

## SPECIES DISTRIBUTION UPDATE OF *MANSONIA* BLANCHARD, 1901 MOSQUITOES (DIPTERA: CULICIDAE) IN INDONESIA WITH THE ILLUSTRATED KEY FOR FEMALE MOSQUITO

Sidiq Setyo Nugroho\*<sup>1</sup>, Mujiyono<sup>1</sup>, and Fahmay Dwi Ayuningrum<sup>1</sup>

<sup>1</sup> Institute for Vector and Reservoir Control Research and Development, Ministry of Health,  
Jalan Hasanudin 123, Salatiga, Central Java 50721, Indonesia

\*Corresponding author: sidiqsugroho148@gmail.com

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### ABSTRACT

*Mansonia* is a genus of mosquitoes of which several species are confirmed vectors of lymphatic filariasis. Many countries including Indonesia are still struggling to eliminate lymphatic filariasis. Report of the *Mansonia* mosquito diversity and its distribution is essential to develop the control strategies. Six of eight *Mansonia* species have been confirmed as lymphatic filariasis vectors in Indonesia. This paper aims to update the distribution of the *Mansonia* mosquito in Indonesia. Species distribution data were summarized from various literature regarding the *Mansonia* mosquito. The data is complemented by the results of the National Research on Disease Vector and Reservoir (Rikhus Vektora) results conducted by the National Institute of Health Research and Development (NIHRD) in 2015-2018. There were new distribution records for four species of *Mansonia* mosquitoes in Indonesia. *Mansonia annulata* Leicester, *Ma. annulifera* (Theobald), and *Ma. indiana* Edwards are now recorded distributed throughout the archipelago. Meanwhile, *Ma. bonneae* Edwards has a new distribution record in the Moluccas. The illustrated identification key for female *Mansonia* mosquitoes in Indonesia is provided in this paper.

**Key words:** distribution, Indonesia, *Mansonia*, mosquito

### INTRODUCTION

The last inclusive checklist of mosquito species in Indonesia was published 40 years ago. The checklist resumed 457 mosquito species in total, and eight of them are in the genus *Mansonia* (O'Connor & Sopa, 1981). National attempt to update the mosquito diversity data was realized in National Research on Disease Vector and Reservoir (Rikhus Vektora) held by the National Institute of Health Research and Development (NIHRD), Indonesia Ministry of Health in 2015 to 2018. The research has collected thousands of mosquito specimens from 29 provinces in Indonesia.

Bonne-Wepster (1954) included *Mansonioides* Theobald and *Coquillettidia* Dyar as subgenera in genus *Taeniorhynchus* Lynch Arribalzaga, synonym for *Mansonia*. Following Ronderos & Bachmann (1963), Knight & Stone (1977) treated *Mansonia* and *Coquillettidia* as separate genera. *Mansonia* mosquito, especially subgenus *Mansonioides*, is generally characterized by: scutal scales at least two colors, scutellar scales always numerous, post-spiracular bristles always present, legs with many pale markings, tarsomeres banded with pale scales, wing speckled dorsally with pale and dark broad scales, many of which are strongly asymmetrical, and abdomen intersegmental membranes very strongly spiculate (Belkin,

1962). In the male, maxillary palpi are longer than the proboscis and turned upwards, with no hair tufts and the terminal segment is minute. The eighth tergite bears a row of stout spines (Wharton, 1962).

The immature stages of *Mansonia* are commonly found attached to the roots of aquatic plants in ponds, lakes, swamps, marshes, ditches, wells, ground pools, and flood pools in forest swamps (Gass et al., 1982). The larvae of *Mansonia* resemble those of *Coquillettidia* in having a sclerotized saw-toothed process at the tip of the siphon, which is modified for piercing submerged parts of aquatic plants to obtain oxygen from the aerenchyma. These larvae have a more sessile habit, hanging head downwards whilst attached to the plant tissues and filtering the water column for food. They are therefore not easily recognized by predators such as fish (Becker et al., 2010).

