GOVERNMENT OF CYPRUS

HEALTH DEPARTMENT PAPERS No. IV.

THE ANOPHELINE MOSQUITOES OF CYPRUS

BY

MEHMED AZIZ, M.B.E., A.R.San.I.

Chief Sanitary Inspector

Cyprus

NICOSIA :

PRINTED AND PUBLISHED BY THE GOVERNMENT PRINTING OFFICE

1934

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FOREWORD.

This paper is the outcome of my desire that the detailed knowledge, which the Chief Sanitary Inspector of the Colony has acquired about the mosquitoes of Cyprus in his twenty years' service in the Health Department, should be recorded. He started as a moustiquier, under the late Sir Ronald Ross, in 1913, and much of his work ever since has been in dealing with these pests.

A list of the other mosquitoes that have been found in Cyprus is attached with the usual references.

I hope that this paper will be developed some time in the future.

I congratulate Miss Melahat Houloussi on the drawings she has prepared for this work.

August, 1933. G. C. STRATHAIRN.

AUTHOR'S PREFACE.

I desire to express my thanks to the Director of Health, Dr. G. C. Strathairn, for his encouragement and assistance in preparing this paper ; to Dr. A. E. Horn, C.M.G., who since his visit in 1927 to this island has given me most valuable advice and assisted in the identification of my specimens of mosquitoes, etc. ; to Sir G. A. K. Marshall and Mr. F. W. Edwards for identifying my specimens and for allowing me to make reference to the latter's work on mosquitoes ; to Dr. M. Gosden, the Government Bacteriologist, as well as to Mr. Morris, the Government Entomologist, and to Dr. Willimott, the Government Analyst, for many useful hints on the subject, and to Miss Melahat Houloussi, Sanitary Inspector, for her drawings reproduced herewith and for other help in preparing this paper. All other acknowledgments are made in the course of the text as occasion occurs.

NICOSIA, M. AZIZ.
CYPRUS.

LIST OF ILLUSTRATIONS.

ANOPHELINE MOSQUITOES OF CYPRUS.

Part 1.—GENERAL.

There are records of the occurrence of the following 7 species of *Anopheles* mosquitoes in Cyprus, 5 of these belonging to the subgenus *Anopheles* and 2 to the subgenus *Myzomyia*:

Subgenus **Anopheles.**

1. *A. maculipennis.*
2. *A. elutus.* [Fig. 3.]
3. *A. bifurcatus.* [Figs. 1 & 4.]
4. *A. hyrcanus.* [Fig. 5.]
5. *A. algeriensis.*

Subgenus **Myzomyia.**

6. *A. superpictus.* [Figs. 2 & 6.]
7. *A. multicolor.* [Fig. 7.]

Key adopted for identification of the larvae of subgenera *Anopheles* and *Myzomyia* of Cyprus:

1. "Shaft of antenna with a branched hair (except in *A. plumbeus*—not recorded in Cyprus). Palmate hairs lanceolate, without long terminal filament. Internal clypeal hairs generally close together." (Edwards, 3) — Subgenus **Anopheles**

2. "Shaft of antenna without a branched hair. Leaflets of palmate hairs generally with long terminal filament. Internal clypeal hairs rather wide apart." (Edwards, 3) — Subgenus **Myzomyia**

Part 2.—DESCRIPTION OF THE ANOPHELINE MOSQUITOES OF CYPRUS.

Adult.

1. Anopheles (Anopheles) maculipennis:

"A rather large brownish mosquito, with small spots in the wing field, formed by tufts of scales" (Barraud, 1). It is easily confused with *A. elutus*. "The pale area in the fringe of the tip of the wing is diagnostic of *A. maculipennis*, when it is present, but can only be seen in perfect specimens" (Edwards, 3). A carrier of malaria.

2. A. (A.) elutus:

"Differs from *A. maculipennis* as follows: No trace of a pale spot in the fringe at the tip of the wing, the fringe being uniformly dark. Dark spots at the bases of fork-cells and at cross-veins very poorly developed, often hardly perceptible, especially in the male . . . . General coloration of the body rather lighter than in *A. maculipennis* . . . ." (Edwards, 3). ". . . . In other places it occurs alone, and then its association with outbreaks of malaria is very clear . . . ." (Buxton, 2).

3. A. (A.) bifurcatus :

" A clear winged mosquito ; palpi unbanded ; thorax with light grey central area in front, bordered on each side by dark brown " (Barraud, 1). " Is a good carrier of malaria." (Buxton, 2).

4. A. (A.) hyrcanus :

" Easily distinguished from all other species in the Palæarctic fauna, except *A. punctibasis* and *A. mauritianus* (which are not recorded in Cyprus) by the distinctly swollen front femora. This character was pointed out by Lœw in his description of *A. pictus*, and together with the shaggily-scaled female palpi forms the best distinguishing mark of the *Myzorhynchus* group, the character of the ventral scale-tuft, on which the group was originally founded, being quite unreliable . . . . *A. hyrcanus* is a variable species in many respects, and shows a strong tendency to the production of local races." (Edwards, 3).

The palpi have three white bands with a small white tip. The first band of the palpi (from the head upwards) is very small. Wing markings quite distinct with 2 white spots on the costa. The fringe on Radius and at Cubitus 2 pale.

Out of 120 wild-caught females of *A. hyrcanus* (at Beisan and Nahr-ez-Zerqa marshes, Palestine) dissected (Buxton, 2) failed in finding oocysts or sporozoits.

5. A. (A.) algeriensis :

ADULT.

" Easily distinguished by the unspotted wings and the absence of a distinct tuft of long white scales on the front of the head . . . . . The mesonotum is uniformly dull light brown, and clothed with dark hair only, the small yellowish hairs or hair-like scales which are found in *A. bifurcatus* being absent in this species. In the female the second segment of the palpi is considerably longer than the first or the third and fourth together." (Edwards, 3).

LARVA.

" Leaflets of float hairs broad and deeply dentated ; comb of eighth segment with about sixteen teeth." (Kirkpatrick, 4).

NOTE : That of *bifurcatus* leaflets of float hairs long and slender, comb with about twenty-five teeth (Kirkpatrick, 4). I am not aware if it is a carrier of malaria. (Buxton, 2) is of the opinion that as this mosquito (like *A. hyrcanus*) remains strictly in the marshes in which it breeds it is of little importance.

6. A. (Myzomyia) superpictus :

Palpi with two white rings and the tip broadly white. " Legs all dark, except for the narrow knee spots. Wings with the costa dark, with three large pale spots, and traces of a small pale spot above the humeral cross-vein." (Kirkpatrick, 4).

" Distinguished from the nearly allied *A. multicolor* by the broad white tips to the female palpi." (Edwards, 3).

