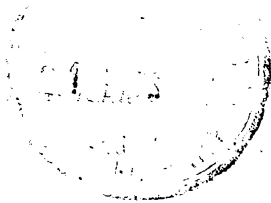


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THE MOSQUITOS OF ZARIA PROVINCE, NORTHERN NIGERIA -
THE ANOPHELINI

by

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I. Introduction

Kaduna, the capital of the Northern Region of Nigeria, is a town with 44 500 inhabitants, situated at latitude 10.30 N and longitude 7.28 E, in an enclave of capital territory enclosed by Zaria Province. The studies described below were carried out between June 1957 and December 1958 within a radius of fifty miles of Kaduna during which time the mosquito population was kept under almost continual observation. As energetic control measures were in force in the urban area all the observations reported were made outside the control zone. Short-term mosquito surveys have been made previously in the district by Brown, Fitzjohn and Mattingly (Federal Malaria Service Records) and records made by these and other workers are included in part IV of the present document.

The topography of the area is gently undulating Guinea savannah with scattered granite outcrops; the altitude is about 2000 feet. The region is traversed by numerous small streams which drain into the Kaduna River. A number of streams are bordered with fringing forest where distinct and isolated mosquito communities occur. During the rains flooding leads to the formation of small swamps.

The rural population is gregarious and lives in villages of varying sizes. It is mainly agricultural and farming activities provide many additional mosquito breeding places. The mud huts in which the people live are mostly rectangular of about 180 square feet in area, with thatched roofs; windows are lacking and the doorways are covered at night with grass mats. The huts are never completely subdivided into rooms. Domestic animals include goat, sheep, dog and fowl which are generally loose in the compounds but occasionally share the hut of their owner.

TABLE 1

CLIMATIC RECORDS - KADUNA 1958

By courtesy of the Director of the West African Institute
for Trypanosomiasis Research

Month	Temperature					
	Mean Max.	Mean Min.	Range	Mean Temp. (fahrenheit)	Absolute Max.	Absolute Min.
Jan.	90.9	64.6	26.3	77.4	100.0	56
Feb.	89.6	64.3	25.3	76.8	98.0	58
Mar.	97.5	72.0	25.5	85.0	101.0	65
Apr.	91.5	73.5	17.0	82.0	98.0	70
May	90.2	73.9	16.3	81.9	94.0	68
June	83.6	71.2	12.4	76.4	88.0	68
July	79.0	75.4	4.4	77.6	83.0	68
Aug.	79.9	70.4	9.5	75.1	88.0	67
Sept.	83.8	70.4	13.4	77.1	88.0	66
Oct.	89.5	71.7	17.8	80.6	93.0	68
Nov.	92.3	68.6	23.7	80.2	95.0	63
Dec.	92.6	64.2	28.4	78.4	98.0	59

Month	Humidity					Rainfall
	R.H. % at Max. °T.	R.H. % at Min. °T.	Range	Mean R.H. %	Mean daily Evaporation ccs.	Monthly (inches)
Jan.	35%	48%	13	41.5	96.4	0
Feb.	26%	38%	12	42.0	116.0	0
Mar.	27%	41%	14	34.0	115.9	0
Apr.	50%	86%	36	68.0	45.8	4.31
May	47%	86%	39	66.5	25.9	5.31
June	49%	81%	32	65.0	19.6	7.95
July	60%	66%	6	63.0	12.3	6.17
Aug.	72%	90%	18	81.0	12.3	8.38
Sept.	66%	90%	24	78.0	10.5	13.08
Oct.	49%	86%	37	66.5	31.2	7.56
Nov.	50%	81%	31	65.5	58.16	0.03
Dec.	32%	65%	33	48.5	90.85	0

The inhabitants of the observation villages generally sat outside their huts until about 10 p.m. before retiring. An average of 2.6 persons sleep in each hut; this differs from the custom in round huts in the Sokoto area where 1.0 - 1.5 persons occupy a hut.