Genus *Mansonia* consists of two subgenera, i.e. *Mansonia* (15 species) and *Mansonioides* (10 species). *Mansonioides* is an Old World taxon, with species in the Afrotropical Region (sub-Saharan Africa and Madagascar), Oriental Region, Manchurian Subregion of the Palaearctic and the Australasian Region (Solomon Islands and northward from Queensland, Australia) (Service, 1990; Tanaka et al., 1979; Lee et al., 1988). All of *Mansonia* species members in Indonesia are included in subgenus *Mansonioides* (O'Connor & Sopa, 1981).

*Mansonia* mosquitoes, especially *Mansonioides* subgenus, are widely known as vectors for lymphatic filariasis. They are regarded as the nocturnal sub-periodic malayan filariasis in Java (*Ma. indiana* and *Ma. uniformis* (Theobald)), Sumatra (*Ma. annulata*, *Ma. bonneae*, *Ma. dives* (Schiner), *Ma. indiana*, and *Ma. uniformis*), Kalimantan (*Ma. annulata* and *Ma. uniformis*), Sulawesi (*Ma. bonneae*, *Ma. dives*, and *Ma. uniformis*), and Moluccas (*Ma. uniformis*) (Hoedojo, 1989). *Mansonia annulifera* is also considered as a major vector for *B. malayi* (periodic) in South Asia region including Indonesia (Ramalingam, 1974; WHO, 2013). The updated distribution data of *Mansonia* mosquito is essential for vector control efforts, considering the 2025 target for the elimination status of lymphatic filariasis in Indonesia.

*Ma. uniformis*, a widespread species in the world, is a vector for several viruses such as Bunyamwera, Chikungunya, Spondweni, and Wesselbron (White & Faust, 2014), in addition to lymphatic filariasis. Converse et al. (1985) reported the isolation of Ingwavuma virus from *Ma. uniformis* caught in Bintan Island, Sumatra. This paper aims to deliver an update regarding distribution data and provide an illustrated key to aid identification of female *Mansonia* mosquitoes in Indonesia.

## MATERIALS AND METHODS

The checklist and distribution data of *Mansonia* mosquito species in this paper update the checklist of mosquito species in Indonesia created by O'Connor & Sopa (1981). Species records, distribution data, and taxonomic information were summarized from several references related to the *Mansonia* mosquitoes and the national research reports of Rikhus Vektora in 2015-2018. Rikhus Vektora was lead by NIHRD in collaboration with local governments, district/city health offices, universities, research institutes, and non-government organizations (NGOs). The research collected mosquito specimens from 87 districts/cities in 29 provinces. However, *Mansonia* specimens were obtained from 76 districts/cities. This observational research was a cross-sectional study that was conducted for 30 days every year from 2015 to 2018. Each enumerator team, consisting of eight persons, collected data from six designated locations within a district/city during the period of time given. A total of 6,985 specimens collected from the research were reconfirmed in the laboratory to avoid misidentification committed in the field. Identification keys used in the process were Ramalingam (1974) for Oriental mosquitoes, and Lee et al. (1988) for Australasian mosquitoes. The distribution data of the *Mansonia* mosquito in this paper is limited to the Indonesian region and excludes Malaysian Borneo and Papua New Guinea. The illustrated key was arranged based on the described morphological characters of each species studied from related references.

## RESULTS

The checklist, distribution data and taxonomic remarks of *Mansonia* mosquito species in Indonesia are presented in Table 1. Indonesia has eight species and all of them are included in the *Mansonioides* subgenus. Papua has the greatest diversity with seven species. Four species are distributed through the entire archipelago, i.e. *Ma. annulata*, *Ma. annulifera*, *Ma. indiana*, and *Ma. uniformis*. *Mansonia indiana* and *Ma. septempunctata* Theobald were described originally from Indonesia. This paper adds some distribution extension for four *Mansonia* species in Indonesia. *Mansonia annulata* is newly recorded from Java, the Lesser Sunda Island (LSI), Moluccas and Papua. *Mansonia annulifera* distribution is extended to LSI and Moluccas, while *Ma. bonneae* and *Ma. indiana* are newly recorded from Moluccas. Distribution of *Ma. papuensis* (Taylor) in Moluccas now has been deleted and recorded only in Papua. The map of *Mansonia* species distribution in Indonesia is presented below (Fig. 1).

