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Population Density, Developmental Period and Fecundity of *Anopheles* Mosquito (Diptera: Culicidae) in the Gezira State, Sudan

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Abstract:

In the Gezira State, insecticides were used for many years for controlling mosquitoes and other agricultural pests. The objective of this work was to study the population density, the developmental periods the reproductive periods and the fecundity of *Anopheles* mosquitoes in the Gezira State, Sudan. The study was conducted in three sites; Elmanagel, Elhosh and Wad Medani.Ten of one-day old or less of the cultured adult males and females of *A. pharoensis* wewe transferred separately to cage. The female pre-oviposition period, daily number of eggs deposited, the oviposition period, the post oviposition period, the adult longevity and the average number of eggs per female were recorded. The results revealed that, the number of *A.arabiensis* larvae collected from the three sites was higher than that of *A. pharoensis* and *A. funestus* during the two seasons (2009 and 2010). The number of *A. funestus* adults collected at Wad Medani site during the two seasons was lowest than that collected from El Managel and El Hosh. The incubation period of the eggs, was relatively similar in all *Anopheles* species, as same as the larval period. The pupal period was relatively longer in *A. funestus* (2.4 days) and *A. pharoensis* (2.2 days) than in *A.arabiensis* (2 days). Adult *A. pharoensis* lived relatively longer (21 days) than *A arabiensis* and *A. funestus* (20 days). The total life cycle was relatively longer (32 days) in *A. pharoensis* than in *A. arabiensis* and *A. funestus* (30 days for each). Females of all species of *Anopheles* mosquito oviposited after one day from their emergence from the pupae and took also one day before they oviposit again. The oviposition period was significantly longer in *A. arabiensis* (3.3 days) than in *A. pharoensis* (2.5 days) and *A. funestus* (1.8 days). The oviposition rate was significantly higher in *A. arabiensis* (191) than in *A. pharoensis* (150) and *A. funestus* (79). The fecundity of *A. arabiensis* (624 eggs/female) was significantly greater than that of *A. pharoensis* (391 eggs/female) and *A. funestus* (141 eggs/female). Such study should be run periodically for all sites in the Gezira State and neighboring States.

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Introduction:

About 380 species of *Anopheles*, were recorded. Sixty of them are attracted to human and act as vectors of many diseases (White, 1991). The family culicidae (subfamily anophelini) includes several species of *Anopheles*, viz. *A. arabiensis, A. gambiae, A. funestus, A. pharoensis, A. dthali, A. rufipes, A. coustani, A. multicolor* and *A. nili* (Wattal and Kalra, 1960; Clements, 1992). *Anopheles* mosquito have a world-wide distribution, occurring not only in tropical areas but also in temperate regions (Gillies, 1956) and they are absent from the extreme northern parts of the temperate zones (Wattal and Kalra, 1960). The biology of *A. arabiensis* and *A. gambiae* were reviewed by White (1991); Elsafi *et al.*, (1985); and Haridi (1972). The biology and behavior of *A. funestus* was reviewed by Gillies (1956) and Service (1988).

The female *Anopheles* lays about 50 – 200 eggs at any one oviposition (Service, 1988) often 30 – 300 eggs (Hawking, 1973 and Christopher, 1911). In the tropics, the eggs hatch within 2-3 days, but in the cooler temperate countries they may take 7 days, or longer (White, 1989; Clements and Boocock, 1984). Moreover, *Aedes* eggs, sometimes, require repeated immersion in water, followed by short periods of desiccation. Mosquito larvae require water to develop, and so they cannot withstand desiccation and are able to survive for a short period in wet mud. There are four active larval instars (Jan, 1997).

In tropical countries, larval development can be as short as 5 – 7 days, while other species may take 7 – 14 days. In temperate areas, the larval period may last several weeks or months and several species overwinter as larvae (White, 1991 and Perry and Agosin, 1974).In tropical countries, the larval period of *A. arabiensis* and *A. gambiae* take only 7 days, but in cooler climates the larval period may be about 2 – 4 weeks (White, 1991).

The pupal period of *Anopheles* mosquito takes 2 – 3 days in tropical countries; 7 – 14 days or longer (Perry and Agosin, 1974 and White, 1991) in cooler countries. At the end of pupal life the skin on the dorsal surface of the cephalothorax spilits and the adult mosquito struggles out (Perry and Agosin, 1974). In tropical countries, the average longevity of adult mosquito may take 2 – 3 weeks, the males live shorter than the females and the species which overwinter live longer (BNHP, 1987). Tesfa – Yohanna (1982) reported that the adult period in *Anopheles* species takes 2 – 4 weeks in tropical countries, while in temperate climates this period may take 4 – 6 weeks or longer. He added that the species which overwinter live for many months.