" A proved carrier of malaria." (Kirkpatrick, 4).

7. A. (Myzomyia) multicolor :

This closely resembles *A. superpictus*, " palpi dark brown with three narrow whitish bands, the basal third or even half of the apical joint may be pale, but the tip is always dark." (Kirkpatrick, 4). Otherwise the markings are the same.

" A proved carrier of malaria." (Kirkpatrick, 4).

Part 3.—DISTRIBUTION, SEASONAL PREVALENCE, BREEDING PLACES, AND HABITS OF THE ANOPHELINE MOSQUITOES OF CYPRUS.

Anopheles (Anopheles) maculipennis, Mg.

Synonyms : (Edwards, 3).

Anopheles maculipennis, Meigen, Syst. Beschr. i, p. 11, 1818.

Culex claviger, Fabricius (*nec* Meigen), Syst. Antl., p. 35, 1805.

Anopheles occidentalis, Dyar and Knab, Proc. Biol. Soc. Wash. xix, p. 159 (1906) ; Howard, Dyar and Knab, Mosq. N. and C. Amer. vi, p. 1026, 1917.

Anopheles lewisi, Ludlow, Psyche, xxvii, p. 74, 1920.

Anopheles selengensis, Ludlow, Psyche, xxvii, p. 77, 1920.

Previous Record.

Theobald (7), *Anopheles maculipennis*, Meigen. Crete and Cyprus. Dr. G. A. Williamson (5) states " mosquitoes of the species capable of carrying malaria (*Anopheles maculipennis*) were breeding in the neighbourhood of the reservoirs of Laxi, Akhyritou and Kouklia."

The writer sent specimens to Sir Ronald Ross from Paphos (21.6.13) and from Larnaca (24.7.13) which were identified by Carter and Newstead (Dec. 11, 1913) as *A. maculipennis*.

A. maculipennis, Prev. Mal. Cyprus, Ross, p. 11, 1914 (6).

Anopheles (Anopheles) elutus, Edwards=Sacharovi, Favr.

Synonyms : (Edwards, 3).

Anopheles sp., Christophers, Ind. J. Med. Res. vii, p. 711, 1920.

Anopheles maculipennis var., Barraud, Bull. Ent. Res. xi, p. 389, 1921.

Previous Record.

F. W. Edwards (3) states that *Anopheles elutus* were recorded from Cyprus by Dr. G. A. Williamson but does not mention anything about *A. maculipennis* having been recorded from Cyprus.

I have a grave suspicion that the specimens from Cyprus previously identified as *maculipennis* were *elutus*.

My opinion, based on experience in Cyprus and Palestine after having examined many specimens, is that there is a very close resemblance between *A. maculipennis* and *A. elutus* both in the larval and in adult

stages as well as in the general habits. These two species cannot be separated without prolonged and careful study. Specimens of *Anopheles* from Athienou marsh, collected while this paper was being prepared in May, 1933, and sent to the Imperial Bureau of Entomology, have been identified by Edwards as *A. sacharovi* Favr.=*elutus* (Edw.) and other specimens collected elsewhere appear to be identical. Edwards (3) states that *elutus* has entirely replaced *A. maculipennis* in Palestine, Lower Mesopotamia and Transcaspia, but in Macedonia the two occur together. For this reason in this paper both *elutus* and *maculipennis* have been considered as one and any remarks made for one are intended to apply to the other so far as Cyprus is concerned.

Distribution in Cyprus.

Found in all coastal marshes, *i.e.*, Tekke, Livadhia, Anaphotia, marsh near Limassol and Akrotiri, marshy area in the flat parts of Diorizos and Xeros rivers, Paphos, Old Paphos marsh, parts of Polis river and marsh, Karavostasi, Pendayia, Ghaziveran, Syrianokhori, Dhenia to Kyra in Ovgos river, Athienou marsh, sluggish parts of Pedias and Yalias rivers from Margo and Miamilea to Messaoria, reservoirs of Kouklia, Akhyritou and sluggish irrigation drains of the reservoirs of Kalopsidha, Fresh Water Lake (Ayios Loukas or Laxi), Koma tou Yialou, Vokolidha, Gastria, Paleomylos, Ayios Theodhoros, Laxia, Athalassa, Yeri, Kolokoshi and Yerolakkos.

The highest point where this mosquito has been recorded by me was at Skouriotissa, which is about 1,000 feet above sea-level.

Seasonal Prevalence.

I have found larva and adult forms of this mosquito in every month of the year. One can find the larvæ in any permanent marsh throughout the year and the adults can be found in houses close to such marshes. Greatest seasonal prevalence, however, is between March and July.

Breeding Places.

Permanent or semi-permanent marshes where there are weeds, etc.: overgrown, sluggish irrigation drains; sluggish parts of a river where there are reeds, etc.; overgrown, neglected or badly managed irrigation tanks. In fresh or brackish water.

Flight Distance.

In 1920 I observed that *A.* (*maculipennis ?*) *elutus* breeding in the Fresh Water Lake, Famagusta, infested Famagusta and Varosha, and reached as far as the Glossa summer residential houses, a direct distance of nearly 3 miles. On several occasions when extensive breeding places were found near Tekke and Pasha Chiftlik, Larnaca town about 2½ miles away was badly infested at the same time. Again any breeding taking place in the Kouklia reservoirs, Famagusta District, affected Lysi, Kondea and other villages up to three miles from the reservoir. This was proved by a house to house search for adults while there was no other breeding place near. Athienou village was also similarly affected when the nearest breeding place was over a mile from the village.

All the above information is based on careful search for adults in the houses, including garden sheds, stables, caves, etc., lying between the marsh and the village, and continued towards the centre and outer parts of the village on the side farthest from the marsh till the houses were found to be free from adults.

From observations carried out at Syrianokhori, Famagusta and Larnaca, I am of opinion that the female of *A. elutus* (*maculipennis?*) rests actually in places where blood is obtainable, or close to habitations in natural or artificial cool places such as caves, dungeons, stables, bedrooms, etc., where there is no smoke. It does not start to bite before sunset in the open, but will bite during the day in cool, dark rooms such as stables, bedrooms, etc. It is found resting as a rule on old clothing, under bedsteads, etc.

Anopheles (Anopheles) bifurcatus, L.

Synonyms : (Edwards, 3).

Culex bifurcatus, Linnæus, Syst. Nat. Ed. x, p. 603, 1758.

Culex claviger, Meigen, Klass. u. Beschr. i, p. 4, 1804.

Culex trifurcatus, Fabricius, Ent. Syst. iv, p. 401, 1794.

Anopheles villosus, Robineau-Desvoidy, Mém. Soc. d'Hist. Nat. Paris, iii, p. 411, 1827.

