

## Morphology of *Glycycometus malaysiensis*, a domestic mite in Malaysia

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**Abstract.** *Glycycometus malaysiensis* is an allergenic domestic mite found in houses. *G. malaysiensis* is known to be highly similar to and is often mistaken as *Blomia tropicalis*, one of the major house dust mite species that causes asthma and allergic diseases in many tropical and subtropical regions. It was also suggested that these mites cross-react with each other and that the prevalence of *G. malaysiensis* might be higher than previous reports. A review on the taxonomic keys as well as light and scanning electron micrographs of *G. malaysiensis* are presented to appreciate the fine morphological structures of *G. malaysiensis*. The mouth, setae, legs (trochanter, femur, genu, tibia and tarsus) and the sexual organs (genital openings, genital setae and genital suckers) of *G. malaysiensis* are outlined. The morphology of *G. malaysiensis* is also compared with that of *B. tropicalis* to delineate the key features for the differentiation between these two mite species.

### INTRODUCTION

The main aeroallergens that trigger allergy and asthma in the majority of Asian countries are from house dust mites (Pawankar *et al.*, 2008). These mites are mainly of three superfamilies: the Glycyphagoidea, Acaroidea and Analgoidea (Figure 1). Some species in the Glycyphagoidea and Acaroidea have been referred to as 'storage mites' or 'stored products mites' while the only Analgoidea in human associations belong to the Pyroglyphidae (house dust mites and others; which includes *Dermatophagoidea*, *Euroglyphus*, and *Malayoglyphus* species). Storage mites have been shown to trigger IgE-mediated sensitisation among rural workers who are exposed to barn dust, and in bakers and grain store workers (Musk *et al.*, 1989; Revsbech & Dueholm, 1990; Cuthbert *et al.*, 1979; van Hage-Hamsten *et al.*, 1985; Terho *et al.*, 1985). Recently, storage mites are also shown to cause non-occupational allergies in urban populations (Spieksma, 1991). Storage

mites therefore may be of as significant in triggering allergic responses as pyroglyphid mites (van Hage-Hasten & Johansson, 1992).

### The *Glycycometus* species

*Glycycometus travancoricus* gen. et sp. nov. was first described by Pillai, 1957. O'Connor later synonymised *Austroglyphophagus* (first described by Fain & Lowry, 1974) with *Glycycometus* and placed the genus in the family Aeroglyphidae in 1982. It is of superfamily Glycyphagoidea and family of Aeroglyphidae (taxonomy tree as shown in Figure 1). The genus *Glycycometus* has been rather neglected from an allergological standpoint. To date, 14 *Glycycometus* species were identified and they seem to be region or country specific (Table 1). They are either associated with insects (bees and flies), nests of small mammals (bats and rats), bird nests and dust collected from human dwellings. The size of an adult ranges between 320–440 µm x 225–295 µm (length x width; Fain & Lowry 1974).

Though not common (< 50% occurrence in house dust; Chew *et al.*, 1999a), *Glycycometus* species were found in house dust in the tropics. However, Colloff (2009) suggested that *Glycycometus* has probably been confused with and mistaken for the better-known *Blomia* (Glycyphagoidea: Echymyopodidae). Therefore, it could be more common and widespread than previous reports. Out of the 14 *Glycycometus* species identified, only *G. malaysiensis* is known to be potentially allergenic (Colloff, 2009).

### Morphological taxonomic keys of *Glycycometus* species

*Glycycometus* species have several general morphological characters that are different to other common Malaysian dust mites such as *Dermatophagoides* species, *Tyrophagus*

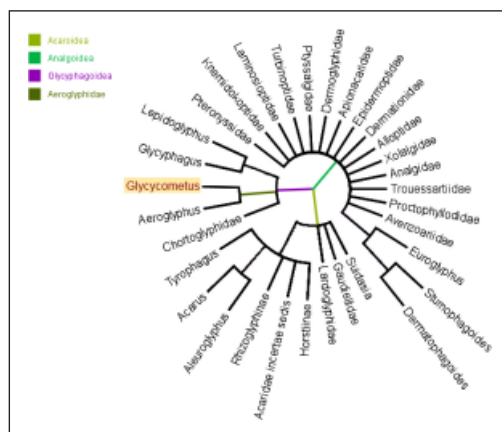


Figure 1. Phylogenetic relationships of the superfamilies of the Glycyphagoidea, the Acaroidea and the Analoidea (Tree file downloaded from NCBI database and modified with FigTree v1.4.0). The genus *Glycycometus* (highlighted) falls under superfamily: Glycyphagoidea, and family: Aeroglyphidae.