Malaria is holoendemic throughout Nigeria but in the Kaduna area as indeed throughout the Northern Region, there is an increased incidence in the wet season. However, at the height of the dry season (January - February) in 1958 the bloods of 200 children aged up to 10 years and living in mosquito observation villages were examined for malaria parasites; 87 per cent. of the total were found to be positive but in two small villages all were infected.

II. Description of the investigation

The object of the studies was primarily to ascertain the bionomics of actual and potential vectors of malaria in the area. Consequently the principal study concentrated on the anthropophilic species which feed in the vicinity of human habitations.

Two village areas were selected for observation. One, Kakuri, including four hamlets is situated about two miles south of Kaduna and within a mile of the Kaduna River. The other, Kangimi, includes two hamlets, lies about twenty miles north of the capital and is in close proximity to small swampy streams.

The seasonal fluctuation of endophilic species was measured by visiting three or four huts in each village at monthly intervals, making early morning pyrethrum floor-sheet collections and calculating the Average Anopheles Densities per hut per day. Mosquitos collected in this way were dissected and the Sporozoite Rates recorded.

The entrance and exit times of endophilic species were studied by using similar methods to Wharton (1951). Here, however, door traps were used instead of window traps. The 'door trap' consists of a large panel of plywood mounted on a frame which fits the doorway of the hut. In the centre of the panel is a baffle with a narrow horizontal slit as in a typical Magoon trap, above this is a square hole over which a gauze funnel trap can be fastened. With the slit open and the funnel trap opening

into the hut the mosquitos are allowed to enter but many of those which attempt to leave are caught in the funnel trap. With the slit closed and the funnel trap opening outwards many mosquitos are caught as they attempt to enter the hut. Since many mosquitos enter and leave by other routes such traps could not be used to estimate actual numbers but if it is assumed that the proportion caught in traps is fairly constant then the times of entry and exit can be ascertained. The trapping experiments were carried out from July to September 1958.

Seasonal fluctuations of anthropophilic mosquitos and biting times were studied by the regular use of human bait throughout the year. Generally four catchers were employed at any one time, they sat in total darkness and collected mosquitos in tubes as they were bitten. Short catches lasting from 7 p.m. until 10 p.m. were made about four times per month at one of the two regular catching stations in the bush. These stations were situated at about 1/2 and 1-1/2 miles respectively from habitations, both were in close proximity to marshy areas. Twice a month all night catches were made in a native village.

III. Bionomics of the principal endophagic species

The principal endophagic Anopheles of the area were A. gambiae, A. funestus, A. nili and A. wellcomei. The first two species comprised almost the whole daytime resting populations obtained from huts by floor-sheet collections. It was not until the collection of mosquitos biting human bait was started that the possible importance of the other two species was realized.

A. Seasonal fluctuations

The results of morning floor-sheet collections (Table 2) show that in the northern village area A. funestus was the dominant species for all but two months of the year, its number being greater at the end of the rains. In the southern area A. gambiae predominated during the rains whereas in the dry season both species occurred in similar low numbers. A. nili was found resting in huts only during the rains; it has never comprised more than 14 per cent. of the total Anopheles population of any hamlet.

TABLE 2

AVERAGE ANOPHELES DENSITIES IN SOUTHERN VILLAGE AREA

Species	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
<u>A. gambiae</u>	4	8	25	89	26	3	2	0.5	2	2.5	4.3	5	3	3	26	12
<u>A. funestus</u>	3	10	15	28	14	8	7	2	10	1	3	3	2	2	3.5	10
<u>A. nili</u>	0	2	0.5	1	0	0	0	0	0	0	0	0	0	1	1	0

AVERAGE ANOPHELES DENSITIES IN NORTHERN VILLAGE AREA

Species	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
<u>A. gambiae</u>	30	14	7	62	3	0	0	0	0	5	11	15	7	24	51	4
<u>A. funestus</u>	25	34	70	161	98	23	51	27	20	18	20	12	26	36	60	67
<u>A. nili</u>	0.5	2	8	1	0	0	0	0	0	0.1	0.5	0.5	0.1	4	9	0

To ascertain the reliability of floor-sheet collections in determining the numbers of mosquitos biting per night, a series of all night indoor catches was made in the village of Kangimi. Generally from two to four collections were made per month between February and December 1958.