Research Objectives:

The Main objectives:

To study the population density of *Anopheles* in the Gezira State, Sudan, in addition to the developmental periods of the different stages, the description of the reproductive periods and fecundity.

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Materials and Methods:

The study area:

The locations selected for conducting the study, were, El Managel, EL Hosh and Wad Medani. The sampling of larvae and adults mosquitoes (*Anopheles* species) was carried out in these locations. Sampling, observation and experimentation were executed monthly during July -December of years 2009 and 2010.

Sampling and identification of larvae and adults:

Sampling of larvae was carried out in the three locations twice a week. In each location, the mosquito larvae were collected from 4 - 8 ponds by means of metal dish (15 cm in diameter and 10 cm deep) put in a plastic bucket (8 liters). The larvae of *Anopheles* mosquito collected from each location were counted using a plastic dropper, and kept in a enamel dish (20 cm in diameter and 10 cm deep) supplied with dry yeast (0.5 mg/ liter water) as a food for rearing, put inside the rearing cage (60 x 60 x 60 cm) covered with white sheet of cloth described by Stewart (1974).

Sampling of adults mosquitoes was carried out monthly in (Hei El Mutamed, Wad El Moselme and El Shabia) in El Managel, (Hei Eljaleen, Hei El Khwalda and Hei Tamem) in EL Hosh and **(**El Darja, Hellat Mahjoop and Kereba campus) in Wad Medani. Various *Anopheles* larvae and adults were identified at various larval stages using the key described by Gillies and Demillion (1968).

Culturing methods:

Eggs incubation, larvae and adults rearing were run in the insectary of the Blue Nile National Institute for Communicable Diseases under laboratory conditions set up at 28°C and 75% RH.

The emerged adults, of *Anopheles*, were collected by means of an aspirator and kept as F1 generation in new cages (60 x 60 x 60 cm). The source of blood meals for females mosquitoes was a pigeon. For the male mosquitoes the source of energy was 10% sugar solution provided in a cotton wick put in an open Petri-dish. A trough containing tap water (20 cm in diameter and 10 cm deep) was provided to each adult's cage for oviposition. The life span for adults of *Anopheles* species was recorded as a range for shorter and longer adult span.

Eggs of *Anopheles* species were inspected daily at 8:00 – 9:00 in the morning. The eggs were kept for hatching for 4 days, then incubation period and the hatchability percentages were recorded.

Larvae that hatched from the cultured eggs were fed on dry yeast (0.5 mg/liter) and rearing was continued until pupation. The pupae were kept in the same larval dishes and cages until adults emerged. The period from eggs hatching to pupal formation was recorded as a larval period while the period from pupation to adult emergence was considered as a pupal period.

Reproductive periods and fecundity:

Ten of one day old or less of the cultured adult males and females were transferred to cage as described before. The oviposition period, the daily number of eggs deposited,

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the post oviposition period, the adult longevity and the average number of eggs per female were recorded.

Statistical analysis:

Appropriate data transformation was carried out when needed and then data were analyzed using analyses of variance (ANOVA). Differences between means were separated using Duncan's Multiple Range Test (DMRT). In addition, simple descriptive statistics were also executed.

Results and Discussion:

4.1 Population density of *Anopheles* larvae at the study Areas

Table (1) shows that, during 2009, the density of *A. arabiensis* larvae was high in El Managel at September (523) and November (494), followed by Wad Medani at November (485) and El Hosh at November (472). Same observation was noticed during 2010, in which the densities were 610, 534, 545, and 529, respectively for the same order of sites.

In case of *A. pharoensis* larvae, during 2009, high densities were recorded at El Managel (total of 1547) followed by Wad Medani (total of 1200) and El Hosh (total of 1117), but small change was observed during 2010, that the highest density was recorded in El Managel (total of 1615) followed by El Hosh (total of 1262), and then Wad Medani (1152).

However, the density of *A. funestus* larvae was observed to be high at El Managel (total of 897 and 720, respectively during 2009 and 2010), while they were about half of that at El Hosh (total of 481 and 369, respectively during 2009 and 2010), whereas they were only nine larvae during 2009 and 506 during 2010.

4.2 Population density of *Anopheles* adults at the study Areas

During 2009, the density of *A. arabiensis* adults was high in El Hosh (total of 408), followed by El Managel (total of 389) and less than half of that at Wad Medani (total of 170). During 2010, the densities were 381, 415 and 220, respectively for the same order of sites (Table, 2).

In case of *A. pharoensis* adults, during 2009, high densities were recorded at El Hosh (total of 366) followed by El Managel (total of 319) and Wad Medani (total of 125), as same as during 2010, that the highest density was recorded in El Hosh (total of 459) followed by El Managel (total of 319), and then Wad Medani (138).

