Hancock* (Fig 1: 9)**

This specimen was similar in appearance to *B. lateritaenia* Drew and Hancock which distributes in the Malay peninsula. Additional specimens are required to reliably identify the species. *B. lateritaenia* is reported from Brunei, Malaysia and Southern Vietnam (Drew and Romig, 2013). Attractant: cue-lure. Host: No record.

***Bactrocera (Bactrocera) tuberculata (Bezzi)* (Fig 1: 10)**

Distribution: Bhutan, China, Myanmar, Thailand and Vietnam (Drew and Romig, 2013). Attractant: methyl eugenol. Host: Anacardiaceae, Caricaceae, Lecythidaceae, Myrtaceae, Polygalaceae, Rosaceae, Sapotaceae (Allwood *et al.*, 1999; CABI, 2017).

***Bactrocera (Bactrocera) zonata (Saunders)* (Fig 1: 11)**

Distribution: Asian countries including Indonesia, Thailand and Vietnam. Introduced into Mauritius and Egypt (CABI, 2017; Drew and Romig, 2013). Attractant: methyl eugenol. Host: Wide range of commercial edible fruits and wild fruits (Allwood *et al.*, 1999; Drew and Romig, 2013; Tsuruta *et al.*, 1997).

***Bactrocera (Parasinodacus) cilifera (Hendel)* (Fig 1: 12)**

Distribution: China, Indonesia, Laos, Malaysia, Taiwan, Thailand and Vietnam (Drew and Romig, 2013). Attractant: cue-lure. Host: Male flowers of *Thladiantha hookeri* (Cucurbitaceae)(Allwood *et al.*, 1999). Requires confirmation (Hancock and Drew, 2017). This is probably the first record in Myanmar.

***Bactrocera (Parasinodacus) incisa (Walker)* (Fig 1: 13)**

Distribution: China, India, Malaysia, Myanmar, Thailand and Vietnam (Drew and Romig, 2013; Hancock and Drew, 2017). Attractant: cue-lure. Host: No record.

***Bactrocera (Sinodacus) hochii (Zia)* (Fig 1: 14)**

Distribution: China, Bangladesh, Vietnam, Malaysia, Thailand and Indonesia (Chua and Ooi, 1998; Drew and Romig, 2013; Hancock and Drew, 2018). Attractant: cue-lure. Host: *Gymnopetalum cochinchinensis*, *Luffa aegyptiaca*, *Trichosanthes wawraei* (Cucurbitaceae). This is probably the first record from the inland area of Myanmar.

***Bactrocera (Sinodacus) sp. near laterum Wang* (Fig 1: 15)**

The specimens had the typical appearance of *B. (Sinodacus) laterum* Wang in having distinct broad-sided lateral post-sutural yellow vittae (Wang, 1996). Drew and Romig (2013) have organized *B. laterum* as a new synonym of *B. (Sinodacus) hochii*. Additional specimens are required to reliably identify the species. *B. laterum* is re-

ported from China (Wang, 1996). Attractant: cue-lure. Host: No record.

Bactrocera (Zeugodacus) caudata (Fabricius) (Fig 1: 16)

Distribution: Brunei, China, India, Indonesia, Malaysia, Myanmar, Sri Lanka, Taiwan, Thailand and Vietnam. Attractant: cue-lure. Host: Male flowers of *Cucurbita moschata* (Cucurbitaceae) (CABI, 2017; Drew and Romig, 2013).

Bactrocera (Zeugodacus) cucurbitae (Coquillett) (Fig 1: 17)

Distribution: The species is reported from many countries in the world. Introduced into many countries including Hawaii (USA), Papua New Guinea and Solomon Islands (Drew and Romig, 2013). Attractant: cue-lure. Host: The species is recorded from nineteen plant families including Cucurbitaceae, Fabaceae and Solanaceae (CABI, 2017).

Bactrocera (Zeugodacus) diversa (Coquillett) (Fig 1: 18)

Distribution: China, India, Pakistan, Nepal, Sri Lanka, Bangladesh, Thailand and Vietnam (Drew and Romig, 2013; Hancock and Drew, 2018). Attractant: methyl eugenol. Host: Flowers of Cucurbitaceae. *Hemigimnodacus* Hardy was placed as a new synonym of subgenus *Zeugodacus* Hendel, with *B. (Z.) diversa* (Coquillett) (Hancock and Drew, 2018). This is probably the first record in Myanmar.

Bactrocera (Zeugodacus) isolata (Hardy) (Fig 1: 19)

Distribution: China, Laos, Thailand, Vietnam and Andaman and Nicobar Islands (Ranganath and Veenakumari, 1999; Drew and Romig, 2013). Attractant: cue-lure. Host: *Capparis* spp. and *Maerua* spp. (Capparaceae) (Allwood *et al.*, 1999). This is probably the first record in Myanmar.

Bactrocera (Zeugodacus) tau (Walker) (Fig 1: 20)

Distribution: Bangladesh, Bhutan, Brunei, China, India, Sri Lanka, Cambodia, Laos, Malaysia, Myanmar, Singapore, Thailand, Vietnam, Taiwan and Indonesia (CABI, 2017; Drew and Romig, 2013). Attractant: cue-lure. Host: The species is recorded from nineteen plant families including Cucurbitaceae and Fabaceae (CABI, 2017). Although sibling species *B. zahadi* is reported from Myanmar (Mahmood, 1999), Drew and Romig (2013) suggests that both species might be synonyms. While further investigation of both species is necessary, we identified the specimens as *B. tau* according to Drew and Romig (2013) in this report.

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和 文 摘 要

ミャンマーのマンゴウ栽培園地におけるミバエの記録

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2014年1-2月及び同年5-6月の2回、JICAによる「ミャンマー植物検疫技術協力に係るニーズ調査」の一環として、ミャンマーの主要なマンゴウ生産地域であるヤンゴン、バゴー、マンドレー、そしてシャン州南部のマンゴウ生産園地において、マンゴウ生果実の害虫であるミバエ種を特定するための野外調査を実施した。マンゴウ生果実を中心とした寄主植物採集とメチルユージノールとキュウルクを用いたトラップにより、ヤンゴン、バゴー、マンドレー、シャン州南部の主要なマンゴウ生

産地で7万頭を超えるミバエを採集して識別・同定した結果、*Bactrocera. correcta*, *B. cucurbitae*, *B. dorsalis*等の主要な害虫種を含む合計20種のミバエが確認された。これらのうち9種は、おそらくミャンマーからは初めての報告となる。マンゴウ生産園地及びその周辺の限られた調査範囲にもかかわらず20種ものミバエが確認され、ミャンマーにおけるミバエ相の多様性が示された。

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