Anopheles grisescens, Stephens, Zool. Journ. xii, 1828.

Anopheles antennatus, Becker, Mitt. Zool. Mus. Berlin, ii, p. 68, 1903.

Previous Record.

Theobald (7) states that *A. bifurcatus*. Linn was recorded from Cyprus and Crete.

Distribution in Cyprus.

This is an urban as well as a rural mosquito. It is not restricted to any particular part of the island. It has been found in wells in Nicosia on 12.4.27, 60 feet deep, and it has been found to be breeding in the cool-shaded or partly-shaded streams on Troödos near Government Cottage, Troodhitissa, Platres river, Pedhoulas, Neokhorio (Paphos), Asgata (Limassol) on 16.4.27 and in practically all other streams early in spring. Specimens of these were kindly identified for me by the Imperial Institute of Entomology, by Sir Ronald Ross and Dr. A. E. Horn.

Seasonal Prevalence.

I have found larvæ, pupæ and adults of this species throughout the year in the plains in wells, and on the hills in the open streams as soon as the winter torrents are over. The adults are found under culverts, or any other natural and artificial protected places close to the breeding ground.

Troodhitissa river on 20.6.33, Platres on 21.6.33 and by Mr. Morris at Trikoukkia on 7.6.33.

Breeding Places.

Deep (up to 60 feet in depth) and shallow wells with clean water; in cisterns and irrigation tanks; at the edges of swift or slow flowing streams on the hills. It is also to be found in artificial collections of water in cool-shaded places, provided that the water is clean. It can be found in the open in sheltered places as early as February and March. It has been recorded in isolated parts of Latourou marsh (Alamino), Athienou and Syrianokhori where the breeding place was heavily shaded in summer.

Flight Distance and Habits.

No record is available as to its flight distance but I do not think it goes far from its breeding places. It will bite at once during daytime as soon as one is a little in the shade and even when there is sun, provided that it is not too strong.

While visiting the Mosque of Omar in Palestine in 1927 an accident led to the discovery of several important breeding places on the premises of that mosque. About 5.30 p.m. on 9.6.27, I was deeply interested looking at the outer walls of the Mosque of Omar and while resting on a cistern-head, which I took no notice of at the time, I felt bites on my arm resting on the edge of the cistern opening, and I was surprised to notice that three *A. bifurcatus* were helping themselves to a meal of blood and that a few others were ready to do the same. On lowering my arm just a little inwards they had no hesitation in attacking my arm.

Again on 24.5.33 at Louroujina at about 6 p.m. while the sun was still up, I was inspecting a well in which *A. bifurcatus* larvæ were found and *A. bifurcatus* soon came to my arm and started to bite while I was collecting the larvæ from the bucket.

Anopheles (Anopheles) hyrcanus, Pallas.

Synonyms: (Edwards, 3).

Culex hyrcanus, Pallas, Reise durch versch. Prov. d. Russ. Reichs. i, p. 475, 1771.

Anopheles sinensis, Wiedemann, Aussereurop. Zweifl. Ins. i, p. 547, 1828.

Anopheles pictus, Lœw, Dipt. Beitr. i, p. 4, 1845.

Anopheles pseudopictus, Grassi, Atti R. Acc. Lincei, Rendic. viii, 1, p. 102, 1899.

Anopheles sinensis var. *mesopotamiae*, Christophers, Ind. J. Med. Res. iii, p. 196, 1916.

Previous Record.

No previous record in Cyprus. First found by the writer on 14.6.33 in an extensive marsh formed by impounding the river bed at Syrianokhori for irrigation works.

Distribution.

No record elsewhere in Cyprus.

Seasonal Prevalence.

Not known for certain.

Breeding Places.

Sluggish marshes with tall reeds.

Flight Distance and Habits.

Flight distance not certain. It bit my arm near its breeding place in the sun at 4 p.m. on 19.6.33. I made some careful observations about the habits of the adult *A. hyrcanus*. It bit in the open in strong sunlight at 4 p.m. on 19.6.33, and continued to do so until sunset, selecting khaki and black coloured clothing but never white. It is very tame during the daytime and continues to suck blood although under a test tube ; after sunset, however, it is very active and cannot be captured easily. Its associate is *A. elutus*. The breeding places of *A. hyrcanus* and *elutus* were just at the same distance from habitations yet while hundreds of *A. elutus* were found in houses only two *A. hyrcanus* were collected there. On the other hand *A. hyrcanus* bites freely in the open near its breeding place while *A. elutus* would wait till sunset and bite close to habitations.

Anopheles (Anopheles) algeriensis, Theo.

Synonyms : (Edwards, 3).

Anopheles algeriensis, Theobald, Mon. Cul. iii, p. 21, 1903.

Anopheles lukisi, Christophers, Ind. J. Med. Res. iv, p. 120, 1916.

Previous Record.

No previous record in Cyprus. First found by the writer on 25.5.33 at Athienou marsh.

Distribution.

Though I have no definite proof on hand I believe that this species may be found in marshes and marshy collections of water in rivers such as Alamino (Latourou), Syrianokhori and Athienou marsh.

Breeding Places.

Sluggish marshes with tall reeds, etc.

Flight Distance and Habits.

Flight distance not certain. I have been bitten by this species near the marsh. It is associated with *A. elutus* and *Culex martinii*.

Anopheles (Myzomyia) superpictus, Grassi.

Synonyms : (Edwards, 3).

Anopheles superpictus, Grassi, Reale Accad. Lincei, p. 78, 1900.

Pyretophorus palestinensis, Theobald, Mon. Cul. iii, p. 71, 1903.

Pyretophorus nursei, Theobald, Mon. Cul. iv, p. 66, 1907.

Pyretophorus cardamitisi. Newstead and Carter, Ann. Trop. Med. iv, p. 379, 1910.

Anopheles superpictus var. *macedoniensis*, Cot. and Hovasse, Bull. Soc. Path. Exot. x, p. 890, 1917.

Previous Record.

Theobald (7), collected by Miss Bate.

Ross (6), *Pyretophorus palestinensis*.

Ross (6), *Pyretophorus cardamitisi*.

Distribution in Cyprus.

Throughout the island. Specimens of these collected by the writer on 29.8.13 at Livadhia (Larnaca) were identified by Carter and Newstead as *Pyretophorus palestinensis*, Theo. The highest point where this mosquito has been found was near Government Offices on Troödos, also found at Platres, Mandria, Kelokedhara and in all the villages near rivers throughout the island.

Seasonal Prevalence.

March to October. Most prevalent from April to August.

Breeding Places.