Since the night catches were made in one hut a very close correlation between the numbers caught biting and the AAD calculated from collections made in a number of huts cannot be expected. From the results given in Table 3 it can be seen in the case of A. funestus and A. gambiae that the average numbers of freshly fed females in floor-sheet collections, divided by 2.5 (the average number of occupants) closely approximates to the numbers caught biting during 10 man hours. The generally higher figures in the biting column are partly due to the fact that a 10 hour rather than a 7 or 8 hour night is calculated.

The highest densities of A. nili recorded in floor-sheet collections were 15 per hut i.e. 6 per man hut but the number actually caught biting one man per 10 hour night was over ten times this number. During August and September A. nili was the dominant

species biting indoors. These results show that of the total A. nili biting, only a very small proportion remain in the huts at dawn. In the case of A. wellcomei, which is quite an important endophagic species in the dry season only two have been recorded in huts at dawn. Should either of these species be incriminated as vectors, control by house spraying with residual insecticides would prove difficult owing to their short stay in huts.

TABLE 3

COMPARISON BETWEEN AAD CALCULATED BY FLOOR-SHEET COLLECTIONS
AND ACTUAL NUMBERS OF ANOPHELES CAUGHT BITING PER 10 MEN/HOURS

	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
No. man/hrs worked	40	50	40	20	40	80	80	40	40	28	40
No. nights	2	2	2	1	2	4	4	2	2	2	2
<u>A. gambiae</u>	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total AAD	0	0	8	14	16	10	34	73	7	1	
Feds AAD	0	0	6	7	9	7	22	60	6	1	
Feds per man	0	0	3	3	4	3	9	24	2	0	
No. biting 1 man/10 hrs	0	0	0.2	0.2	7	6	21	15	5	2	0.2
<u>A. funestus</u>	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total AAD	47	29	18	21	8	18	48	66	57	72	
Feds AAD	17	8	14	10	3	8	32	41	37	46	
Feds per man	7	3	6	4	1	3	13	16	15	18	
No. biting 1 man/10 hrs	10	3	2	0.2	5	4	17	12	24	16	6
<u>A. nili</u>	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Total AAD	0	0	0.3	1	1	0	7	15	0	0	0
Feds AAD	0	0	0.3	1	1	0	7	15	0	0	0
Feds per man	0	0	0.1	0.4	0.4	0	3	6	0	0	0
No. biting 1 man/10 hrs	0	0	0.	0.2	6	3	26	62	0.5	0	0
<u>A. wellcomei</u>	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
No. biting 1 man/10 hrs	12	1	1	0	0.2	0	3	3.5	8	3.5	3

B. Sporozoite rates in principal Anopheles

The proportion of A. funestus and of A. gambiae infected with malaria parasites was approximately the same, the dry season sporozoite rates being half of those found during the wet season. No infections were found in any A. nili or A. wellcomei examined. (In French West Africa A. nili has been recorded with a sporozoite rate of 4.0 per cent. and A. wellcomei with 0.01 per cent - Hamon et al. 1956.)

TABLE 4

SPOROZOITE RATES IN PRINCIPAL ANOPHELES IN ZARIA PROVINCE

Species	Period	No. dissected	No. positive	Rate
<u>A. funestus</u>	Dec. - May 1958	190	6	3%
	June - Oct. 1958	334	26	7.7%
<u>A. gambiae</u>	Nov. - May 1958	100	4	4%
	June - Oct. 1958	238	16	6.7%
<u>A. nili</u>	Wet seasons 1957 and 1958	144	0	0%
<u>A. wellcomei</u>		68	0	0%
<u>A. coustani</u>		62	0	0%

C. Times of entry and departure from houses

Between July and October 1958 three huts at the observation village of Kangimi were selected as trapping huts. Entrance door traps were placed in position on six nights and exit traps on ten nights at intervals of at least a week. The traps were fastened at 2 p.m. and removed and replaced by empty traps at 11 p.m., 1 a.m., 3 a.m., 5 a.m., and 6 a.m. The mosquitos caught in the entrance traps (Table 5) were practically all unfed but those in the exit traps were at all stages of nourishment and are figured separately (Table 6).