Table 1. Habitats and locations where the *Glycycometus* species are found (Mariana *et al.*, 2000, 2009; Chew *et al.*, 1999a, 1999b; Fain, 1974, 1977, 1978; Zhu *et al.*, 2004, 2005, 2007; Wang *et al.*, 2012; Cui & Wang, 2003; Li *et al.*, 1998; Nangia & Channa Basavanna, 1989; Putatunda, 2004; Chaudhury *et al.*, 2012; Miranda *et al.*, 2002; Fain & Gerson, 1990; Fain & Lowry, 1974)

Species	Habitats/Locations	Country
<i>G. hughesae</i>	• Bird nest	• Slough, England
<i>G. kenyensis</i>	• Bat guano at Kimakia cave, Coleura cave, Shimoni cave and Similani cave	• Kenya, East Africa
<i>G. lukoschusi</i>	• House dust	• Paramaribo, Suriname
<i>G. rodentorum</i>	• Nest of thicket rats	• Butare, Rwanda
<i>G. rwandae</i>	• Bee hives at Rugege forest	• Crete Congo Nile, Rwanda
<i>G. spieksmai</i>	• Bat	• Paramaribo, Suriname
<i>G. squamulatus</i>	• Flies	• Eala, Democratic Republic of Congo (formerly called Zaire), Central Africa
<i>G. asthmatiucus</i>	• Bat guano	• Bujumbura, Burundi, East Africa
<i>G. geniculatus</i>	• Bee nest	• East Africa
	• Flies, bird nests, grains	• Slough, England
	• House dust	• Haikou, China
	• Dust collected from cars, stored seeds	• Anhui, China
	• Dust collected from air-conditioners' filters, Chinese traditional medicinal materials	• Huainan, China
	• Stored products	• Karnataka and Himachal Pradesh, India
	• Bird nest	• West Bengal, India
<i>G. kualalumpurensis</i>	• House dust	• Kuala Lumpur, Malaysia
<i>G. malaysiensis</i>	• House dust, rice grains	• Kuala Lumpur, Malaysia
	• House dust	• Singapore
	• House dust	• La Chorrera, Panama
<i>G. thailandicus</i>	• Bee hives	• Koh Samui, Thailand
<i>G. troglodytus</i>	• Bat at Murra-el-Elevyn cave	• Nullabor, Western Australia
<i>G. weelawadjiensis</i>	• Bat guano at Weelawadji cave	• Eneabba, Western Australia

species, *Blomia* species and *Aleuroglyphus* species. In brief, *Glycycometus* spp. have long and densely pectinate dorsal setae, setae *ve* on the anterolateral prodorsal margin, and subtarsal scales on its legs (Figure 2). The tibia of leg I (Ti) is considerably shorter than genu (Ge) in *Glycycometus* species while Ti and Ge in other mite species of Glycyphagoidea are of approximately same length (Colloff, 2009). *Glycycometus* species also 1) lack a crista metopica, prodorsal shield (except for *G. hughesae*, which has

medially fused sclerites on the lateral portion of propodosoma), and dorsal transverse groove; 2) have a pattern of minute triangular scales pattern on the idiosomal cuticle; 3) have long and densely pectinated dorsal setae except for *d1*, which is acuminate, thin and smooth; 4) have elongated tarsi with sucker-like pulvillus at the tip, and 5) have subtarsal scales on the legs (Figure 2). The identification keys to differentiate the 14 *Glycycometus* species discovered so far is given in Figure 3.