River beds with or without frogweeds, preferably where there are no tall reeds ; in seepage outcrops ; in irrigation drains and tanks, provided that the breeding place is exposed to sun wholly or partly. It is never found in cisterns or wells unless the well is shallow (2–3 feet in depth) and exposed to sun. Never found in cesspits or other filthy water. Seldom found in big marshes and then at the edges only. It is found to resist sweeping of drains in river beds and has the power of clinging to stones in rapidly flowing drains, etc., so that one may have to remove the stone to see the larvæ.

Flight and other Habits.

It enters houses and stables and shelters on spider webs, dark clothing and in corners. It is found sometimes over half a mile from its breeding place, in caves, stables and houses. The range of flight, however, must be greater. It passes the winter in its adult stage, its breeding place having been washed away by the winter rains. Its principal associate is *Culex mimeticus* which has wing markings somewhat similar to *A. superpictus*.

Anopheles (Myzomyia) multicolor, Camb.

Synonyms : (Edwards, 3).

Anopheles multicolor, Camboulin, C. R. Acad. Sci. cxxxv, p. 704, 1902.

Pyretophorus chaudoyei, Theobald, Mon. Cul. iii, p. 68, 1903.

Pyretophorus cleopatrae, Willcocks (*nom. nud*).

Anopheles impunctus, Dönitz, Zeitschr. f. Hygiene, xli, p. 67, 1902.

Previous Record.

Ross (6), *Pyretophorus nigrifasciatus.*

Distribution in Cyprus.

A rare species. Specimens of these collected by the writer on 17.10.26 at Nicosia were identified by T. W. Kirkpatrick as *A. multicolor* Camb.

Nicosia, Kolokoshi, Almiros river, 7th mile from Nicosia on way to Nisou, Koma tou Yialou, Salt Lake (Larnaca), Mammari and Syrianokhori. Restricted to areas where the water is brackish.

Seasonal Prevalence.

April to September.

Breeding Places.

In marshes near the seashore ; Koma tou Yialou lake ; edges of salt lake and marshes near Larnaca, and also in other partly brackish water, breeding with *A. superpictus* and *A. elutus.* In partly brackish drains with weeds at the road side.

Flight Distance.

I have caught adults in my house when the nearest breeding place I could trace was about 2½ miles away. Kirkpatrick (4) states that it is attracted to light and my own experience confirms this. I was bitten in my house in a room with bright light on the part most exposed to the light.

Part 4.—RELATIVE IMPORTANCE OF EACH SPECIES OF ANOPHELES IN CONNECTION WITH MALARIA PROBLEM IN CYPRUS.

A. bifurcatus :

As has already been stated, *A. bifurcatus* is capable in breeding in wells, cisterns and other clean water close to habitations as well as in the cool-shaded streams and marshes, and, therefore, it is not affected by seasonal changes as are the other Anophelines and may be classed by itself as breeding throughout the year. There are numerous breeding opportunities for this mosquito both in towns and villages. During a sanitary survey recently carried out in Nicosia town 7,009 such possible breeding places were recorded and in many villages, particularly in Famagusta District, practically every house has a well in addition to the alakati wells in the gardens and the shepherds' wells in the fields which remain sometimes for half of the year disused. Sir Ronald Ross (Prev. Mal. Cyprus) section 10, page 22, stated " wells occur all over the island and may or may not be associated with high spleen rates. I think that the explanation is that they supply only a few Anophelines as a rule, perhaps enough to cause a low spleen rate of something up to 10%. Where the spleen rate rises above this I have always found some

additional breeding surface in the close neighbourhood. This is important, because the wells are often very troublesome to deal with."

In 1913 after the visit of Sir Ronald Ross a campaign against malaria in Cyprus was started. The spleens of 1,115 children in Nicosia town were examined during the last three months of that year and it was found that 20.1% of the children examined had enlarged spleen ; in 1914 it dropped to 5.1% and in 1932 it was only 1.2%. Nicosia town in 1914 had more water than it required and for months surplus water was flowing from the aqueducts at the Paphos and Kyrenia Gates and forming marshy breeding places for *A. superpictus* and *elutus* in the moat between the Paphos and Famagusta Gates and also near Kaimakli. In addition to this, there were many leakages from the aqueduct, particularly at Koshlu Chiftlik, and the Pedias river had extensive breeding surface for *A. superpictus* from March to June and sometimes to July. Domestic breeding places were attended to as far as possible, goldfish were issued free of charge for the tanks and covers were insisted upon for other receptacles of water. As soon as these major and minor breeding places were dealt with, Nicosia was almost but not quite freed from malaria and even to-day after 20 years of struggle against mosquitoes, Nicosia town has not yet been completely cleared of malaria and this is mainly due to *A. bifurcatus*, and it is doubtful if any further reduction can be effected because as soon as the vigilance of the sanitary staff slackens the majority of the registered breeding places are neglected by the owners and opportunity is given for this mosquito to breed and keep up malaria in an endemic form.

It can, therefore, safely be stated that most of the malaria cases in our towns and in many villages in the plains which are not situated near any marsh or river, and in villages in the hills situated near streams are due to *A. bifurcatus*.

What are the reasons, since there are so many breeding opportunities for *A. bifurcatus*, which are so often close to habitations, that we do not get a higher spleen rate or more malaria cases ? Is it due, as Sir Ronald Ross stated, to the supposition that wells may supply only a few Anophelines, or to some other cause ? My observations regarding the number of mosquitoes breeding in wells do not agree in some respects with Sir Ronald Ross's opinion. I have noticed on many occasions that from an "alakati" well or even a round well when not constantly in use (and there are many of them) I have collected in a single bucket of water over 50 larvæ and pupæ. Wells which are in use, unless properly protected, will supply a number of larvæ at each bucket if only one is careful in searching for them. I think the probable reasons may be the following :—

(*a*) *A. bifurcatus* may not go far from its breeding place in order to bite and it is only where the breeding place is actually close to where people sleep that they get bitten.

(*b*) There are seasons when most of the wells are in constant use and the breeding opportunities are less.

(*c*) There is more regular control of such breeding places by the sanitary staff.

(*d*) When the population is high and the number of the existing wells comparatively few, and where the wells are deeper than sixty feet, there is only a small infection.

