MALAYAN FILARIASIS STUDIES IN KENDARI REGENCY, SOUTHEAST SULAWESI, INDONESIA : III

Surveillance of *Mansonia* mosquitoes with reference to seasonal and ecological aspect of *Ma. uniformis* and *Ma. indiana*

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ABSTRACT

Studi nyamuk penular filariasis malayi pada empat desa endemis (Wawolemo, Pondidaha, Lalohao dan Teteona) di Kabupaten Kendari, Sulawesi Tenggara, telah dilakukan dari bulan November 1980 sampai Oktober 1982.

Nyamuk penular Brugia malayi di alam selain Anopheles barbirostris dan An. nigerrimus adalah Mansonia uniformis, Ma. indiana dan Ma. bonneae/dives. Ma. uniformis dan Ma. indiana merupakan jenis yang terbanyak ditemukan di antara 5 jenis nyamuk Mansonia spp. Tidak ditemui perbedaan yang bermakna untuk kepadatan kedua jenis nyamuk ini di antara empat desa yang diteliti. Daur gonotrofik Ma. uniformis dan Ma. indiana di laboratorium masing-masing berkisar antara 80–98 jam dan 81–92 jam. Puncak kepadatan waktu menggigit orang dari kedua jenis nyamuk ini adalah antara jam 19.00 – 22.00. Kedua jenis nyamuk ini lebih cenderung bersifat zoofilik.

Kepadatan bulanan Ma. uniformis dan Ma. indiana tidak mempunyai keeratan hubungan yang positif dengan curah hujan, dengan puncak kepadatan antara bulan Agustus dan Oktober. Nisbah nyamuk parous untuk kedua jenis nyamuk ini relatif rendah dan tidak mempunyai keeratan hubungan dengan kepadatannya dan juga dengan curah hujan.

Nisbah infeksi alamiah dari Brugia sp. pada Ma. indiana (0,6%) lebih tinggi dari Ma. uniformis (0,4%). Indeks infeksi buatan rata-rata 1,88 pada Ma. uniformis dan 0,55 pada Ma. indiana.

Uji kerentanan DDT terhadap Ma. uniformis dan Ma. indiana memperlihatkan kedua jenis nyamuk ini rentan terhadap DDT.

INTRODUCTION

The malayan filariasis survey carried out in the four villages at Kendari Regency revealed that the *Brugia malayi* is the nocturnal periodic form. The mosquito vectors confirmed were several species of *Mansonia* and *Anopheles barbirostris* (Arbain Joesoef et al. 1984). The mosquito fauna studied in the areas revealed 56 species including 5 *Mansonia spp.* The biology of *An. barbirostris*, one of the principal vector of the parasite, and *An. nigerrimus*, a potential vector were studied (Bahang et al, 1984). The present paper deals with (1) density of various *Mansonia spp.*, (2) natural and artificial infections of *Mansonia spp.*, and (3) some ecology aspects of *Ma. uniformis* and *Ma. indiana.*

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STUDY AREA

The topography, ecology and socio-economic status of the four villages (Teteona, Lalohao, Pondidaha and Wawolemo) in districts of Wawotobi surveyed have been presented by Arbain Joesoef et al (1984).

MATERIALS AND METHODS

The sampling procedures of monthly collections of mosquitoes from five different methods are described by Bahang et al., (1984). To assess seasonal variations of *Ma. uniformis* and *Ma. indiana*, the monthly catches, expressed in mean number mosquito per man/hour were plotted against the monthly rainfalls and density. Parous rates of these mosquitoes were determined by ovarian dissection.

All night collections of landing mosquitoes for both indoors and outdoors were conducted from 1800 to 0600 in one of the villages for once a month for 12 months.

Mansonia mosquitoes collected from the five collecting methods were individually dissected for presence of *Brugia* larvae. The procedures followed that of Bahang et al., (1984). Identification of the *Brugia* larvae was based on keys by Nelson (1960) and Ramachandran (1970).

Wild caught *Ma. uniformis* and *Ma. indiana* infested with water mites supposedly to be newly emerged were used for efficacy tests, followed the procedures by Bahang et al.,(1984). Three sets of experiments for *Ma. uniformis* and two for *Ma. indiana* of a varying number of mosquitoes were used to feed on microfilariae carriers with 2, 3.2 and 7 Mf per 1 mm^3 blood.