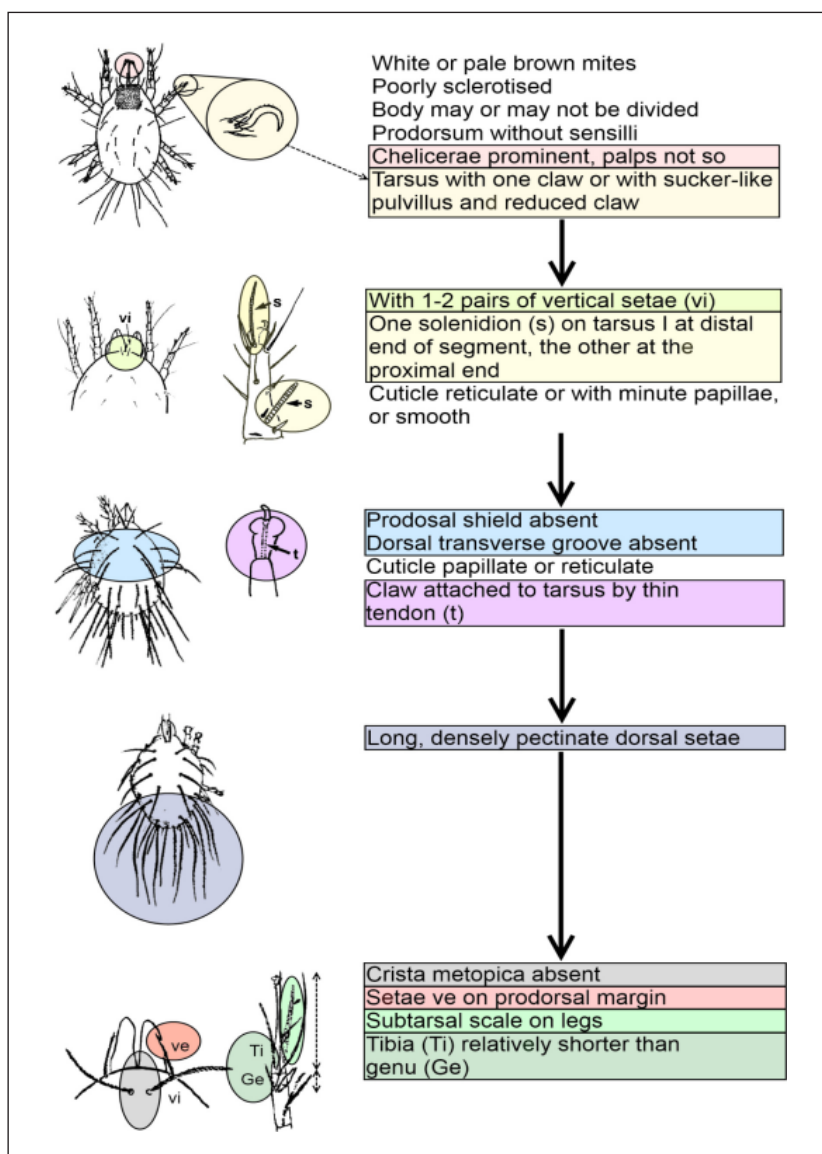


Figure 2. The general morphological characters to identify *Glycycometus* species to genus level (adapted from Colloff and Spieksma 1992; Colloff, 2009).