However, the density of *A. funestus* adults was higher at El Hosh (total of 190 and 264, respectively during 2009 and 2010), while at El Managel it was (total of 185 and 227, respectively during 2009 and 2010), where as there were only four adults during 2009 and 0 during 2010.

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Table (1): Population densities of the identified larvae at the three selected sites during July – December 2009 and 2010

Site	Month	*A. arabiensis*		*A. pharoensis*		*A. funestus*	
		2009	2010	2009	2010	2009	2010
Wad Medani	**July**	**89 e**	**0 f**	**41 f**	**0 f**	**0**	**0 e**
	Aug.	205 d	68 e	117 e	61 e	0	3 e
	Sept.	375 b	379 b	**334 a**	184 c	0	49 d
	Oct.	362 c	269 d	318 b	130 d	0	60 c
	Nov.	**485 a**	**554 a**	251 c	**433 a**	3	**257 a**
	Dec.	207 d	346 c	139 d	344 b	6	137 b
	Total	**1723**	**1616**	**1200**	**1152**	**9**	**506**
El Managel	**July**	**73 e**	**114 f**	**24 e**	**60 f**	**30 e**	**35 f**
	Aug.	170 d	255 e	159 d	198 e	57 d	49 e
	Sept.	**523 a**	474 c	**388 a**	**413 a**	162 c	179 b
	Oct.	378 c	392 d	214 c	298 c	158 c	69 d
	Nov.	494 b	524 b	**392 a**	380 b	**316 a**	157 c
	Dec.	492 b	**610 a**	370 b	302 c	174 b	**231 a**
	Total	**2130**	**2369**	**1547**	**1651**	**897**	**720**
El Hosh	**July**	**112 f**	**0 f**	**70 f**	**0 f**	**7 e**	**0 d**
	Aug.	177 e	149 e	140 d	44 e	30 d	0 d
	Sept.	347 b	347 c	106 e	290 c	79 b	50 c
	Oct.	298 d	325 d	170 c	158 d	**151 a**	49 c
	Nov.	**472 a**	**529 a**	**350 a**	380 b	**153 a**	**158 a**
	Dec.	318 c	415 b	281 b	**390 a**	61 c	112 b
	Total	**1724**	**1765**	**1117**	**1262**	**481**	**369**

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Table (2): Population densities of the identified adult at the three selected sites during July – December 2009 and 2010

Site	Month	*A. arabiensis*		*A. pharoensis*		*A. funestus*	
		2009	**2010**	**2009**	**2010**	**2009**	**2010**
Wad Medani	July	0 c	11 c	0 c	9 c	0	0
	Aug.	22 b	36 b	19 b	22 b	0	0
	Sept.	27 b	37 b	23 b	23 b	0	0
	Oct.	48 a	53 a	18 b	19 b	0	0
	Nov.	42 a	48 a	34 a	34 a	1	0
	Dec.	31 b	35 b	31 a	31 a	3	0
	Total	**170**	**220**	**125**	**138**	**4**	**0**
El Managel	July	37 d	43 d	33 e	33 e	16 c	13 c
	Aug.	45 d	45 d	42 d	42 d	23 b	29 b
	Sept.	65 c	56 c	71 a	55 c	43 a	33 b
	Oct.	76 b	86 b	56 c	56 c	39 a	49 a
	Nov.	88 a	98 a	62 b	62 b	23 b	52 a
	Dec.	78 b	87 b	55 c	71 a	41 a	51 a
	Total	**389**	**415**	**319**	**319**	**185**	**227**
El Hosh	July	0 d	29 d	0 d	49 d	0 d	21 d
	Aug.	71c	51c	73 b	81 b	31 c	39 c
	Sept.	82 b	69 b	67 c	74 c	29 c	38 c
	Oct.	89 a	72 b	69 c	76 c	36 b	47 b
	Nov.	87 a	81 a	81 a	96 a	45 a	58 a
	Dec.	79 b	79 a	76 b	83 b	49 a	61 a
	Total	**408**	**381**	**366**	**459**	**190**	**264**

4.3 Mean Developmental periods of the three species of *Anopheles* mosquitoes reared under laboratory conditions (28°C and 75% RH) during 2009-2010:

The incubation period of the eggs, was relatively similar in all *Anopheles* species, as same as the larval period. In temperate areas, the larval period may last several weeks or months and several species overwinter as larvae (White, 1991 and Perry and Agosin, 1974). In tropical countries, the larval period of *A. arabiensis* and *A. gambiae* takes

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only 7 days, but in cooler climates the larval period may be about 2 – 4 weeks (White, 1991).