There is no doubt that *A. bifurcatus* is a carrier of malaria, although this has not been proved by dissection in Cyprus, but there are places where there is only *A. bifurcatus* and there is malaria. There is also certain proof that where there are wells and particularly "alakati" wells which are not in constant use the spleen rate may be higher than 10%; this will be seen from the following examples :—

Centres	Year	No. of children examined	S.R. %	Explanation
Akacha or Akaki ..	1931	135	5.1	Population : 1,046 ; River dry, seldom opportunity for *A. superpictus*, few wells, irrigation water, nearest malarious village, Avlona, 2½ miles.
	1932	123	4.0	
Peristerona	1931	113	0.8	Population : 1,181 ; same as Akacha, but less irrigation water.
	1932	113	2.6	
Astromeritis ..	1931	109	0.0	Population : 789 ; no river, no marsh, depends on wells for its water supply and the depth of the wells in this village is 100 feet and over.
	1932	104	0.0	
Avlona ..	1931	33	78.7	Population : 249 ; very few wells, irrigation water, Avlona river suitable for *A. superpictus*.
	1932	23	86.9	
Lefkoniko	1931	319	0.0	Population : 2,435 ; few wells, very few "alakati" wells, water not potable, no rivers or marshes.
	1932	375	0.0	
Gypsos ..	1931	118	1.6	Population : 1,005 ; number of wells, water potable, no rivers or marshes.
	1932	142	1.4	
Trikomo ..	1931	232	2.1	Population : 1,804 ; many wells, no rivers or marshes.
	1932	238	2.1	
Perivolia tou Trikomou	1931	14	7.1	Population : 105 ; great many wells, no rivers or marshes.
	1932	16	6.2	
Kokkini Trimithia ..	1931	62	22.5	Population : 539 ; no marsh or river within several miles of the village, it depends on wells.
	1932	67	22.3	
Mammari ..	1931	57	82.4	Population : 523 ; this village has only one or two wells, has irrigation water, seepage water in the centre of the village suitable for *A. superpictus* and *multicolor*, and is affected by Ovgos river where *A. elutus* breeds.
	1932	67	46.2	

Buxton (2) states that "the *A. bifurcatus* which breeds in the cisterns is a good carrier of malaria; of that there is no doubt at all, because epidemics of malaria occur in places from which other *Anopheles* are completely absent. Of this the classical example is Jerusalem itself, a city lying on the very water-shed of the country, miles from any running water or swamps, rainless or nearly so for half of the year. In this city (Sept.–Dec., 1912) Mühlens found actual parasites in 26.1% of 7,921 people examined."

As already stated it is difficult to get rid of all the domestic breeding places of *A. bifurcatus* but with good will on the part of the inhabitants, as well as greater care by the oilers, it is possible to achieve good results; but the problem is not yet solved, for in certain seasons and places *A. bifurcatus* breeds in the open in the rural parts of the island. Several years ago when the Swedish archæologists were excavating at Vouni they complained of mosquitoes and malaria; on my investigation I could find no other *Anopheles* but *A. bifurcatus* on the hill.

Practically all our summer resorts are similarly affected. At Kakopetria, Pedhoulas, Prodhromos, Platres and Troödos *A. bifurcatus* is on the wing in summer breeding in the cool waters of Troödos. On 20th June, 1933, I caught adult *bifurcatus* biting me while I was collecting their larvæ at Troodhitissa stream and again on 21.6.33 at Platres in the stream near Mr. Hay's house. The importance of this both from public health as well as from the economic point of view is obvious, because a few cases of malaria amongst our summer visitors would have a very bad effect on our summer resorts.

It is, therefore, quite clear in my mind that *A. bifurcatus* is the important *Anopheles* in connection with the malaria problem in Cyprus and its extermination though possible is difficult, requiring the whole-hearted co-operation of each person and constant vigilance on the part of the health services. Its destruction, therefore, is the greatest problem with which we are faced.

A. superpictus :

The next most important *Anopheles* in connection with the malaria problem in Cyprus I consider to be *A. superpictus*. As soon as the rains stop and floods do not wash away their breeding places, about the middle or towards the end of March, one will find *A. superpictus* in every stream, in rivulets, etc., where it is exposed to the sun, and they continue to breed as long as there is water in river beds, etc., till it dries up or is washed away again by the autumn and winter rains. It passes the short cold season in the adult stage in houses, particularly in stables and other rooms where there is no smoke, and the larvæ will be found even in winter in natural breeding places as long as there is no heavy rain to wash them away. On 22.12.32 I visited Margo river and parts of Athienou marshy area and found *A. superpictus* and *A. elutus*. That morning the water in the open at Nicosia had frozen and there is no difference in height between Nicosia and Athienou.

A. superpictus does not require much or deep water to breed in. It will breed in very small collections and even where the depth of water is, to quote the words of Buxton (2): "Seldom more than a span wide and a centimetre deep," provided it is not in a completely shaded place.

Most of our villages are situated actually near river beds or short distances away from them and they suffer very badly from malaria. In such places one seldom finds any other species but *A. superpictus* with perhaps a few *A. bifurcatus* (if it is on the hills) and to a less extent *A. elutus* (if in the plains).

At Dheftera, 9 miles from Nicosia on the Pedias river, I always found *A. superpictus*, but *A. bifurcatus* may also be found in wells. From Dheftera towards Pera the river bed is dry. I give the distances of the other nearby villages and the spleen rates :—

Centre	Year	No. of children examined	S.R. %	Population	
Dheftera	1931	147	23.1	904	
	1932	172	9.8		
Psomolophou ..	1931	76	6.5	476	1½ miles from Dheftera.
	1932	69	0.0		
Pera	1931	103	5.8	606	4 miles from Dheftera.
	1932	101	2.7		

In 1913–14 when the work against mosquitoes was beginning *A. superpictus* used to infest the Nicosia General Hospital as well as the offices of the Health administration so badly that we had to engage gangs of 3–4 labourers and kill them as best as we could. The Central Prison was also badly infested with these mosquitoes and caused a high malaria incidence among the prisoners. Trakhoni and Orta Keuy were also badly affected. The breeding place was found to be in the Pedias river between the bridge on the Morphou–Troödos road and that near Miamilea. Each year and particularly in wet years unless prompt action is taken the same will happen. The Sanatorium is similarly affected by the Laxia river and the late Mr. Campbell's house at Boghaz is similarly affected mainly from *A. superpictus* and *A. bifurcatus* breeding in the stream below. In Paphos and Limassol districts practically every village is similarly affected by *A. superpictus* and to a less extent by *A. bifurcatus*.

As regards its flight distance I am inclined to believe that this is farther than any one would expect. For example : around Nicosia there is hardly any other place for *A. superpictus* to breed but the Pedias river and that is very carefully attended to and dries up all around for a distance of at least 4 miles. It is flooded several times in normal years but at the first opportunity the next March or April the whole river bed will be teeming with *A. superpictus* larvæ. I cannot believe that the eggs if laid would remain during the whole of the strong winter floods. It is either that the adult travels great distances or remains inactive for such a long time, which seems impracticable.

A. superpictus enters houses and hides in bedrooms, stables and other dark corners.

To control the breeding places of *A. superpictus* is very difficult. River beds will always be a problem. Early attention to their breeding places is essential.