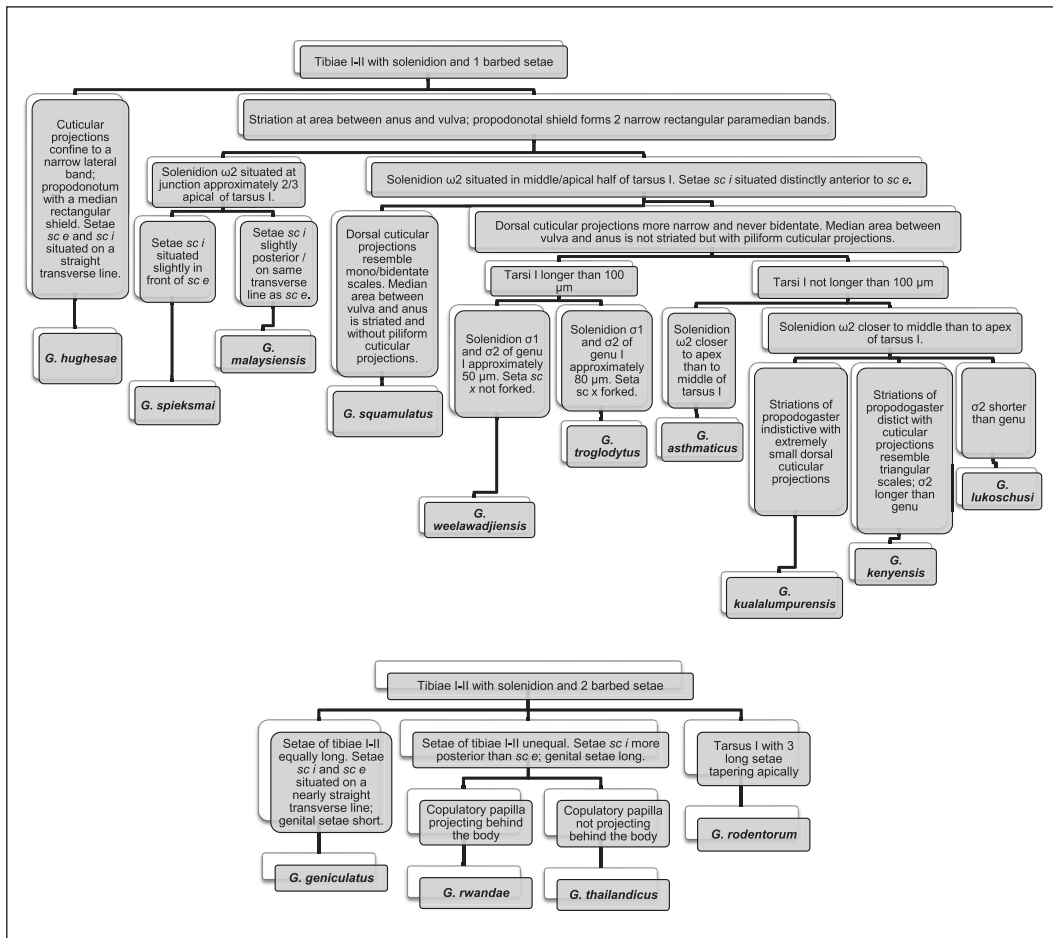


Figure 3. The identification keys for 13 *Glycycometus* species (adapted from Fain and Nadchatram 1980; Fain and Gerson 1990; Fain 1976). *G. travancoricus* is omitted from the key due to lack of significant morphology that could differentiate it from the other *Glycycometus* sp. based on the original description.

### *G. malaysiensis*

*G. malaysiensis* was first isolated and identified in Malaysia by Fain and Nadchatram (1980). Since then, though mentioned in books and reviews (Colloff, 2009; Fan *et al.*, 2010; Cui, 2014; Vogel *et al.*, 2015), there is merely a handful of research findings in relation to *G. malaysiensis*. It was reported that *G. malaysiensis* was found on the egg laying bowl of the mosquito *Culex quinquefasciatus* by Ho (1984). Mariana *et al.* (2000) found *G. malaysiensis* in approximately 40% of houses in the Klang Valley, Malaysia. Twenty to fifty-four percent of dust samples ( $n = 50$ ) collected from Singaporean homes were found to have *G.*

*malaysiensis* (Chew *et al.*, 1999a). Miranda *et al.* (2002) also reported the occurrence of *G. malaysiensis* at La Chorrera, Panama.

The medical significance of *G. malaysiensis* cannot be neglected even though limited studies were conducted. To date, several publications provided evidences which suggest *G. malaysiensis* to be allergenic and could be a potential contributor to occupational and non-occupational storage mite allergy (Tang *et al.*, 2011; Mariana *et al.*, 2000; Baratawidjaja *et al.*, 1999; Chew *et al.*, 1999b). While the identity of the allergenic components of *G. malaysiensis* has not been identified, preliminary characterisation of *G.*

*malaysiensis* (method undisclosed) by Chew *et al.* (1999b) had revealed approximately 20 IgE-binding proteins (11-90 kDa). Prevalence studies conducted on allergic patients from Malaysia, Indonesia and Singapore showed sensitisation rates between 16-78.2% to *G. malaysiensis* (Tang *et al.*, 2011; Mariana *et al.*, 2000; Baratawidjaja *et al.*, 1999; Chew *et al.*, 1999b). It was suggested by Chew *et al.* (1999b) that *G. malaysiensis* might be highly cross-reactive with *B. tropicalis* because specific IgE levels to *B. tropicalis* and *G. malaysiensis* were highly correlated (Spearman's rank coefficient = 0.76;  $P < 0.001$ ). Therefore, patients allergic to *B. tropicalis* could be at risk of developing allergic responses against *G. malaysiensis* and vice versa. *B. tropicalis* is now known to be very common in tropical, subtropical and temperate countries (Miyamoto *et al.*, 1969; Yeoh *et al.*, 2003; Ding *et al.*, 2012; Hong *et al.*, 2011; Garcia-Robaina *et al.*, 1997). *G. malaysiensis*, which shares similar allergenicity with *B. tropicalis*, may therefore be of great importance in these countries also.

### Morphology of *G. malaysiensis*

The morphology of *G. malaysiensis* was described and illustrated in details (Figures

4-17). The distinguishing characters of *G. malaysiensis* include: a) tibiae I and II with 1 solenidion and 1 barbed setae (Figures 4a and b); b) solenidion  $\omega 2$  is situated at junction of 1/3 basal and 2/3 apical of tarsus I (Figure 4b); c) opithogaster is not striated but covered with cuticular projections; d) appearance of two narrow rectangular paramedian bands at dorsal prodorsoma (Figures 5a and b); e) setae *sci* is slightly posterior to or on the same transverse line as setae *sce* (Figures 5a and b). Another morphological characteristic of *G. malaysiensis* is that setae *d5* and *l5* are very long (200-300  $\mu\text{m}$ ; Figure 6).