Ninety *Ma. uniformis* and 30 *Ma. indiana* from wild caught populations infested with water mites were used for larval development experiments. These were fed to two Mf carriers with 3.2 and 7 Mf per one mm^3 blood. Mosquitoes died during the holding periods and those survived at day 11 were individually dissected for larval stages of development. Another 30 of each of these species were used as control. They were not infected and during the holding period they were fed on 10 % sugar water.

DDT susceptibility tests were carried out for *Ma. uniformis* and *Ma. indiana*. The mosquitoes were collected between 1900 to 2100 hours while resting on walls of the house. The houses where these mosquitoes were collected have not been sprayed with any insecticide before. All mosquitoes used were unfed. The procedures followed that described by Bahang et al., (1984).

RESULT

Comparison of *Mansonia spp* between different villages

A total 12 308 *Mansonia* mosquitoes were examined by the five collecting methods. These comprised of 58.7% *Ma. uniformis*, 37.8% *Ma. indiana*, 3.2% *Ma. bonneae/dives*, 0,1% *Ma. annulata* and 0.2% *Ma. annulifera* respectively.

An analysis of variance (ANOVA) of *Ma. uniformis* showed no difference among the four villages where the catches were made ($p < 0.1$). Similarly, there was no significant difference of catches among the villages for *Ma. indiana* ($p < 0.1$) (Table 1).

Evaluation of trapping methods with two *Mansonia spp*

The total catch from the five catching methods showed *Ma. uniformis* 1½ times more than *Ma. indiana*. The paired 't' test shows no significant difference between indoor and outdoor net catches of *Ma. indiana* ($p < 0.1$), however *Ma. uniformis* was significantly higher in outdoors bait net catch ($p < 0.001$). The night indoor resting catches consistantly caught the most mosquitoes of both species. An analysis of variance (ANOVA) between indoor bait net, outdoor bait net, indoor night resting, indoor morning resting and outdoor drop net catches shows a significant difference amongst the type of catches ($p < 0.001$). The outdoor drop net catch gave the lowest catch for both species (Table 2).

Table 1. Examination of *Ma. indiana* and *Ma. uniformis* from 4 villages in Kendari Regency, Southeast Sulawesi

Months 1980/81/82	*Mansonia indiana*				*Mansonia uniformis*			
	Wawo-lemo	Pondi-daha	Lalo-hao	Teteo-na	Wawo-lemo	Pondi-daha	Lalo-hao	Teteo-na
November	0	0	0	0	0	0.13	0.24	0.21
December	0	0	0	0	0	0.21	0.22	0.05
January	0	0	0	0	0.07	0.12	0.16	0.11
February	0	0	0	0	0.15	0.09	0.88	0.15
March	0	0	0	0	0.16	0.25	0.54	0.26
April	0.03	0.02	0	0.02	0.33	0.46	1.04	0.63
May	0.05	0.20	0.18	0.03	0.23	0.79	0.93	0.31
June	0.17	0.32	0.39	0.05	0.33	0.57	0.40	0.35
July	0.17	0.30	0.85	0.11	0.43	0.84	0.69	0.19
August	1.49	1.09	1.43	0.22	1.03	0.97	1.03	0.69
September	0.82	1.08	1.72	0.29	0.96	1.64	1.80	1.04
October	0.72	1.83	0.73	0.14	1.32	3.89	1.99	0.91
November	0.48	0.51	0.96	0.08	0.28	0.39	0.41	0.23
December	0.18	0.81	0.22	0.11	0.29	0.56	0.25	0.40
January	0.13	0.12	0.10	0.08	0.11	0.15	0.11	0.25
February	0.10	0.46	0.30	0.08	0.11	0.24	0.13	0.44
March	0.18	0.49	0.21	0.16	0.13	0.23	0.09	0.23
April	0.13	0.21	0.24	0.07	0.05	0.24	0.22	0.31
May	0.17	0.18	0.31	0.11	0.16	0.35	0.28	0.19
June	0.73	0.28	0.19	0.13	0.21	0.51	0.15	0.39
July	0.25	0.38	0.53	0.26	0.19	0.16	0.10	0.34
August	0.05	0.02	0.18	0.03	0.16	0.23	0.11	0.06
September	0	0.03	0.06	0.04	0.01	0.01	0.02	0.07
Oktober	0.01	0	0.01	0.03	0	0	0	0.01
$\bar{X}$	0.24	0.35	0.36	0.09	0.28	0.54	0.49	0.33

Gonotrophic cycle

A series of experiments were made with 35 *Ma. indiana* and 20 *Ma. uniformis* collected resting inside houses. All mosquitoes collected were fully fed. Specimens were individually held in beaker glass containing *Pistia* plants, and allowed to deposit eggs on the plants. During the holding period, the mosquitoes were fed with 10% sugar water soaked in the cotton wool placed on top of beaker gauze cover. Observations were made every 4 hours till they laid eggs. For *Ma. indiana,* it began from 81–92 hours with an average of 211 eggs per cluster (range : 124–347). For *Ma. uniformis,* it started from 80–98 hours with an average of 192 eggs per cluster.