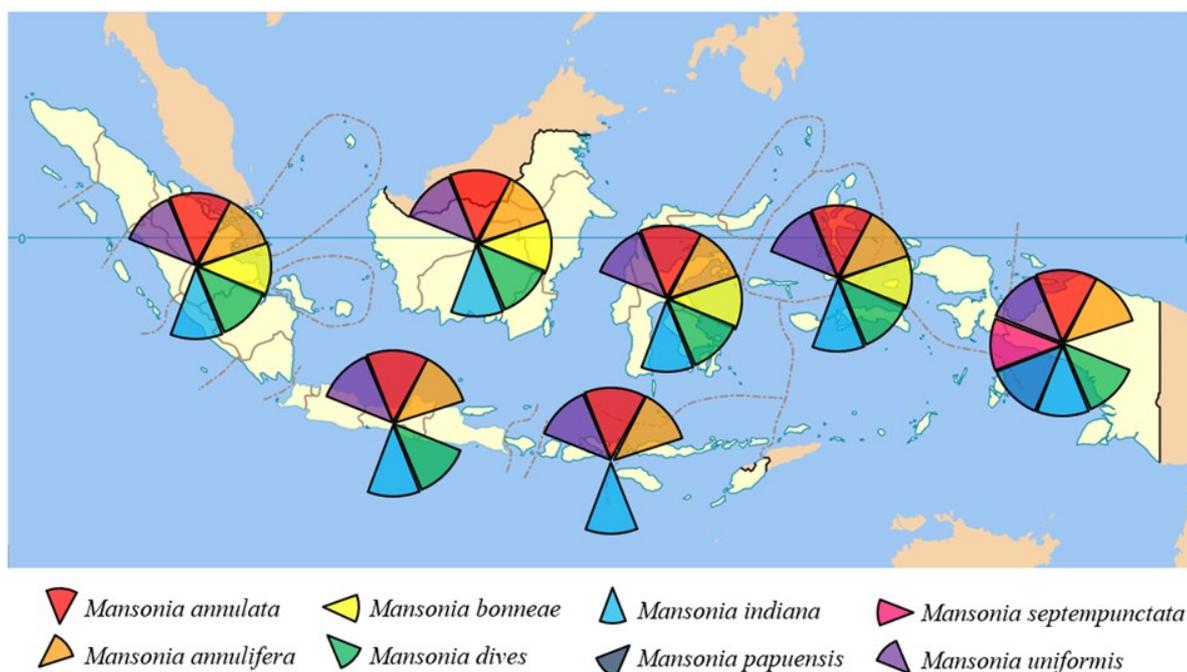


Figure 1. Distribution map of mosquito species of Genus *Mansonia* in Indonesia.

Table 1. Species checklist and distribution of *Mansonia* mosquito species in Indonesia

Valid species	Synonymy	Geographical distribution	<sup>1</sup> Remarks
<i>Ma. annulata</i> Leicester, 1908	-	Sumatra, Kalimantan, Java <sup>1</sup> , LSI <sup>1</sup> , Sulawesi, Moluccas <sup>1</sup> , Papua <sup>1</sup>	Newly recorded from Java, LSI, Moluccas, and Papua
<i>Ma. annulifera</i> (Theobald, 1901)	<i>Ma. sequini</i> Laveran <i>Ma. septemguttata</i> Theobald	Sumatra, Kalimantan, Java, LSI <sup>1</sup> , Sulawesi, Moluccas <sup>1</sup> , Papua	Newly recorded from LSI and Moluccas
<i>Ma. bonneae</i> Edwards, 1930	-	Sumatra, Kalimantan, Sulawesi, Moluccas <sup>1</sup>	Newly recorded from Moluccas
<i>Ma. dives</i> (Schiner, 1868)	<i>Ma. annulipes</i> Walker <i>Ma. longipalpis</i> van der Wulp	Sumatra, Kalimantan, Java, Sulawesi, Moluccas, Papua	
<i>Ma. indiana</i> Edwards, 1930	-	Sumatra, Kalimantan, Java*, LSI, Sulawesi, Moluccas <sup>1</sup> , Papua	Newly recorded from Moluccas
<i>Ma. papuensis</i> (Taylor, 1914)	-	<del>Moluccas</del> <sup>1</sup> , Papua	Distribution record in Moluccas is deleted
<i>Ma. septempunctata</i> Theobald, 1905	<i>Ma. bonnewepsterae</i> van den Assem	Papua*	
<i>Ma. uniformis</i> (Theobald, 1901)	<i>Ma. australiensis</i> Giles <i>Ma. marquesensis</i> Dyar <i>Ma. reversus</i> Theobald	Sumatra, Kalimantan, Java, LSI, Sulawesi, Moluccas, Papua	