### Sexual Dimorphism of *G. malaysiensis*

From dorsal view, both sexes of *G. malaysiensis* are indistinguishable because the dorsa of adult female and male are identical. The appearance of legs of both sexes is the same. However, one could still grossly differentiate between the two sexes by body size. In general, the average size of the idiosoma of an adult female (400  $\mu\text{m}$  long, 250  $\mu\text{m}$  wide) is relatively bigger than that of an adult male (300  $\mu\text{m}$  long, 230  $\mu\text{m}$  wide).

The character that differentiates between the two sexes of *G. malaysiensis* is the external appearance of their sexual

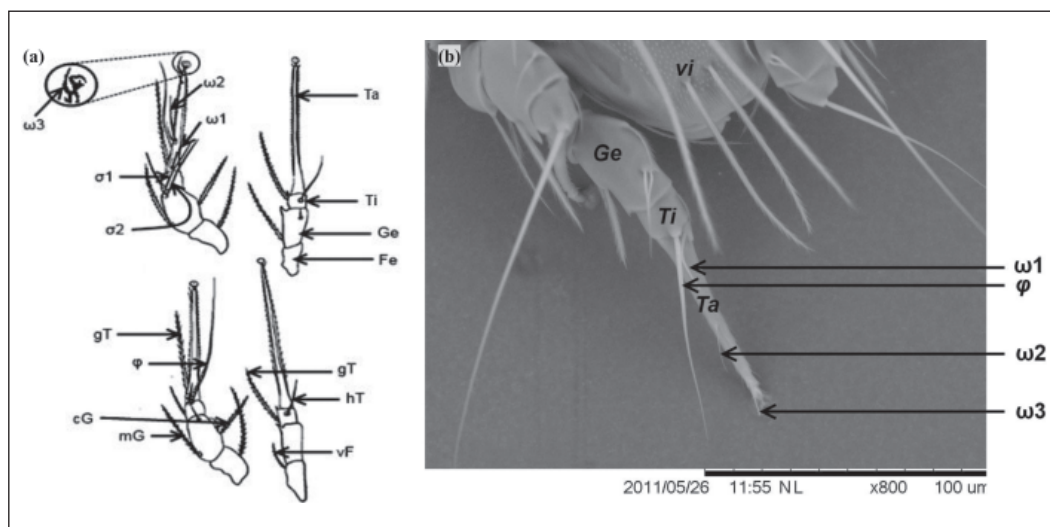


Figure 4. (a) Illustration of legs I-IV of *G. malaysiensis* (adapted from Fain and Nadchatram 1980); (b) scanning electron micrographs of right legs I and II of *G. malaysiensis*. *Ge*: genu; *Ti*: tibia; *Ta*: tarsus; *vi*: setae *vi*; *mG* and *cG* are setae of genu, *gT* and *hT* are setae of tibia, *vF* is seta of femur,  $\sigma 1$  and  $\sigma 2$  are solenidia of genu while  $\phi$  and  $\omega 1-3$  are solenidia of tarsus.