The pupal period was relatively longer in *A. funestus* (2.4 days) and *A. pharoensis* (2.2 days) than in *A.arabiensis* (2.0 days). The pupal period of *Anopheles* mosquito takes 2 – 3 days in tropical countries; 7 – 14 days or longer (Perry and Agosin, 1974 and White, 1991) in cooler countries. Adult *A. pharoensis* lived relatively longer (21.5 days) than *A arabiensis* (20.1 days) and *A. funestus* (20.2 days). The total life cycle was relatively longer (32.2 days) in *A. pharoensis* than in *A. arabiensis* and *A. funestus* (30.6 days for each). In tropical countries, the average longevity of adult mosquito may take 2 – 4 weeks, the males live shorter than the females and the species which overwinter lives longer (BNHP, 1987 and Tesfa – Yohanna, 1982).

Females of all species of *Anopheles* mosquito oviposited after one day from their emergence from the pupae (Table, 3). This agreed with the findings of Christopher (1911) and Steffen (2011) who reported the same period in *Anopheles* mosquito. The oviposition period was significantly longer in *A. arabiensis* (3.3 days) than in *A. pharoensis* and *A. funestus* (2.5 and 1.8 days, respectively). The oviposition period recorded for the same species of *Anopheles* was 2 days (Hawking, 1973), 4 days (Christopher, 1911) and much longer i.e. 6 days (Schaefer *et al*., 2007). The differences might be due to the differences in the experiments locations. In all tests this period took only one day. This agreed with the findings of Steffen (2011) who reported the same period in *Anopheles* mosquito.

The oviposition rate was significantly higher in *A. arabiensis* (191.15) than in *A. pharoensis* and *A. funestus* (150 and 79.15, respectively). The oviposition rate of *A. arabiensis* ranged between 50-200 eggs /female/ day (Hawking, 1973). Belkin (2006) and Barnard and Mulla (2007) reported a wider range i.e., 30-300 eggs /female/ day for most species.

As was shown in Table (3), the fecundity of *A. arabiensis* (624.90 eggs/female) was significantly greater than that of *A. pharoensis* and *A. funestus* (391.90 and 141.40 eggs/female, respectively). Belkin (2006) reported that, the fecundity of *A. gambia* (A and B) ranged between 600-800 eggs/female.

Table (3): Development periods, reproductive periods (days) of the three species of *Anopheles* mosquito reared under laboratory conditions of (28 C° and 75% RH), during 2009-2010

Stage	***A. arabiensis***	***A. pharoensis***	***A. funestus***
Egg	2.3 ± 0.15	2.1 ± 0.10	2.2 ± 0.16
Larva	6.4 ± 0.22	6.1 ± 0.23	6.1 ± 0.23
Pupa	2.0 ± 0.00	2.2 ± 0.13	2.4 ± 0.16
Adult	20.1 ± 0.62	20.2 ± 0.42	21.5 ± 0.40

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Total L.C	30.6 ± 0.79	30.6 ± 0.5	32.2 ± 0.47
Pre-oviposition	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0
Oviposition	3.3 ± 0.15	2.5 ± 0.22	1.8 ± 0.13
Post- oviposition	1.0 ± 0.0	1.0 ± 0.0	1.0 ± 0.0
Oviposition Rate	191.2 ± 9	150 ± 17.4	79.2 ± 2.5
Fecundity	624.9 ± 27.2	391.9 ± 22.8	141.4 ± 10.5

Conclusion:

The number of *A.arabiensis* larvae collected from the three sites was higher than that of *A. pharoensis* and *A. funestus*. The number of *A. funestus* adults collected at Wad Medani site during the two seasons was lowest than that collected from El Managel and El Hosh. The incubation period of the eggs, was relatively similar in all *Anopheles* species, as same as the larval period. The pupal period was relatively longer in *A. funestus* (2.4 days) and *A. pharoensis* (2.2 days) than in *A.arabiensis* (2 days). Adult *A. pharoensis* lived relatively longer (21.5 days) than *A arabiensis* (20.1 days) and *A. funestus* (20.2 days). The total life cycle was relatively longer (32.2 days) in *A. pharoensis* than in *A. arabiensis* and *A. funestus* (30.6 days for each). Females of all species of *Anopheles* mosquito oviposited after one day from their emergence from the pupae and took also one day before they oviposit again. The oviposition period was significantly longer in *A. arabiensis* (3.3 days) than in *A. pharoensis* and *A. funestus* (2.5 and 1.8 days, respectively). The oviposition rate was significantly higher in *A. arabiensis* (191.2) than in *A. pharoensis* and *A. funestus* (150 and 79.15, respectively). The fecundity of *A. arabiensis* (624.9 eggs/female) was significantly greater than that of *A. pharoensis* and *A. funestus* (391.9 and 141.4 eggs/female, respectively).

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