Note: \*: type locality

## DISCUSSION

All species records in LSI in this paper are considered new compared to the checklist compiled by O'Connor & Sopa (1981). *Ma. indiana* in LSI has been reported by Bonne-Wepster (1954) who found the species in Flores Island. *Mansonia uniformis* has been reported in Lombok Island (Lee et al., 1988) and Timor Island (Whelan & Hapgood, 2000). The latest record was reported from Timor Leste, and occurrence of this species in East Nusa Tenggara Province (Indonesia) in the same island is highly possible.

Females of *Ma. annulata* sometimes bite in swampy jungles during the day. Larvae were collected from marshy pools near the forest edge (Macdonald, 1957). This species is known as a primary vector for *W. malayi* (Wharton, 1962). Now *Ma. annulata* has also been recorded from Purworejo and Serang (Java Island), West Lombok (LSI), Central and South Halmahera (North Moluccas Province) and Sarmi (Papua Province) (B2P2VRP, 2015a; B2P2VRP 2015c; B2P2VRP, 2016a; B2P2VRP, 2016c; B2P2VRP, 2016d).

Early record of *Ma. annulifera* from Papua New Guinea was based on Edwards (1913) erroneous synonymy of the Australasian species *Ma. septempunctata* with *Ma. annulifera*. The only other Australasian region record of *Ma. annulifera* is that of Bonne-Wepster (1938) from Merauke, Irian Jaya, and this may be a misidentification of *Ma. septempunctata*, which has been recorded (as *Ma. bonnewepsterae*) as abundant in the area (van den Assem & van Dijk, 1958). Females of *Ma. annulifera* are strongly anthropophilic (Bohart, 1945) and greedy biters (Bonne-Wepster, 1954). Horsfall (1955) considered this species a dependable component of the vector for *Wuchereria* species. Now *Ma. annulifera* has also been recorded from Jembrana (Bali Island/LSI) and from Central and South Halmahera (North Moluccas Province). Besides, it is confirmed that *Ma. annulifera* is also distributed in South, Central and North Kalimantan Provinces (B2P2VRP, 2015b; B2P2VRP, 2016c; B2P2VRP, 2017a; B2P2VRP, 2017b; B2P2VRP, 2018).

Bonne-Wepster (1930) recognized a male specimen of *Ma. annulipes* (now *Ma. dives* and formerly *Ma. longipalpis*) which had slightly different male terminalia and described it as *Ma. annulipes* var. AA. Edwards (1930) found two males in the collection at the British Museum with similar terminalia and designated one from Kuala Lumpur as the type of a new species, *Ma. bonneae*. Female specimens of the two species were not distinguishable until Edwards suggested that the presence of a small patch of white scales at the side of the scutum just in front of the wing roots would separate *Ma. dives* from *Ma. bonneae* (Wharton, 1962). This species has been newly recorded from Aru Islands (Moluccas Province) and Central and South Halmahera (North Moluccas Province) (B2P2VRP, 2016b; B2P2VRP, 2016c).

The name of *Ma. dives* has a quite long history. Edwards (1922) previously declared *dives* to be an unnecessary new name for *Culex annulipes* Walker. Later, *C. annulipes* Walker was transferred to the genus *Taeniorhynchus* (former name *Mansonia*). Edwards (1930) acknowledged that *annulipes* Walker was a junior homonym for *C. annulipes* Meigen (now as *Aedes annulipes* Meigen) and required a new name. Edwards rejected *dives* again because specimen described by Schiner for *dives* was a different species than *annulipes* Walker. Edwards (1925) had already synonymized *longipalpis* van der Wulp with *annulipes* Walker. However, Stone (1957) pointed out that even though Schiner may have misidentified *annulipes* Walker, *dives* is a valid substitute name for *annulipes* Walker and must be applied to that species (Lee et al., 1988).