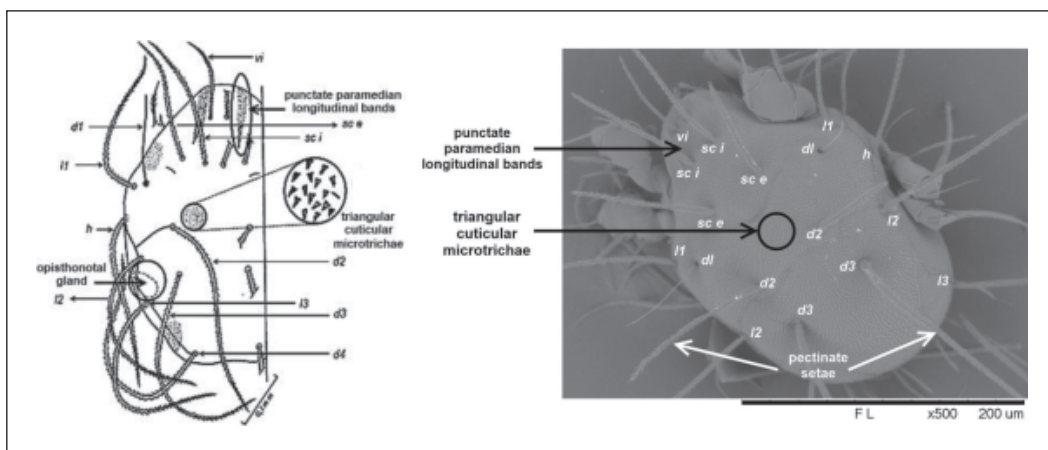


Figure 5. (a) Pictorial (adapted from Fain and Nadchatram 1980) and (b) scanning electron micrograph (500× magnification) of *G. malaysiensis* (dorsal view). *vi*: internal vertical setae; *sc i* and *sc e*: internal and external scapular setae; *d1-2*: dorsal 1-2 setae; *h*: humeral setae; *l1-3*: lateral 1-3 setae.

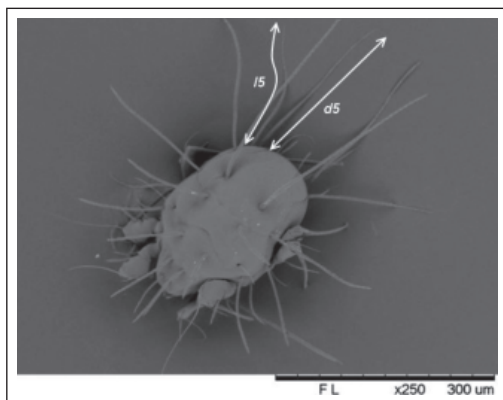


Figure 6. Scanning electron micrograph showing the lengthy *d5* and *l5* setae of *G. malaysiensis* at 250× magnification.

organs (Figures 7a and b). The genital opening of adult females and males is located in between coxa III and IV. Even though both sexes have 3 pairs of genital setae: *ga* (genital anterior), *gm* (genital medial) and *gp* (genital posterior); the setae *ga* and *gm* of adult females are situated closer to each other while those of adult males are situated further apart (Figure 8a and b). In general, the size of genital opening of an adult male is smaller than that of the adult female. The vulva of female *G. malaysiensis* is in an

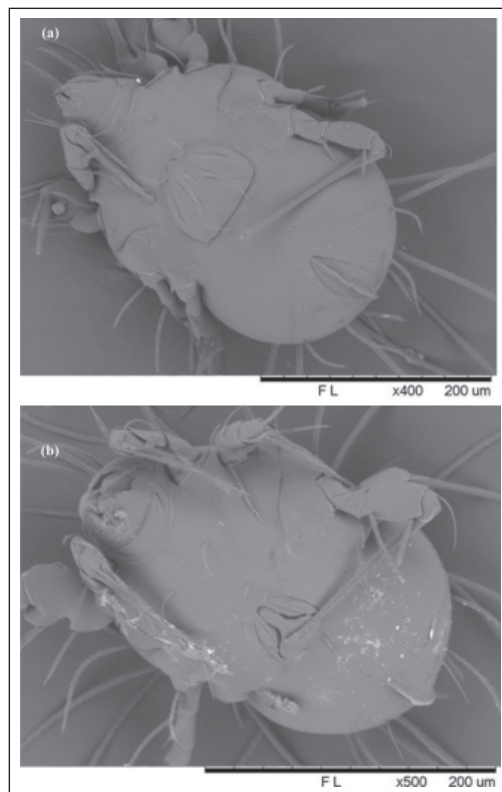


Figure 7. Scanning electron micrographs showing ventral view of (a) female and (b) male *G. malaysiensis* at 400× and 500× magnifications respectively.

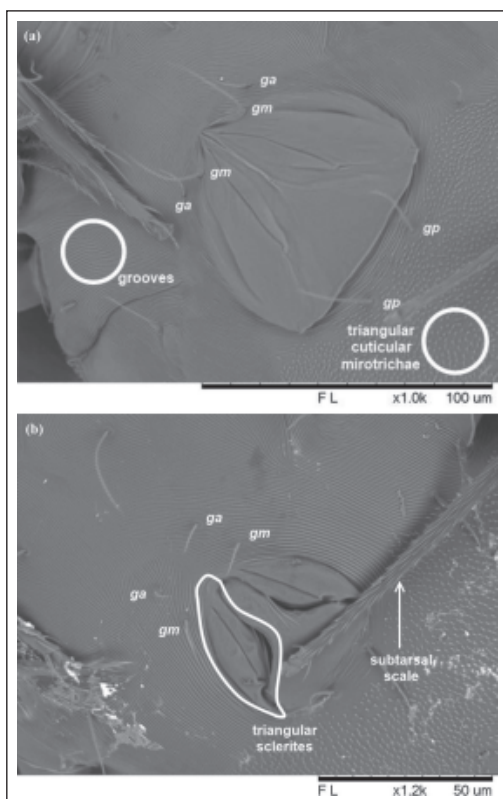


Figure 8. Scanning electron micrographs focusing at genital openings of adult (a) female and (b) male *G. malaysiensis* at 1000 $\times$  and 1200 $\times$  magnifications respectively.