Biting Peak

All night collections of *Ma. uniformis* and *Ma. indiana* showed that these mosquitoes bite throughout the night from 1900–0600 hours. For *Ma. uniformis,* 62.4% bites between 1900–2400 hours with peak biting activity of 40.6% during the first three hours, 1900–2100 from indoor. For outdoors, 66.8% bites between 1900–2400 hours with peak biting activity of 48.7% between 2000–23000 hours. In the case of *Ma. indiana* it was 82.8% during 1900–

Table 2. Comparison of five Catching methods on *Mansonia indiana* and *Mansonia uniformis*

Months 1980/81/82	*Mansonia indiana*					*Mansonia uniformis*				
	Indoor Net bait	Outdoor Net bait	Indoor Resting Night	Indoor Resting Morning	Outdoor Drop net	Indoor Net bait	Outdoor Net bait	Indoor Resting Night	Indoor Resting Morning	Outdoor Drop net
November	0	0	0	0	0	0.03	0.23	0.31	0.19	0.01
December	0	0	0	0	0	0.06	0.18	0.29	0.25	0.03
January	0	0	0	0	0	0.08	0.10	0.43	0.07	0.01
February	0	0	0	0	0	0.32	0.32	0.54	0.29	0.04
March	0	0	0	0	0	0.28	0.25	0.58	0.43	0.12
April	0.11	0.01	0.04	0	0	0.37	0.44	1.97	1.18	0.18
May	0.18	0.08	0.14	0.07	0.01	0.32	0.52	1.19	1.03	0.29
June	0.22	0.21	0.42	0.40	0	0.27	0.42	1.05	0.44	0.24
July	0.32	0.47	0.93	0.42	0.03	0.33	0.52	1.32	0.96	0.19
August	0.52	0.86	2.65	2.96	0.19	0.53	0.93	2.07	1.92	0.26
September	0.80	0.86	1.96	1.64	0.39	0.90	1.17	3.05	2.58	0.92
October	0.35	0.85	2.10	1.49	0.53	1.06	2.08	4.05	3.89	0.99
November	0.33	0.45	1.49	0.69	0.21	0.18	0.31	0.67	0.58	0.19
December	0.18	0.33	0.83	0.54	0.14	0.17	0.40	0.80	0.71	0.26
January	0.07	0.08	0.29	0.21	0.04	0.07	0.14	0.36	0.25	0.21
February	0.11	0.20	0.83	0.36	0.08	0.13	0.19	0.46	0.50	0.22
March	0.17	0.19	0.85	0.36	0.14	0.07	0.13	0.54	0.29	0.24
April	0.10	0.07	0.50	0.44	0.05	0.23	0.13	0.65	0.50	0.05
May	0.08	0.08	1.04	0.35	0.03	0.15	0.20	0.55	0.53	0.17
June	0.39	0.11	0.65	0.75	0.15	0.23	0.22	0.75	0.67	0.17
July	0.26	0.28	0.87	0.62	0.17	0.11	0.18	0.46	0.32	0.18
August	0.03	0.05	0.28	0.08	0.05	0.08	0.11	0.30	0.28	0.10
September	0.01	0.02	0.14	0.07	0.01	0.02	0.01	0.05	0.07	0.04
October	0	0.01	0.03	0.03	0.03	0	0	0.01	0	0.01
$\bar{X}$	0.18	0.22	0.67	0.48	0.09	0.25	0.38	0.94	0.75	0.21

2400 hours with peak biting activity of 75.5% during the first four hours between 1900–2200.

Host preference

Precipitin tests on 42 *Ma. uniformis* and 57 *Ma. indiana* from outdoor resting collections showed the following results: For *Ma. uniformis*, 11.9% fed on man, 66.7% on bovids, 2.3% each on cats and bird, 4.6% on unidentified mammals and 12.2% negative. For *Ma. indiana*, it was 50.9%, 26.3%, 5.3%, 0, 1.8% and 15.7% respectively.