A. elutus (? formerly **A. maculipennis**) :

It has already been stated in Part 3 that *A. elutus* is particularly attracted to permanent or semi-permanent marshes and other collections of sluggish water, particularly in the plains.

The idea that marshes had some connection with malaria is an old one and we have records of drainage work having been carried out before the anti-malarial campaign started in 1913. The idea of course was quite correct, provided there were no breeding places for other species of *Anopheles* which do not require a marsh to breed in.

The selection of Mathiati as a camp for the army of occupation in the early days of the British occupation, I believe, was mainly to get the men away as far as possible from the marshes which at that time existed extensively close to all our towns ; but it did not take long to find out that it is not always the marshes that cause the trouble, because Mathiati although miles away from marshes had extensive breeding opportunities for *A. superpictus* in the rivulets, etc., which made this camp just as unhealthy as the towns.

There is no doubt that the drainage work so far carried out has been the chief factor in reducing malaria in most of our towns and villages in the plains, thus reducing the number of *A. elutus*, which was the principal mosquito to breed in such places. I can say that had this paper been written a dozen or so years ago, *A. elutus* with its well-known connection with epidemics of malaria wherever it is found, its long range of flight, habits of searching and entering houses and attacking man, would certainly have earned the first place in importance.

Unless one knew the conditions prevailing formerly, one would have some doubt in believing that there existed so many marshy places in the island. For example, few people would believe that the portion of the moat between the Famagusta and the Ayios Antonios gates at Nicosia was a dangerous marsh. There I got my first lesson about mosquitoes from Sir Ronald Ross in 1913. Now it is a fine dry forest. St. Lazaros plantation in Larnaca town was also a very bad marsh ; Pendayia Hospital and the works of Cyprus Mines Corporation at Xeros, etc., exist to-day after anti-malarial drainage works had been carried out at Karavostasi, Pendayia, etc., marshes. Famagusta, Varosha and Ayios Loukas people remember very well how badly they were affected by malaria and mosquitoes before any anti-malarial work had been done in the moat, at Ayios Ioannis and the Fresh Water Lakes.

LIST OF BREEDING PLACES OF A. ELUTUS WHICH HAVE BEEN DRAINED OR DEALT WITH.

	Drained	Reclaimed	Afforested	Filled
1. Karavostasi	+	+	—	—
2. Xeros	+	+	—	—
3. Linarovroshi	+	+	—	—
4. Ghaziveran	+	+	—	—
5. Ovgos between Dhenia and Kyra	+	+	—	—
6. Fresh Water Lake, Famagusta	+	—	+	—
7. Area in the moat, Nicosia	+	—	+	—
8. Engomi, Famagusta	+	—	—	—
9. Gastria	+	+	—	—
10. Spathariko and Arnadhi	+	+	—	—
11. Makrasyka	+	+	—	—
12. Paralimni	+	—	—	—
13. Ayios Ioannis Lake, Famagusta	—	—	—	+
14. Pyla	+	+	—	—
15. Voroklini	+	—	—	—
16. Ormidhia	+	+	—	—
17. Livadhia	+	+	—	—
18. St. Lazaros	+	—	+	—
19. Pamboula	+	+	+	—
20. Anaphotia	+	+	—	—
21. Mazotos	+	—	+	—
22. Marsh, west of Limassol	+	—	—	—
23. Marsh, Kato Paphos	+	+	—	—
24. Ayios Nikolaos, Paphos	+	—	+	—
25. Laxi, near Polis	+	+	—	—
26. Athienou	+	+	—	—

I regret that I have no official record of the number of donums of land reclaimed as a result of this drainage work, but I estimate the area to be well over 3,000 donums. In most places the value of the land before being drained seldom exceeded 10 shillings per donum. Now it is difficult to get the same at £20 per donum.

Apart from a number of isolated centres which are situated close to big marshes, there are few places now left where *A. elutus* can be found in years with normal rainfall, unless of course breeding places are created for them through carelessness or unavoidable reasons. I will give a few examples which may be of some help to future workers.

BREEDING PLACES THAT MAY BE FORMED FOR A. ELUTUS.

1. Unavoidable reasons :—

A heavy rainfall will—

(*a*) fill a number of low-laying places which would retain water in them up to June or July. Such places may be difficult to drain, fill up or pump dry. In such places artificial control

with Paris Green, etc., has to be carried out and the success of this sort of control depends on the care that is given to the work and on the vigilance of the sanitary staff ;

(*b*) break the flood dams around the salt lake at Larnaca ;

(*c*) fill up with fresh water (rain water) the salt water marshes ;

(*d*) raise the sub-soil water and cause seepage outcrops ;

(*e*) form sluggish marshy places in the river beds in the flat parts of the Pedias and Yalias rivers, in the irrigation drains to the reservoirs, etc.

2. Ignorance and carelessness :

(*a*) making of deep borrow pits near villages ;

(*b*) badly managed irrigation or anti-malarial drains, tanks, etc. ;

(*c*) uncontrolled irrigation works, *i.e.*, impounding rivers, etc., in order to obtain irrigation water and thus creating extensive breeding places such as at Syrianokhori.

Water of course is badly needed in Cyprus for irrigation, and for this purpose reservoirs have been constructed in some parts of Famagusta District where winter flood water is retained and used in proper season. But unless the reservoirs are properly constructed and maintained, and emptied in good time, they become such an important source for mosquitoes and malaria that no matter how great, their benefit, their harm to the health of the people may be greater.

On the 12th August, 1931, I submitted a report on the Akhyritou and Kouklia reservoirs. Extracts from this are given below :—

" Director of Health,

I have the honour to state that I have good reasons to consider that Kouklia reservoir, the seepage water from the reservoir and the main drain passing close to Kalopsida and Akhyritou are detrimental to the health of the surrounding neighbourhood, *i.e.*, Kouklia, Kalopsida, Akhyritou, Gaidhouras, Prastio, Kondea and Lysi villages, and this is the causation of malaria fever apart from mosquito annoyance."

Previous Study.

In January, 1909, a report was made by the commission which was appointed to enquire into the " Working of the Irrigation Reservoirs in the Messaoria " M.P. 1055/08 and M.P. 3/09, 19th January, 1909, and section 3 of this report was restricted to consideration of the extent to which the health of the people in that area was affected.

Considering the period when the Report of the Hygienic Sub-committee (pages 8 to 10) was made and the limited amount of information available at that time as regards the flight distance of the Anopheline mosquitoes, etc., it can be accepted as a good piece of work but from the researches made in various parts of the world since that time and from my own personal experience gained during the 18 years of service, I am convinced and there is sufficient proof to-day that the area affected by the Kouklia reservoir, its seepage water and main drain extends to a distance well over a mile which was taken as a limit in 3 of page 8 of the Commission's report. In fact even a distance of two miles cannot be considered a safe distance when the area in which mosquitoes are breeding is extensive. Example, Fresh Water Lake affecting Famagusta and Varosha, marshes near Tekke affecting Larnaca town.