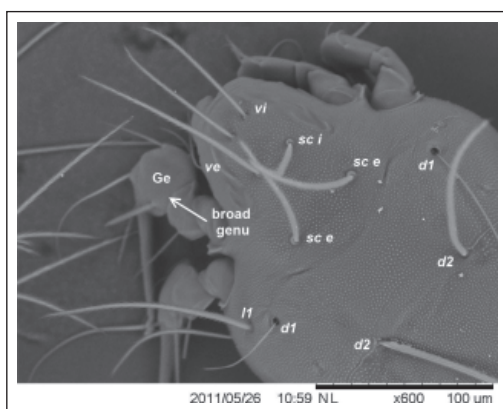


Figure 9. Scanning electron micrograph showing the broad genu of *G. malaysiensis* at 600 $\times$  magnification.

inverted Y shaped with posterior lip while the genital plate of the male is sclerotized, with two triangular sclerites (Figures 8a and b).

### Comparison of the Morphology between *G. malaysiensis* and *B. tropicalis*

Since *G. malaysiensis* and *B. tropicalis* are highly cross-reactive, it is important to differentiate with confidence, mites of these two species. Comparing the micrographs of *B. tropicalis* (Mariana *et al.*, 2007) and those of *G. malaysiensis*, it is clear that some morphological characters of these two genera differ greatly.

Firstly, *G. malaysiensis* has triangular microtrichae on its cuticle (Figure 5a and b) while *B. tropicalis* has a rugose surface with short rod-like microtrichae on its cuticle (Mariana *et al.*, 2007). Though the tarsi in both of these genera are elongated, the genua of legs I and II of *G. malaysiensis* are much broader, approximately of height: width ratio of 1:2 (Figures 9 and 10) compared with those of *B. tropicalis* that is approximately ratio of 1:1 (Fain & Nadchatram, 1974; Mariana *et al.*, 2007). Even though both mite species are described as globular in shape, *G. malaysiensis* is more edgy and angular compared with the much rounder body shape of *B. tropicalis* (Figure 11). Last but not least, barded setae are observed on legs of *G. malaysiensis* (Figure 12) but not for *B. tropicalis*.

The genital opening of adult female *B. tropicalis* is covered by a paragnathial flap as demonstrated by Mariana *et al.* (2007) while there is none for adult female *G. malaysiensis*. Unlike adult male *G. malaysiensis*, there is no triangular sclerite at the genital opening of adult male *B. tropicalis* that instead, is concealed by two folds.

The distribution of the setae between these two species is different. For example, setae *vi* and *ve* of *B. tropicalis* are positioned close together on the anterior prodorsal margin as demonstrated in the scanning electron micrograph presented by Mariana *et al.* (2007). Setae *ve* of *G. malaysiensis* are located on the anterior prodorsal margin but well-separated from the more posterior setae *vi* (Figures 7 and 8). All but a pair of the dorsal setae of *B. tropicalis* and *G. malaysiensis* are long, serrated/barbed and whip-like. In the case for *B. tropicalis*, the pair of *d2* setae are acuminate, thin and