Seasonal variations on density and parous rate

The outdoor and indoor net bait collections of *Ma. uniformis* and *Ma. indiana* were combined, and attempts were made to find out the seasonal variations and parous rates of each of the species.

The correlation coefficient test for *Ma. uniformis* showed no significant relationships between density and rainfall ($r = -0.11$), and similarly to *Ma. indiana* ($r = 0.08$). During the first five months (November 1980–March 1981) no *Ma. indiana* was caught, but by July it had reached the population level of *Ma. uniformis*, and thereafter the two population levels remained very similar. The highest population level of these two species was in August 1981 to October 1981, followed by a slightly lower level plateau till July 1982, then both species showed a rapid decline (Fig. 1).

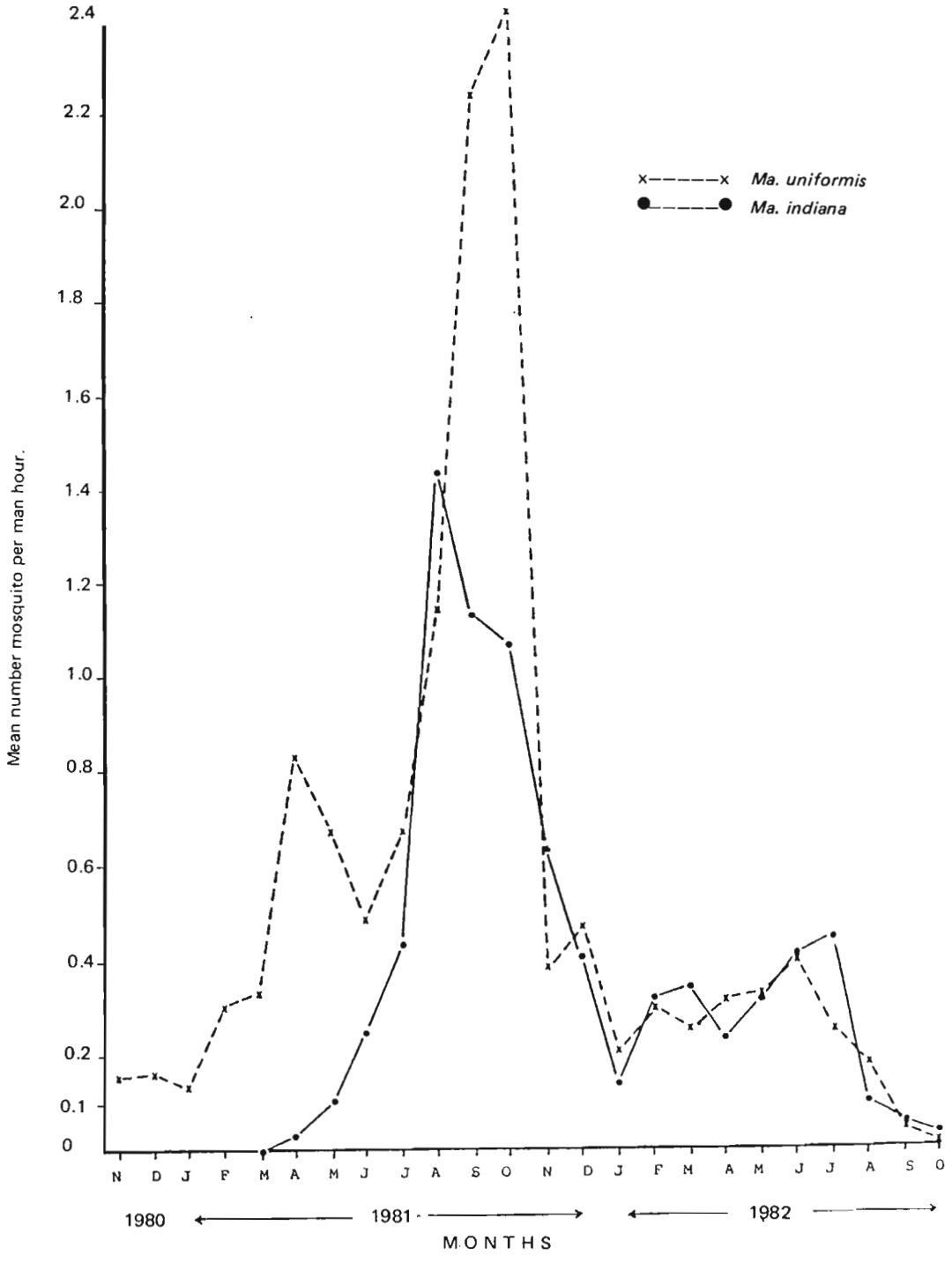

Fig. 1. Seasonal variations of *Mansonia uniformis* and *Ma. indiana* from Kendari Regency, Southeast Sulawesi.