Recent Studies.

On 15th June I had occasion to inspect a part of the Kouklia reservoir and from the great number of *A. elutus* larvæ found breeding at the edges I anticipated a big outbreak of malaria for Kouklia village, on 28th July the large number of adult *A. elutus* in houses at Kondea and Lysi and the tour of inspection made on 7th and 8th August to Akhyritou, Kalopsida, Kouklia, Prastio, Pyrga and the large number of *A. elutus* found in houses confirm the idea that the reservoir of Kouklia and its drains, etc., form the principal source for Anopheline mosquitoes, hence the great number of malaria cases now found in these villages . . . .

Conclusion.

I am not aware of the revenue derived by the Government from the reservoir of Kouklia or the value of the water from the reservoir to the farmers but be it great or small I think that if a careful investigation were to be made and if a comparison of the loss sustained by the people of the villages in that neighbourhood in the way of loss of working days on account of malaria, generally lowering of vitality due to malaria and the deaths directly or indirectly caused by malaria, excluding the annoyance from the mosquitoes, I am inclined to think that the loss would exceed the gain . . . . ."

Chief Sanitary Inspector.

This was submitted to Director of Agriculture and the following is an extract from the reply of Irrigation Superintendent.

" Director of Health,

. . . . . .

I suggest that in future no water be retained in the reservoir after April, should cereal waterings take place or not.

From summer waterings this year I anticipate a revenue of about £200 while we could have received the sum more or less from the lease of lands in the bed of reservoir. In addition the expenses of supervision, etc., would be done away with."

Irrigation Superintendent.

I give the spleen rate of six villages affected by the reservoirs :—

Village.	1914	1928	1929	1930	1931	1932
Akhyritou	73.1	5.6	1.6	9.3	75.0	56.3
Kalopsida	83.8	11.5	7.6	1.3	94.5	69.4
Kouklia	62.5	13.3	7.6	17.1	66.6	54.5
Lysi	29.3	1.9	10.0	3.7	9.6	10.3
Kondea	69.5	1.9	11.8	0.9	42.7	15.3
Gaidhouras	60,6	3.5	10.7	3,0	44.4	44.1

Here of course rarely other species of *Anopheles* except *A. elutus* were to be found.

In summing up I desire to point out that—

(*a*) *A. elutus* is gradually becoming less important in connection with the malaria problem in Cyprus ;

(*b*) *A. elutus* is restricted to the plains where there are still permanent or semi-permanent marshes ;

(*c*) that drainage work has abolished many of its former breeding places ;

(*d*) that in years with big rainfall many places near the coast and in the plains may become suitable for *A. elutus*, and that early and careful action on the part of the sanitary staff is needed to prevent an epidemic of malaria.

(*e*) irrigation reservoir drains, etc., must always be carefully controlled.

A. multicolor :

A. multicolor of course is of less importance, but considering that it has a long range of flight and it enters houses and bites human beings, that we have many places where the water is partly brackish and that it is a proved carrier of malaria elsewhere, it deserves consideration. It is of some importance that all places which are considered as salt marshes, etc., should receive careful inspection, especially after a heavy rainfall when the salt water may be sufficiently diluted with fresh water to be suitable for both *A. multicolor* and *A. elutus* to breed in.

A. hyrcanus :

My knowledge of the habits of this mosquito is as yet too small to enable me to express an opinion. It appears that this mosquito does not go far away from its breeding places, but any person who happens to go close to the marsh will get bitten, even during the day in the sun. Syrianokhori is the only place where this mosquito has been found in Cyprus and considering that *A. elutus* is the predominent mosquito there and that there are also suitable conditions for all the other *Anopheles* known to exist in Cyprus, one is not able to say what part this mosquito takes in the spread of malaria in that village. I think that the people who are most likely to be affected by this *Anopheles* are those that go to Syrianokhori during day from Morphou and elsewhere for shooting, fishing and other purposes.

A. algeriensis :

A. algeriensis like *hyrcanus* has not yet been carefully studied in Cyprus. Records from other countries show that it does not enter habitations but will bite near its breeding places. The people who are most likely to be affected by this mosquito are shepherds, hunters, reedcutters and people who have summer crops near marshes. Since it is, however, often found breeding with *A. elutus* and *A. superpictus* it is difficult to say what part this mosquito takes in the spread of malaria in this island.

A List of Mosquitoes recorded from Cyprus, Names under which they were mentioned, and the Collector's Name.

Present Name of Species.	Name under which it was previously recorded, Collector's Name and Date.		
Anopheles :			
1. A. (Anopheles) maculipennis ..	A. maculipennis	G. A. Williamson	1909
,, ,, ..	,, ...	? (Ross, 6)	
,, ,, ..	,, ...	Aziz..	21. 6.13
2. A. (Anopheles) elutus, Edw. ..	A. elutus	G. A. Williamson (Edwards, 3)	
,, Sacharovi, Favr.	,, (Athienou marsh)	Aziz..	25. 5.33
3. A. (Anopheles) bifurcatus	A. bifurcatus	(Theobald, 7)	1903
,, ,, ...	,, ...	Aziz..	10. 6.13
,, ,, ...	,, ...	Aziz	28. 4.27
,, ,, ...	,, ...	Aziz..	16.12.27
4. A. (Anopheles) hyrcanus	Not recorded before (Syrianokhori marsh)..	Aziz	14. 6.33
5. A. (Anopheles) algeriensis	Not recorded before (Athienou marsh)	Aziz	25. 5.33
6. A. (Myzomyia) superpictus ..	A. superpictus	Miss Bate	1903
,, ,, ...	Pyretophorus palestinensis	? (Ross, 6)	
,, ,, ...	,, cardamatisi, Theo. ..	Aziz..	29. 8.13
,, ,, ...	? A. superpictus, Grassi	Aziz	20.12.26
7. A. (Myzomyia) multicolor	Pyretophorus nigrifasciatus	? (Ross, 6)	
,, ,, ...	? A. multicolor	Aziz..	1926
Allotheobaldia :			
1. Theo. (Allo.) longiareolata, Mcq.	Theobaldia spathipalpis	? (Ross, 6)	
,, ,,	,, longiareolata (well) ..	Aziz..	24. 5.33
Theobaldia :			
1. Theo. (Theo.) annulata, Sch. ..	Theobaldia annulata	? (Ross, 6)	
Culicella :			
1. Theo. (Culicella) morsitans ..	Theobaldia morsitans, Theo.	? (Ross, 6)	