Edwards (1930) proposed name *indiana* for Indonesian specimens described by Bonne-Wepster (1930) on the basis of a misidentification by Edwards himself, as *Taeniorhynchus africanus*. Most authors have continued to include New Guinea in the distribution of *Ma. indiana* on the basis Bonne-Wepster's record in Upper Digoel. This paper confirmed that *Ma. indiana* is indeed distributed in Papua based on species collection in Merauke. This species was also reported from South Halmahera (North Moluccas Province) (B2P2VRP, 2016c).

*Mansonia papuensis* is known only from New Guinea. Brug & Bonne-Wepster (1947) listed this species from Seram (Moluccas), but this record is questionable (Lee et al., 1988). There is no report of *Ma. papuensis* collection from any region in Moluccas, so the authors decided to delete this species distribution in Moluccas. In Irian Jaya, van Dijk (1958) found that larvae of *W. bancrofti* could develop to maturity in *Ma. papuensis* but the high mortality of experimental mosquitoes made it difficult to assess the susceptibility of this species. He then concluded that in experimental conditions the development of *W. bancrofti* in *Ma. papuensis* was a slow and laborious process (Lee et al., 1988).

Adults of *Ma. septempunctata* are pests, biting after sunset and also in daytime in wet and shady places. In Sentani Lake, they were collected from aquatic plants *Pistia stratiotes* and *Hydrocharis asiatica* in a restricted area where the water was proven to be heavily polluted with waste from native houses nearby (van den Assem & Bonne-Wepster, 1964). Van Dijk in 1958 caught specimens of *Ma. septempunctata* (in his paper recorded as *Ma. longipalpis*) on a microfilaria carrier and kept them alive afterwards in test tubes, dissecting the dead ones. In 22 specimens, he estimated 87 percent were infected, but he could not trace infective instars. The development of the microfilariae within the mosquito seemed inhibited in the presausage stage and a subsequent degeneration was noted (van den Assem, 1958).

*Mansonia uniformis* distribution is extensive. It is listed by Knight & Stone (1977) as Ethiopian (Afrotropical), Oriental and Australasian regions east to Bismarcks archipelago, Japan, Ryukyu-Retto. In Indonesia, *Ma. uniformis* is distributed throughout the archipelago. This species occurs in wet conditions in swampy areas and is certainly one of the most aggressive biters, ready to attack at day or night. They often bite in large numbers indoors at night and bite in the shade during the day (van den Assem, 1959). *Mansonia uniformis* is an important vector for *W. bancrofti* in areas with large swamps where anopheline mosquitoes are virtually absent (de Rook & van Dijk, 1959). Brug & de Rook (1933) stated that *Ma. uniformis* was hospitable to *W. malayi* in Seram, and it was also highly hospitable to *Brugia patei* and *B. pahangi* (Laurence & Pester, 1961).

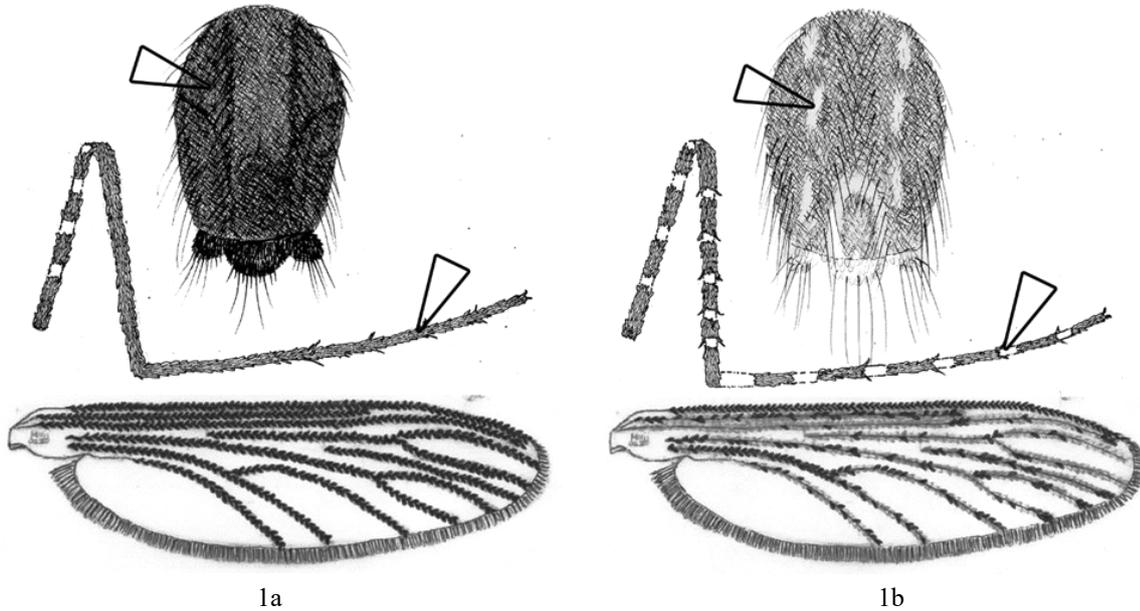
Dalilah et al. (2017) reported the collection of *Ma. africana* in large numbers from Sungai Rengit Murni village in South Sumatra. This report is questionable, because *Ma. africana* is restricted in distribution to tropical Africa (Laurence, 1960). The author suggested that the species was probably *Ma. indiana*. Misidentification would likely occur because *Ma. africana* is closely related to *Ma. indiana* and *Ma. septempunctata* (Wharton, 1962). Bonne-Wepster had also misidentified *africanus* for some females from the Upper Digoel, Irian Jaya. Edwards (1930) then suggested that these specimens were *Ma. septempunctata* (Lee et al., 1988).