The parous rates of *Ma. uniformis* was found to be low ranging from 22.2% to 61.7% with an average of 40.0%. For *Ma. indiana*, it ranged from 14.8% to 53.9% with an average of 24.2%. Correlation coefficient tests showed the parous rate of *Ma. uniformis* was neither correlated with rainfalls (r = 0.04) nor density (r = –0.20). Similarly, the parous rate of *Ma. indiana* was also found neither to be correlated with rainfall (r = 0.08) nor density (r = –0.20).

Natural infection of filarial worm of mosquitoes

The natural infection rates of the *Mansonia spp.* are presented in Table 3. The infection rate of *Ma. indiana* was 0.6% (28/4,426), *Ma. uniformis* 0.4% (30/6,895), *Ma. annulata* o (16), *Ma. annulifera* 0 (27) and 0.25% (1/390) in *Ma. bonneae/dives.* The overall infection rate of combined *Mansonia spp.* from indoor net bait collection was 0.45%, outdoor net bait 0.28%, indoor resting night 0.56%, indoor resting morning 0.46% and outdoor drop net 0.9% respectively. The infective rates of *Mansonia spp.* in the same order of catches were 0.26%, 0.14%, 0.21%, 0.23% and 0.39% res pectively. The mean worm-load of all stages of larvae and third stage larvae for *Ma. indiana* were 5.7 & 5.7, *Ma. uniformis* 6.8 & 4.3, *Ma. bonneae/dives* 4 & 4 and none of the *Ma. annulata* and *Ma. annulifera* were infected. The range of larvae of infected *Mansonia spp.* is shown in Table 3.

Experimental infections

Ninety *Ma. uniformis* and 30 *Ma. indiana* were fed to two human microfilariae carriers to study the development stages of the Mf in these mosquitoes, and the results are presented in Table 4. The results showed 63.3% of *Ma. uniformis* and 76.7% *Ma. indiana* were experimentally infected. Infective *B. malayi* larvae developed in 6½ days post infection in *Ma. indiana* and 7½ days in *Ma. uniformis.* At 8½ days post infections, only infective *B. malayi* larvae were found in both *Ma. indiana* and *Ma. uniformis.* The mean worm load of 1st and 2nd stage larvae and infective stage in *Ma. indiana* was 12.5 & 6.4 as compared to 16.9 & 7.5 in *Ma. uniformis.*

Fifty *Ma. uniformis* and 30 *Ma. indiana* were used as control. Two *Ma. uniformis* were infected with 2 other nematodes, and one *Ma. indiana* was found with four 3rd stage *Dirofilaria* larvae only.

Table 3. Natural filarial infection *(Brugia sp)* in *Mansonia* spp. by different methods of catches from the four villages combined at Wawotobi district, Kendari Regency, Southeast Sulawesi Province, Indonesia

Remaks	Indoor net bait			Outdoor net bait			Indoor resting night			Indoor resting morning			Outdoor drop net			Total		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Number of mosq. dissected	1.101	1.564	150	1.705	2.384	225	876	1.445	7	618	1.121	1	126	381	7	4.426	6.895	390
Infection rates	0.45 % (5)	0.45 % (7)	0	0.47 % (8)	0.17 % (3)	0.44 % (1)	0.57 % (5)	0.55 % (8)	0	0.65 % (4)	0.35 % (4)	0	4.76 % (6)	2.1 % (8)	0	0.63 % (28)	0.43 % (30)	0.25 % (1)
Infective rates	0.27 % (3)	0.25 % (4)	0	0.23 % (4)	0.04 % (1)	0.44 % (1)	0.23 % (2)	0.21 % (3)	0	0.48 % (3)	0.09 % (1)	0	0	0.52 % (2)	0	0.27 % (12)	0.16 % (11)	0.25 % (1)
Range number of infected larvae	(1–11)	(2–15)	0	(2–14)	(2–22)	4 *	(2–18)	(1–15)	0	(1–6)	(2–18)	0	(3–19)	(2–18)	0	(0–19)	(1–22)	4 *
Range number of infective larvae	(3–10)	(2–8)	0	(2–6)	10 *	4 *	(5–9)	(2–8)	0	(2–6)	2 *	0	0	(4–7)	0	(0–10)	(2–10)	4 *