TABLE 5

NUMBERS OF ANOPHELES CAUGHT IN 18 ENTRANCE TRAPS

Time of fixing	Time of removal	<u>A. gambiae</u>				<u>A. funestus</u>				<u>A. nili</u>			
		UF.	FF.	HG.	G.	UF.	FF.	HG.	G.	UF.	FF.	HG.	G.
9.0 p.m.	11.0 p.m.	32	0	0	0	22	0	0	0	19	1	0	0
11.0 p.m.	1.0 a.m.	7	1	0	0	5	0	1	0	2	0	0	0
1.0 a.m.	3.0 a.m.	2	0	0	0	8	0	0	0	13	0	0	0
3.0 a.m.	5.0 a.m.	0	0	0	0	5	0	1	0	1	0	0	0
5.0 a.m.	6.0 a.m.	7	0	2	0	3	1	3	1	3	1	0	0

(UF = Unfed; FF = Fully fed; HG = Half gravid; G = Gravid)

The numbers caught in the entrance traps show that all three principal endophagic species - A. gambiae, A. funestus and A. nili entered in greatest numbers between 9 and 11 p.m. i.e. before the occupants slept. A. gambiae in this area entered earlier than in French West Africa where the maximum entry was recorded between 11 p.m. and 1 a.m. (Holstein 1952). In this species two-thirds of the total caught at the Kangimi traps entered between 9 and 11 p.m. but in A. funestus and A. nili only one half of the total entered early. At all times between 11 p.m. and dawn A. funestus entered fairly regularly but A. nili showed a well-marked second peak of entrance between 1 and 3 a.m.

TABLE 6

NUMBERS OF ANOPHELES CAUGHT IN 30 EXIT TRAPS

Time of fixing		<u>A. gambiae</u>				<u>A. funestus</u>				<u>A. nili</u>			
		UF.	FF.	HG.	G.	UF.	FF.	HG.	G.	UF.	FF.	HG.	G.
9.0 p.m.	11.0 p.m.	46	3	3	3	67	6	6	1	13	8	2	2
11.0 p.m.	1.0 a.m.	14	13	2	0	7	13	1	0	10	13	3	0
1.0 a.m.	3.0 a.m.	66	33	3	0	36	8	4	0	21	52	2	0
3.0 a.m.	5.0 a.m.	104	51	8	2	68	41	10	0	20	42	2	0
5.0 a.m.	6.0 a.m.	35	28	8	0	25	27	4	1	4	18	1	0

The catches from exit traps show that in all three species the maximum exodus occurred before 5 a.m., well before dawn. In A. gambiae and A. funestus the peak occurred between 3 and 5 a.m.; two-thirds of the individuals leaving at that time were unfed, most of the remainder being gorged. Large numbers of unfed mosquitos were also caught leaving huts between 9 and 11 p.m. There was no well-marked dawn exodus. In the case of A. gambiae only 17 per cent. of the total number caught in the exit traps left between 5 and 6 a.m., in A. funestus 12 per cent. and in A. nili 10 per cent.

The behaviour of A. nili differs from that of the other two species mainly in the fact that two-thirds of those leaving are fed, also its peak biting time is earlier.

D. Biting activity

The biting times for different endophagic species were recorded in the same hut and by the same personnel but on different occasions. The records below (Table 7) are taken from catches made on nights when Anopheles of the species considered were frequent. To obviate the discrepancies due to weather inhibiting biting, catches were only recorded on nights when mosquitos were biting continuously.