The role of *Mansonia* species as lymphatic filariasis vectors has been recorded by Directorate General of Infectious Disease Elimination and Environmental Health (PPM&PL), Ministry of Health. *Mansonia uniformis* is competent as a lymphatic filariasis vector in all main islands where they occur. Closest to *Ma. uniformis*, *Ma. indiana* was also recorded as vector in Java, Sumatra, Kalimantan and Sulawesi but has never been confirmed from the Moluccas and Papua region. Compared to other species that have entire achipelago distribution, for instance *Ma. annulifera*, it was only recorded as vector in Sumatra, Kalimantan, and Sulawesi. Meanwhile *Ma. annulata* was only confirmed as vector in Sumatra and Kalimantan (PPM&PL, 2008).

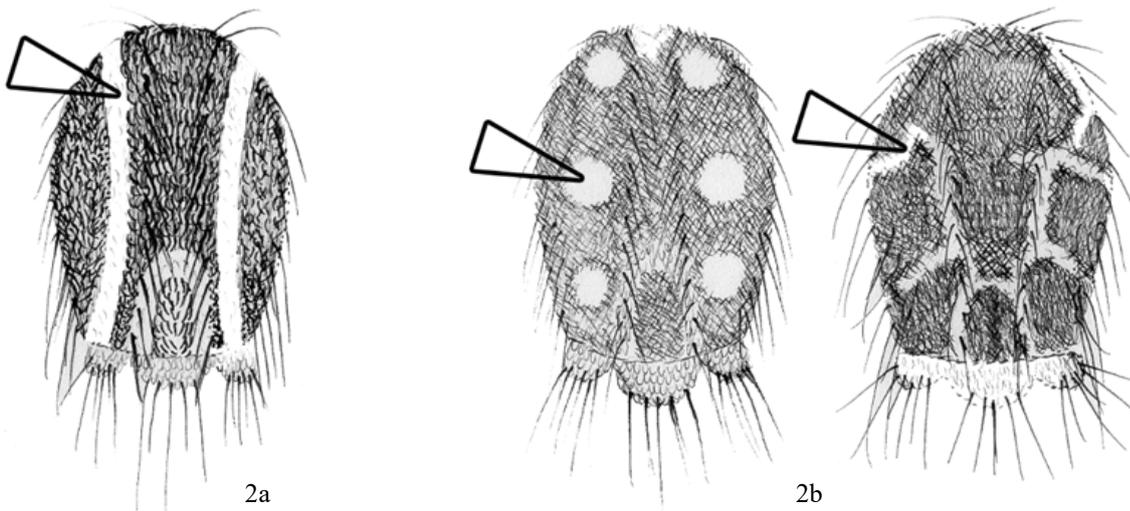
In conclusion, Indonesia has eight species of *Mansonia* mosquitoes that are entirely included in *Mansonioides* subgenus. The distribution data is updated for the following species: *Mansonia annulata* (Java, the Lesser Sunda Islands, Moluccas, and Papua), *Ma. annulifera* (the Lesser Sunda Islands and Moluccas), *Ma. indiana* and *Ma. bonneae* (Moluccas). The distribution of *Ma. annulifera* (Kalimantan) and *Ma. indiana* (Papua) has been confirmed. Meanwhile, the distribution record of *Ma. papuensis* in Moluccas has been removed. The identification key of female *Mansonia* mosquitoes is provided in this paper.