1 = *Ma. indiana*
2 = *Ma. uniformis*
3 = *Ma. bonneae/dives*

* Single infection

Table 4. Number of infected mosquitoes after feeding on microfilariae carrier with 7 Mf per cu. mm in experimental studies

Mosquitoes species	No. of infected mosquitoes/No. of mosquitoes dissected on days after feeding											% of infected mosquitoes	% of infective mosquitoes
	½	1½	2½	3½	4½	5½	6½	7½	8½	9½	10½		
Mansonia uniformis	5/8	4/4	11/21	3/3	7/15	3/3	5/8	5/7	5/9	5/8	4/4	63.3	26.7
Mansonia indiana	4/5	2/2	2/2	1/1	1/4	1/1	2/3	5/5	2/4	1/1	2/2	76.7	33.3
	Control												
Mansonia uniformis	0	0	0	0/2	0/4	0/8	0	0	0/11	0/2	1/23 **	2.0	–
Mansonia indiana	0	0	1/2 *	0	0/1	1/2 *	0/2	0/4	0	0/2	0/17	6.7	–

* 2 other nematodes
** 4 *Dirofilaria* larvae (3rd stage)

Efficacy of mosquitoes as experimental vectors

Comparison of host efficiency between *Ma. indiana* and *Ma. uniformis* was made, and the results are presented in Table 5. Index of experimental infection in *Ma. indiana* showed the effect of microfilarial densities on the production of stage III (infective) larvae. It was 1.06 when fed on microfilarial carrier with 3.2 Mf per mm^3 blood, and 0.03 on Mf carrier with 7 Mf per mm^3 blood with an overall of 0.55. For *Ma. uniformis* the index was 1.34 when fed on microfilariae carriers with 2 Mf per mm^3 blood, 3.85 on Mf carrier with 3.2 Mf per mm^3 blood, and 0.47 on Mf carrier with 7 Mf per mm^3 blood with an overall of 1.88.

Insecticide susceptibility test

The insecticide susceptibility tests with DDT impregnated papers on *Ma. uniformis* and *Ma. indiana* are presented in Table 6. The LC_{50} and LC_{95} determined for *Ma. uniformis* were 0.54% and 1.80% compared to 1.05% and 2.80% for *Ma. indiana* (Table 6).

Observation of *Mansonia* habitat

Natural freshwater swampy areas are scattered within the villages, in fields and at the fringe of secondary forests. Man-made ponds are very common in the villages. They are infested with water plants such as *Pistia* and *Eichornia spp.* During the dry season, most of the man-made ponds are dry, while water is present all the year round in natural freshwater swamps. Examination of the water plants were found with clusters of mosquito eggs, which were identified to be *Mansonia* eggs. No attempt was made to hatch them in the laboratory. From drop net catches of adult mosquitoes on the banks of ponds in the villages, quite a number of *Mansonia spp.*, particularly *Ma. uniformis* and *Ma. indiana* were obtained. From these observations, it was apparent that the breeding and resting grounds of *Mansonia spp.* are prevalent in the areas.

DISCUSSION

The investigation of mosquito fauna revealed 56 species of 12 genera was present in the study area including 5 *Mansonia spp.* (Bahang et al., 1984). Longitudinal study of the 5 *Mansonia* spp. revealed both *Ma. uniformis* and *Ma. indiana* are the predominant species. The densities of the other 3 species *Ma. annulata, Ma. annulifera*

Table 5. Observation on the efficacy of *Mansonia indiana* and *Ma. uniformis* as laboratory vector of *Brugia malayi* (mosquitoes dissected 10.5 – 11.0 days after feeding on human carriers with different microfilariae densities in the peripheral blood)