TABLE 7.

BITING TIMES OF PRINCIPAL ANTHROPOPHILIC ANOPHELES

Time	<u>A. gambiae</u>		<u>A. funestus</u>		<u>A. nili</u>		<u>A. wellcomei</u>	
	(12 nights, 24 man/hrs)		(14 nights, 28 man/hrs)		(12 nights, 24 man/hrs)		(7 nights, 14 man/hrs)	
	Total caught	No. per 10 man/hrs	Total caught	No. per 10 man/hrs	Total caught	No. per 10 man/hrs	Total caught	No. per 10 man/hrs
8 - 9	4	1.5	4	1.4	19	8.0	25	18
9 - 10	3	1.5	5	1.5	33	13.5	17	12
10 - 11	18	7.5	7	2.5	87	36.0	13	10
11 - 12	19	7.5	49	17.0	78	32.5	13	10
12 - 1	42	17.5	55	20.0	79	32.5	6	4
1 - 2	32	13.5	46	16.0	52	21.5	5	4
2 - 3	47	20.0	43	16.0	42	17.5	3	1.5
3 - 4	45	18.5	50	17.0	30	12.5	2	1.5
4 - 5	43	18.0	45	16.0	17	7.0	0	0
5 - 6	26	11.0	47	16.5	15	6.0	0	0

A. wellcomei - Maximum biting activity was recorded between dusk and 9 p.m., gradually falling off until 4 a.m. when activity ceased.

A. gambiae - Small numbers were caught biting from 8 p.m. but activity was greatest between 2 a.m. and 5 a.m. This behaviour differs to that of exophilic gambiae studied in forest country at Itowolo near Lagos (Mattingly 1950) and at Bwamba (Haddow 1947). In these localities the peak was found to be during the period of nautical twilight (sun 6° - 12° below the horizon).

A. funestus - This species came to bait very regularly throughout the night from 11 p.m. until dawn.

A. nili - Biting commenced at 8 p.m., rising to a definite peak between 10 p.m. and 1 a.m. then falling gradually until dawn.

E. Preferences for indoor and outdoor feeding

The purpose of this study was to determine whether species regarded as endophagic do in fact prefer to feed inside when other food is available outside. During this series of night observations, one catching team of two men worked inside a hut, another about ten yards away, outside. The personnel were changed every hour.

The results (Table 8) show that in the wet season over twice as many gambiae were caught outside as inside, of funestus the majority were caught inside, of nili, the majority outside. A. wellcomei was captured in about equal numbers inside and out. In the dry season funestus was even more endophagic, four times as many being caught inside as out. In the case of wellcomei twice as many were taken outside as in. The species arranged in order of degree of endophagism are - A. funestus, A. nili, A. gambiae and A. wellcomei.

TABLE 8
NUMBERS OF ANOPHELES BITING HUMAN BAIT IN AND OUT OF DOORS

Date	<u>A. wellcomei</u>		<u>A. nili</u>		<u>A. gambiae</u>		<u>A. funestus</u>	
	Out	In	Out	In	Out	In	Out	In
3/2	14	22	0	0	0	0	0	0
12/2	26	13	0	0	0	0	6	34
20/2	14	3	0	0	0	0	1	2
28/2	25	9	0	0	0	0	1	6
23/4	0	2	1	0	0	0	0	3
23/5	1	0	7	2	4	2	1	2
25/6	1	0	1	21	5	15	1	14
2/7	0	0	14	2	35	9	6	5
10/7	0	0	11	4	33	9	10	9
17/7	0	0	10	7	27	21	5	9
24/7	0	0	26	7	10	14	0	2
31/7	0	0	5	3	24	4	13	7
8/8	0	0	62	24	25	13	5	15
15/8	0	0	16	12	24	25	8	28
22/8	0	0	40	51	135	43	26	39
28/8	20	26	87	118	171	86	16	56
11/9	5	5	99	70	67	37	33	33
23/10	2	3	0	0	8	5	27	25