**IDENTIFICATION KEY FOR FEMALE *MANSONIA* MOSQUITO IN INDONESIA**  
 Modification from Ramalingam (1974)

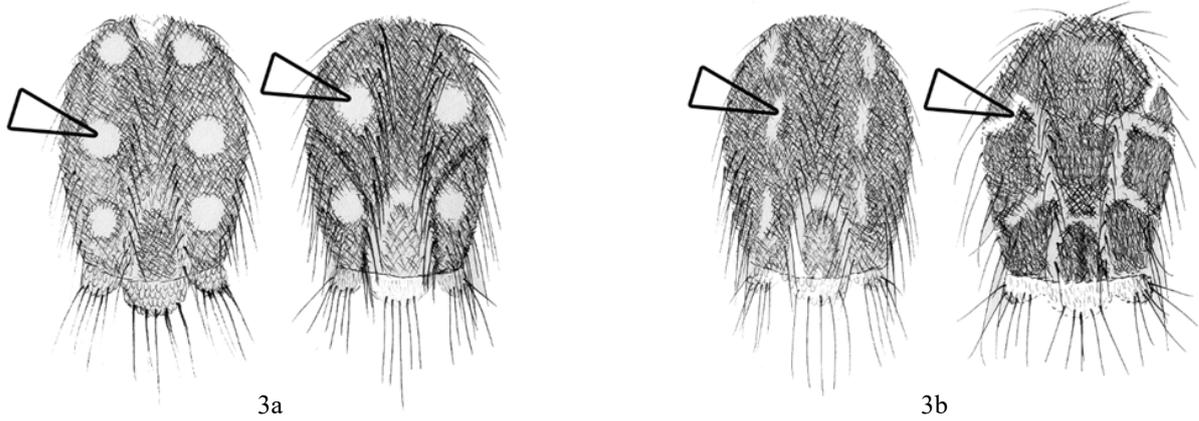
1. Scutum entirely dark, wing dark scaled, tarsomere without distinct pale bands, small species (Fig. 1a) ..... *papuensis*  
 Scutum with variable ornamentation, wing speckled, larger species (Fig. 1b) ..... 2



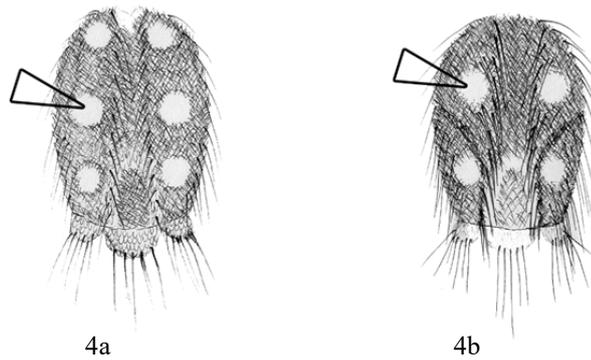
2. Scutum with a pair of pale greenish longitudinal lines, brown colored mosquito (Fig. 2a) ..... *uniformis*  
 Scutum with round spots or irregular patches of scales (Fig. 2b) ..... 3



3. Scutum with distinct and regular round spots of light scales (Fig. 3a) ..... 4  
 Scutum with irregular patches of pale scales (Fig. 3b) ..... 7