Experiments No.	Microf. per cu. mm x	No. mosq. dissected	% of mosquitoes infected	% of mosquitoes infective a×100	% of mosquitoes survived b×100	Number of larvae found Stage I	Number of larvae found Stage II	Number of larvae found Stage III	% Stage III	No. of larvae per infective mosquito Mean (range)	Stage III larvae per infective mosq. c	Index of experimental infection a x b x c x
Mansonia indiana												
1	3.2	27	59.3	48.2	75	0	37	122	81.3	9.4 (2–29)	9.4	1.06
2	7	37	40.5	18.9	58.7	0	89	14	46.7	6.9 (2–37)	2	0.03
	–	64	49.9	33.6	66.9	0	63	69	64	8.2 (2–37)	5.7	0.55
Mansonia uniformis												
1	2	43	51.2	51.2	93.5	0	64	123	100	8.5 (2–31)	5.6	1.34
2	3.2	12	50	50	80	7	24	185	100	34 (7–91)	30.83	3.85
3	7	24	58.3	58.3	71	6	147	112	100	18.9 (1–41)	8	0.47
	–	79	53.2	53.2	81.5	4.3	78.3	140	100	20.5 (1–91)	14.8	1.88

Table 6. 24 hours mortality of *Mansonia uniformis* and *Ma. indiana* exposed to DDT for one hour

% DDT	Replicate 1				Replicate 2				Replicate 3				Replicate 4				Total				% mortality	
	Ma. uniformis		*Ma. indiana*		*Ma. uniformis*		*Ma. indiana*		*Ma. uniformis*		*Ma. indiana*		*Ma. uniformis*		*Ma. indiana*		*Ma. uniformis*		*Ma. indiana*		*Ma. uniformis*	*Ma. indiana*
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2		
0.25	18	5	20	2	20	5	15	0	18	3	19	0	15	2	20	1	71	15	74	3	21.1	4.1
0.50	20	12	18	3	19	7	17	1	20	9	18	2	18	7	19	2	77	35	72	8	45.5	11.11
1.00	18	18	18	9	20	17	15	7	20	16	20	8	15	12	20	10	73	63	73	34	86.3	46.6
2.00	17	17	17	17	20	20	15	15	16	16	20	20	16	16	17	17	69	69	69	69	100.00	100.00
Control	16	0	16	0	16	0	15	0	15	0	16	0	15	0	17	0	62	0	64	0	0	0

1 = Number of mosquitoes tested
2 = Number of mosquitoes dead

Eve fitted regression line for *Ma. uniformis* LC_{50} = 0.54 % ; LC_{95} = 1.80 %
Ma. indiana LC_{50} = 1.05 % ; LC_{95} = 2.80 %

and *Ma. bonneae/dives* complex were found to be very low. There was no consistant seasonal peak shown by any of the *Mansonia* spp. Correlation coefficient tests for the two predominant *Ma. uniformis* and *Ma. indiana* showed no significant relationship between density and rainfall, nor between parous rates and density, but population levels of these two species were observed in August to October 1981 with a slightly lower level plateau in July 1982. Sudomo et al (198) also found that rainfall does not influence peak cycles of *Mansonia* spp. in Bengkulu, Sumatera and Wharton (1962) found rainfall does not effect the breeding places of *Mansonia* spp. in Malaysia as the habitats where they breed never dry out completely. The low

parous rates of both these mosquito species which neither correlated with rainfall nor densities were probably reflected by their breeding places where there was a quick turnover on the emergence of nearly hatched adult mosquitoes most of the time.

The gonotrophic cycle studies on both these species, showed the period from feeding to egg-laying on *Ma. uniformis* was 3.3 – 4.1. days and *Ma. indiana* was 3.4 – 3.8 days. Wharton (1962) found the gonotrophic cycle of *Ma. uniformis* was 3 days but it usually took 4 – 5 days, and the period was the same for the first and subsequent cycles. Jayawickrema and Niles (1952) found the gonotrophic cycles for all *Mansonia* spp. were about 4 days in Ceylon, and Bertram and Samawickrema (1958) showed similar period in *Mansonia spp.* studied in London. The biting peak of *Ma. uniformis* and *Ma. indiana* was found to be rather similar. In indoors, these mosquitoes bite during 1900 – 2100 hours, while in outdoors, it was between 2000 – 23000 hours. Sudomo et al (1984) showed the biting peak activity of *Ma. uniformis* was between 1800 – 1900 hours, and a second peak between 0300 – 0500 hours in outdoors and indoors in Bengkulu, Sumatera. Wharton (1962) found the biting peak habits *Ma. uniformis* indoors commenced shortly after 1800 hours and continued through the night with the main biting peak between midnight, and in outdoors the biting peak occurred between 1800 – 1900 hours.