SUMMARY OF TABLE 8

	<u>A. wellcomei</u>		<u>A. nili</u>		<u>A. gambiae</u>		<u>A. funestus</u>	
	Out	In	Out	In	Out	In	Out	In
No. catches (Wet season)	6	6	13	13	13	13	13	13
No. caught (Wet season)	29	36	392	321	568	283	151	221
No. of catches with majority (Wet season)	0	2	9	3	10	2	2	8
No. catches (Dry season)	5	5					3	3
No. caught (Dry season)	79	47					8	42
No. catches with majority (Dry season)	3	1					0	3

IV. Bionomics of other Anopheles

(a) Seasonal fluctuations of prevalent species

All the anthropophilic mosquitos in the province show a marked seasonal fluctuation in numbers, the majority being most abundant during the rains, reaching a peak towards the end. Such species include A. coustani, A. theileri, A. squamosus, A. rufipes and A. pharoensis. The first two species were caught in moderate numbers throughout the year, squamosus and rufipes were absent from catches during the first half of the rains whilst pharoensis was only taken at the end of the wet season.

The most important dry season Anopheles recorded at human bait were A. wellcomei and A. flavicosta, the former having its peak at the end of the dry season, the latter during the middle.

(b) A summary of all Anopheles recorded from Zaria Province with notes on their distribution and bionomics

A. coustani Laveran and A. coustani var. ziemanni Grunberg - Both the type form and var. ziemanni are common in the area. They are easily distinguishable from each other as no intermediates have been found. In the type the white markings at the base and apex of the first hind tarsal segment and at the apex of the second segment are always twice the size of the corresponding bands in var. ziemanni. There appears to be a seasonal alternation in numbers in at least some localities. During short night catches made in the Kaduna area during the wet season 66 coustani sensu lato were caught of which 11 were var. ziemanni; during the dry season 65 were caught of which 58 were var. ziemanni.

In many A. coustani typicus the black ring at the base of the third hind tarsal segment was absent. Fed specimens of both types were commonly captured in goat stables and in traps baited with sheep, donkey and goat. A. coustani was taken outdoors as human bait at all hours of the night, the peak being before 9 p.m. A few specimens have been caught biting indoors. Larvae of both types were common in overgrown streams.

A. implexus Theobald - This species is confined to isolated belts of gallery forest bordering streams. It was quite abundant during both the wet and dry seasons and was a most persistent biter. During surveys it was observed to bite at all times between 12 noon and 9 p.m. Larvae were frequent in small temporary pools in the forests. Since the areas where it occurs are rarely visited by humans A. implexus must be largely zoophilic. It has not previously been recorded from Nigeria, but its occurrence in the Northern Region was predicted by Mattingly (1944).

A. nili Theobald - A common wet season species. Fed specimens sometimes found resting in horse, goat and pig sheds.

A. brunnipes Theobald - A single specimen was caught biting outdoors at midnight in December 1957.

A. domicolus Edwards - Only three females were captured during the eighteen month period; from a goat stable (Aug. 1957), from an undeneu bank (Aug. 1957) and one caught biting outdoors at midnight during December 1957.

A. funestus Giles - Only larvae of the type form have been found by the writer. This species appears to be almost totally anthropophilic. In one observation village huts were found which sheltered both man and goat; of 56 bloods from funestus taken in such huts all were positive only for man.

A. funestus var. fuscivenosus Leeson - Two specimens.

A. flavicosta Edwards - A common outdoor biter during the dry season. Several fed specimens have been taken from traps containing sheep and goat also from horse stables. Bloods taken from specimens found resting in poultry houses were found to be positive for avian blood. Larvae have only been obtained from one swamp by trampling the tall grass and collecting from the puddles formed. Examination of larvae and associated adults has led the writer to conclude that all previous records of A. moucheti made in this area refer to A. flavicosta (Hanney in press).