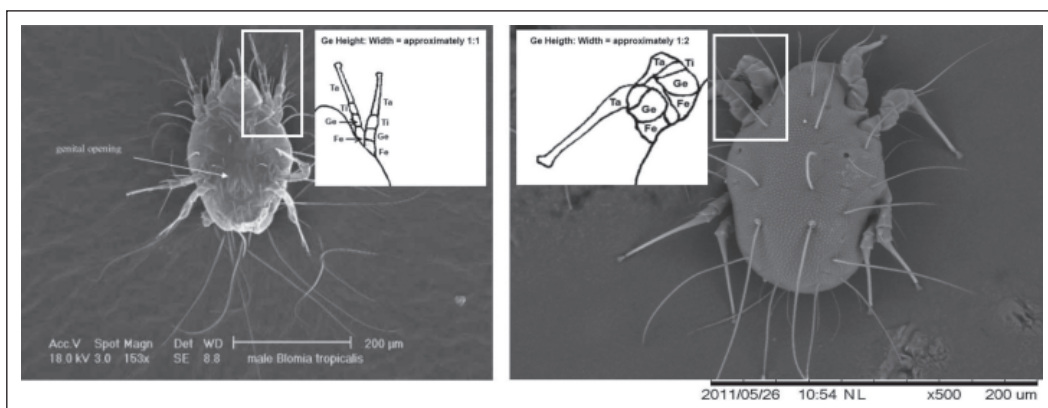


Figure 10. Pictorial illustration of legs I and II of *B. tropicalis* (left; scanning electron micrograph adapted from Mariana *et al.*, 2007) and *G. malaysiensis* (right); Ge: genu.

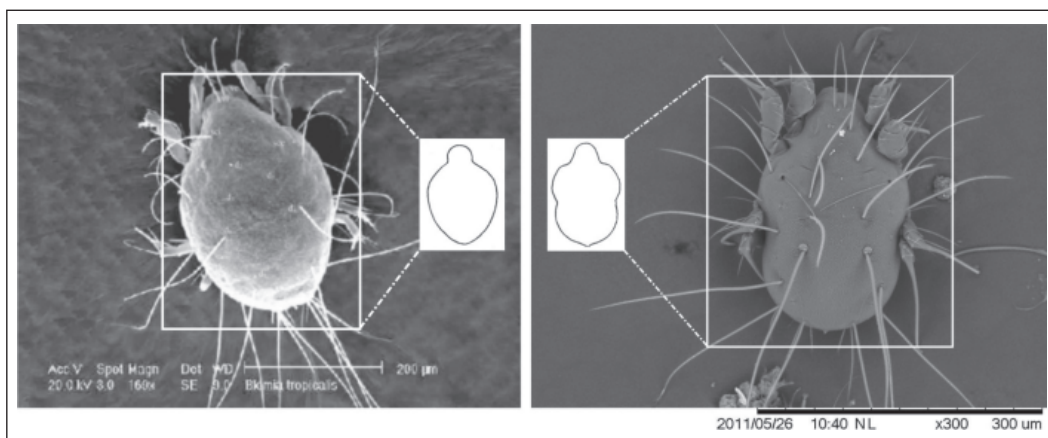


Figure 11. Pictorial illustration of the idiosoma (body shape) of *B. tropicalis* (left; scanning electron micrograph adapted from Mariana *et al.*, 2007) and *G. malaysiensis* (right).

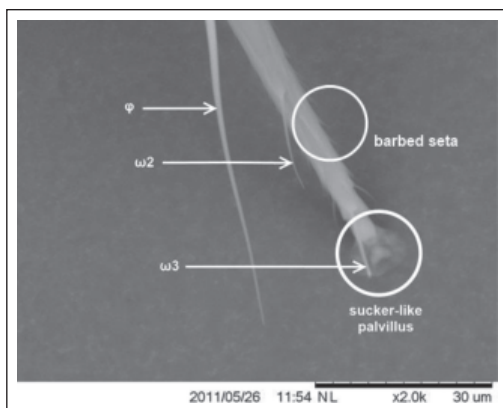


Figure 12. Scanning electron micrograph showing the barbed seta, solenidia  $\phi$ ,  $\omega_2$  and  $\omega_3$  on tarsus of *G. malaysiensis*. The tip of tarsus is sucker-like palvillus.

smooth while that of *G. malaysiensis*, the pair of *dl* setae (Mariana *et al.*, 2007; Figure 5).

#### Alternative methods to differentiate *G. malaysiensis* from *B. tropicalis*

Nevertheless, it is important to note that alternative methods were reported to aid in the identification of mite species. To date, two molecular methods were reported for the differentiation of *G. malaysiensis*, *B. tropicalis* and other important dust mite species. For example, Hart *et al.* (1990) had demonstrated the use of cellulose acetate and equilibrium polyacrylamide gel electrophoresis of isoenzymes to differentiate mite species up to the genus level and that *Glycycometus* sp. had



relatively unique carboxylesterase isoenzymes profile compared to *B. tropicalis* and other astigmatic mites. Application of polymerase chain reaction – restriction fragment length polymorphism (PCR-RFLP) to complement the morphological identification of *G. malaysiensis* as when necessary was reported by Wong *et al.* (2011), where restriction digestion of ITS2 gene product with Bfa I was able to differentiate this mite species from others (*A. ovatus*, *B. tropicalis*, *D. pteronyssinus*, *D. farinae* and *T. putrescentiae*).

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