Host preference study showed *Ma. uniformis* has a more catholic in its feeding habits than *Ma. indiana.* Iyengar (1938) found *Ma. uniformis* and *Ma. indiana* fed to a large extent on man even though they were found resting more often in cattle sheds rather than in houses by day. Wharton (1962) found the feeding habits of *Ma. uniformis* from indoors and outdoors behaved similar to what we have studied in Sulawesi.

Natural infections of *Mansonia* mosquitoes with *Brugia* larvae were found in three of the 5 *Mansonia* spp. The infection rates from all these mosquitoes were very low. Similarly infection rate of *Mansonia* spp. from Bengkulu, Sumatera was also found to be low (Sudomo et al., 1984). Brug and de Rook (1930) found it difficult to explain why so few *Mansonia* spp. were naturally infected with filarial larvae when a high percentage of humans were infected. Wharton (1962) speculated that although the natural infection rates of these mosquitoes were low, but the intensity of human transmission is related directly to the numbers of infective bites. In a high endemic filariasis areas like Southeast Sulawesi Province where infection rates were high (Arbain Joesoef et al., 1984), and infective *Mansonia* mosquitoes were low, it is quite probable that the same situation exist as what speculated by Wharton (1962).

Experimental infection of *Ma. uniformis* and *Ma. indiana* on human filaria carriers revealed that these mosquitoes became infective at day 6½ post infection, and efficacy tests showed the index of infectivity with *Ma. uniformis* was 3.4 times higher than *Ma. indiana.* This indicate that although the natural infection rate of *Ma. uniformis* was low, but as a transmitting host, this mosquito showed to be more efficient. Arbain Joesoef et al. (1984) in his experiments on both of these mosquitoes species with laboratory animal models, confirmed that they are authentic vectors of *B. malayi.* There were too few other *Mansonia spp.* available for experimental studies, however from natural infection results, it was shown that they are also good potential vectors of brugian filariasis in the areas studied Bahang et al. (1984) and Arbain Joesoef et al. (1983) also confirmed another mosquito vector, *An. barbirostris* as one of the principal vectors in the areas based on natural and experimental infections, and *An. nigerrimus* as a potential vector.

Insecticide susceptibility tests revealed that both *Ma. indiana* and *Ma. uniformis* were susceptible to DDT. But the lethal concentration required for *Ma. indiana* was shown to be higher than that found for *Ma. uniformis.*

In conclusion, the present study established that 3 of 5 *Mansonia* spp. *(Ma. uniformis, Ma. indiana* and *Ma. bonneae/dives)* are vectors of brugian filariasis in Kendari Regency, Southeast Sulawesi. Bahang et al. (1984) found *An. barbirostris* is the predominant mosquito

species in the study areas, and the natural infective rate with brugian larvae was 0.07% (12/17, 407) as compared to *Ma. uniformis* 0.16% (11/6, 895) and *Ma. indiana* 0.27% (12/4, 426) respectively. The results indicate that *An. barbirostris, Ma. indiana* and *Ma. uniformis* are the vectors in the study areas. Jurgens (1932) reported *An. barbirostris* and *Ma. dives* are the vectors in Mamoedjoe area, South Sulawesi. Partono et al. (1972) examined 3 *Ma. uniformis* in Margolembo, South Sulawesi were found to be negative. The present findings of *Mansonia* spp. being vectors of brugian filariasis is the first authenticated report in Southeast Sulawesi.

SUMMARY

Longitudinal studies of *Mansonia* mosquitoes in four villages of Southeast Sulawesi showed among five *Mansonia* spp. examined, *Ma. uniformis* and *Ma. indiana* were the most predominant mosquitoes. The densities of both these species showed no significant relationships between rainfall. Their parous rates were also found no correlation with rainfall and with density. Their biting peaks were between 1900 – 2400 hours, and the feeding habit of both the species are catholic in nature. The gonotrophic cycle of *Ma. uniformis* started from 80 – 98 hours and *Ma. indiana* began from 81 – 92 hours.

Three of the five species of *Mansonia* spp. examined were naturally infected with *Brugia* larvae with relatively low rates. Experimental studies showed the development of infective larvae of *B. malayi* in *Ma. uniformis* in 7½ days as compared to 6½ days in *Ma. indiana.* The indices of efficacy experimental studies in *Ma. uniformis* and *Ma. indiana* was 1.88 and 0.55 respectively.

Insecticide susceptibility test with DDT impregnated papers revealed that both these *Mansonia* species were susceptible.

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