A. hancocki Edwards - Two females were taken resting in goat stables in August 1957. Three were caught biting human bait between 5 and 6 a.m. in September 1958, one being taken indoors. Recorded by Brown (1942) as breeding in small streams near Kaduna.

A. leesoni Evans - Recorded from Kaduna by Brown (1942).

A. theileri Edwards and A. theileri var. septentrionalis Evans - Both the typical form and var. septentrionalis have been frequently caught outdoors at human bait from 8 p.m. until 2 a.m., the peak of biting being before 9 p.m. The two forms keep fairly separate from one another. In the northern observation area the numbers caught during the period were 115 A. theileri and 20 var. septentrionalis. In the Kaduna southern area the numbers were 2 A. theileri and 20 var. septentrionalis. Both forms were most abundant during the rains, the majority of specimens being captured at human bait between 8 p.m. and midnight. Several specimens have been obtained in traps baited with goat and sheep and occasionally biting in houses. The larvae have been found in stagnant ditches with profuse emergent vegetation.

A. wellcomei Theobald - Larvae have only been found amongst floating vegetation in small open pools in a water course.

A. gambiae Giles - During the wet season many A. gambiae and A. funestus were found infected with nematodes (Agamomermis). In many cases the nematodes so filled the haemocoel that the ovaries could not develop. Of 48 A. gambiae examined 2 (4 per cent.) were infected, in 107 A. funestus examined 10 (9 per cent.) were infected. The writer is of the opinion that transmission may be through hydrachnid mites with which a number of adult mosquitos were found to be infested; of 178 A. gambiae examined 32 (18 per cent.) carried mites.

A. maculipalpis Giles - A few specimens have been caught biting during the wet season. Fed females have also been captured resting in goat stables. Larvae were occasionally found in shallow swamps and Cocoa Yam plantations.

A. pretoriensis Theobald - This species has never been taken at bait and only very few recorded as resting in houses. Very few breeding sites were found during the survey but in those it was abundant. It appears to prefer clear water without vegetation and a slight flow as in irrigation furrows.

A. rufipes Gough - Both the type form and var. ingrami were taken at human bait at the end of the rains. The larvae however were amongst the most common species at all times of the year, chiefly in exposed streams and small marshy pools. A. rufipes was only occasionally found resting in huts but was quite frequent in goat and horse stables and appears to be mainly zoophilic.

A. pharoensis Theobald - Very small numbers were captured at human bait towards the end of the rains. Of 672 huts examined during the survey only one A. pharoensis was found resting indoors.

A. squamosus Theobald - Small numbers have been taken at human bait throughout the dry season, the peak being at the end of the rains. It appears to be primarily exophilic but has been found rarely in goat stables. Breeding places included streams, hoof prints and shallow swamps.

Discussion

The studies have shown that in Zaria Province, Northern Nigeria there are four species of Anopheles which are largely endophilic and thus potential vectors of malaria. Of these however, only A. gambiae and A. funestus have been found with sporozoites. A. funestus was found to be predominantly endophilic; A. gambiae on the other hand has been shown to prefer to feed outside. One would expect therefore, to find large numbers of the latter in outdoor resting places but this in fact is not the case; very few specimens have been found resting in granaries, holes in banks and in zana mats. A large number have however been found resting under the eaves of huts. During September 1957 the eaves of six huts were sprayed with pyrethrum followed by a floor-sheet collection inside the huts. In the case of A. gambiae 10 per cent. and A. funestus 12 per cent. of the total were found in the outside eaves of the thatched huts.

Summary

The results of a general Anopheles survey carried out in Zaria Province, Northern Nigeria between June 1957 and December 1958 are presented.

An account is given of the entrance, exit and biting times of the principal endophagic species - A. funestus, A. gambiae, A. nili and A. wellcomei. The seasonal fluctuations and feeding habits are also described.

Notes are given on the distribution and bionomics of 17 species of Anopheles which have been recorded from the province.

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