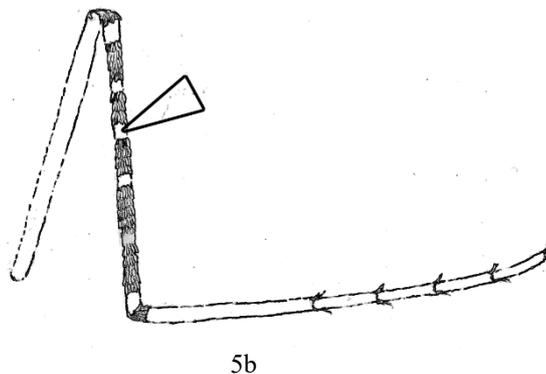


4. Scutum with six distinct silvery spots, midlobe of scutellum with moderately wide flat white scales, small to medium species, pale or yellowish colored mosquito (Fig. 4a) ..... *annulifera*  
 Scutum with four distinct rounded spots of white scales, femur with distinct white bands and scattered pale scales, medium species (Fig. 4b) ..... 5



5. Fore tibia with 10-15 scattered small white dots, ventral surface white from base to apex (Fig. 5a) ..... *septempunctata*  
 Fore tibia with about six well-defined bands (Fig. 5b) ..... 6

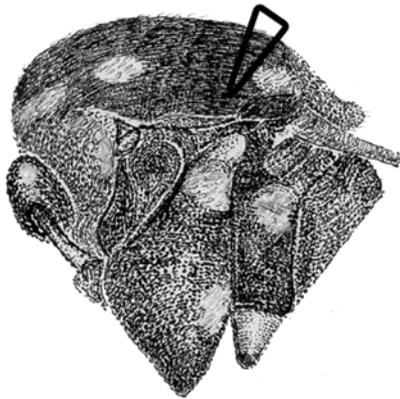
No available specimens



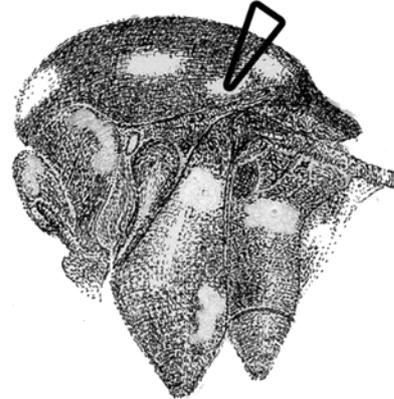
5a

5b

6. Supra alar area with wide or curved white scales (Fig. 6a) ..... *dives*  
 Supra alar area without wide or curved white scales (Fig. 6b) ..... *bonneae*

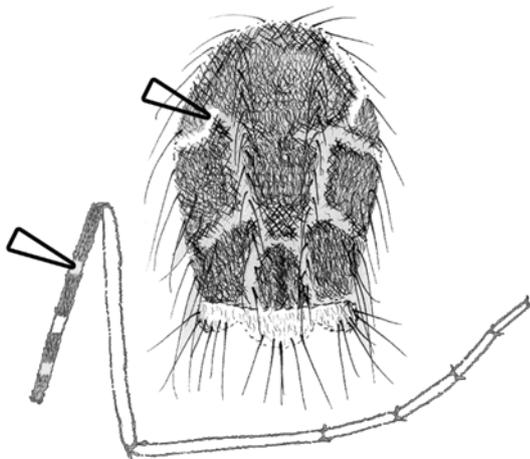


6a

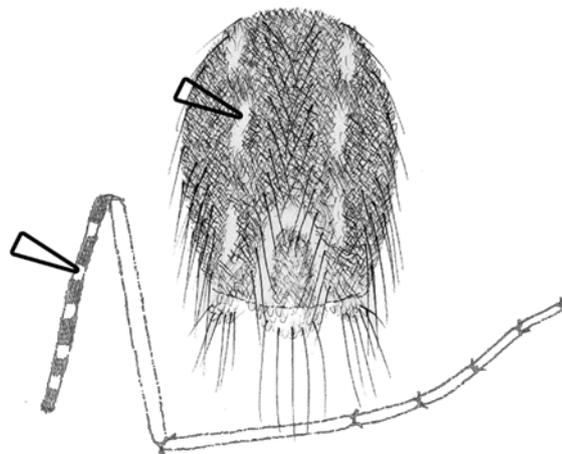


6b

7. Hind femur with three distinct pale bands, scutum dark with irregular pattern of narrow yellow scales (Fig. 7a) ..... *annulata*  
 Hind femur with about five pale bands, scutum golden-brown with irregular patches of white scales (Fig. 7b) ..... *indiana*



7a



7b

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