Present Name of Species.	Name under which it was previously recorded, Collector's Name and Date.		
Aedes :			
1. Aedes (O.) caspius	Aedes (Ochlerotatus) caspius (Salt Lake, Larnaca)	Aziz..	10. 4.26
2. A. (O.) mariæ, Serg.	Not recorded before (seashore, Kyrenia)	Aziz..	30. 8.33
3. Aedes (S.) argenteus	Stegomyia fasciata	? (Ross, 6)	
,, ,, ,, ...	,, ,, ...	Aziz..	8. 5.13
Culex :			
1. Culex pipiens	Culex pipiens, L.	? (Ross, 6)	
,, ,, ...	,, ,, ...	Aziz..	7. 6.13
,, ,, ...	,, ,, L. (Wells)	Aziz..	24. 5.33
2. Culex tipuliformis	,, ,, tipuliformis	? (Ross, 6)	
,, ,, ...	,, ,, ...	Aziz..	26.12.26
3. Culex hortansis	,, hortansis..	? (Ross 6)	
4. Culex perexiguus	,, perexiguus	Aziz..	26.12.26
5. Culex mimeticus, Noé	,, mimeticus, Noé	Miss Bate	1903
,, ,, ...	,, ,, ...	Aziz..	12. 7.13
6. Culex martinii, Medjid	Not recorded before (Athienou marsh)	Aziz	25. 5.33
7. Culex (Uranotænia) unguiculata, Edw.	Not recorded before (Syrianokhori marsh) ..	Aziz	10. 8.33
8. Culex univittatus, Theo.	Not recorded before (Syrianokhori marsh) ..	Aziz	4. 8.33

As far as I am aware the first official record of mosquitoes sent from Cyprus for identification dates from 7th Dec., 1899, when specimens were sent by Mr. Gennadius.

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ILLUSTRATIONS.

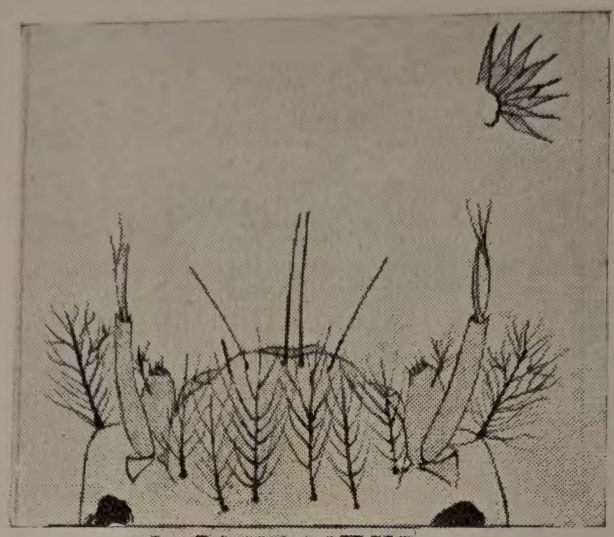


FIG. 1.—Subgenus *Anopheles*

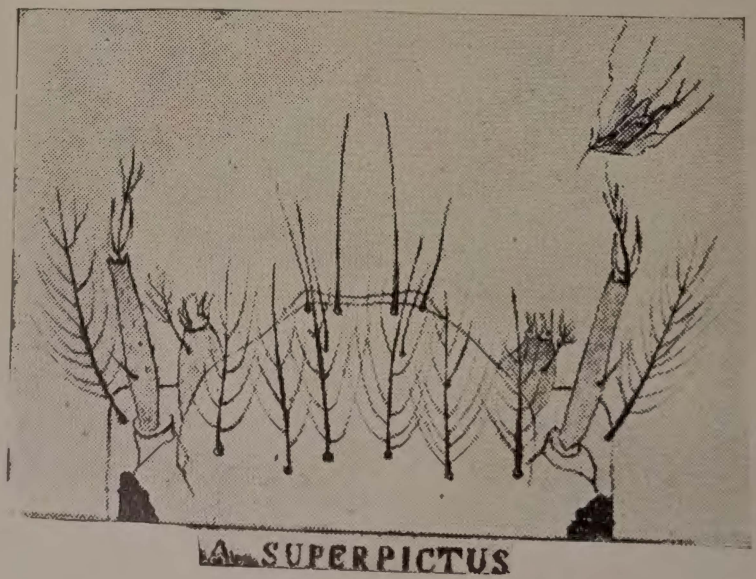


FIG. 2.—Subgenus *Myzomyia*.

ILLUSTRATIONS.

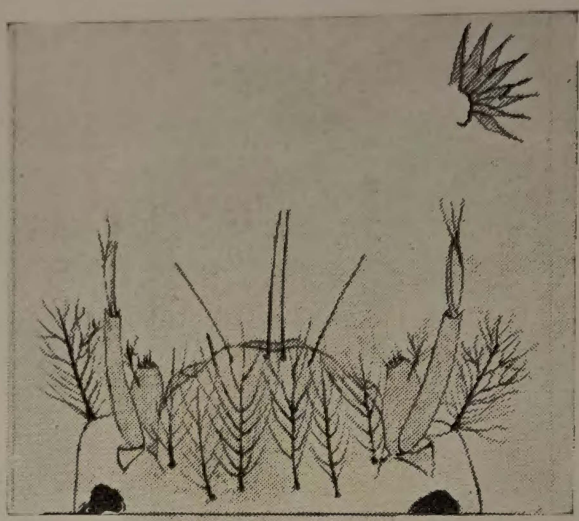


FIG. 1.—Subgenus *Anopheles*

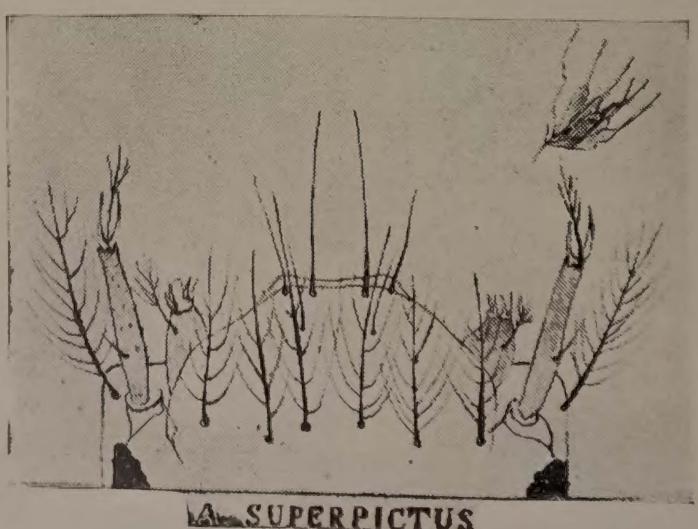


FIG. 2.—Subgenus *Myzomyia*.

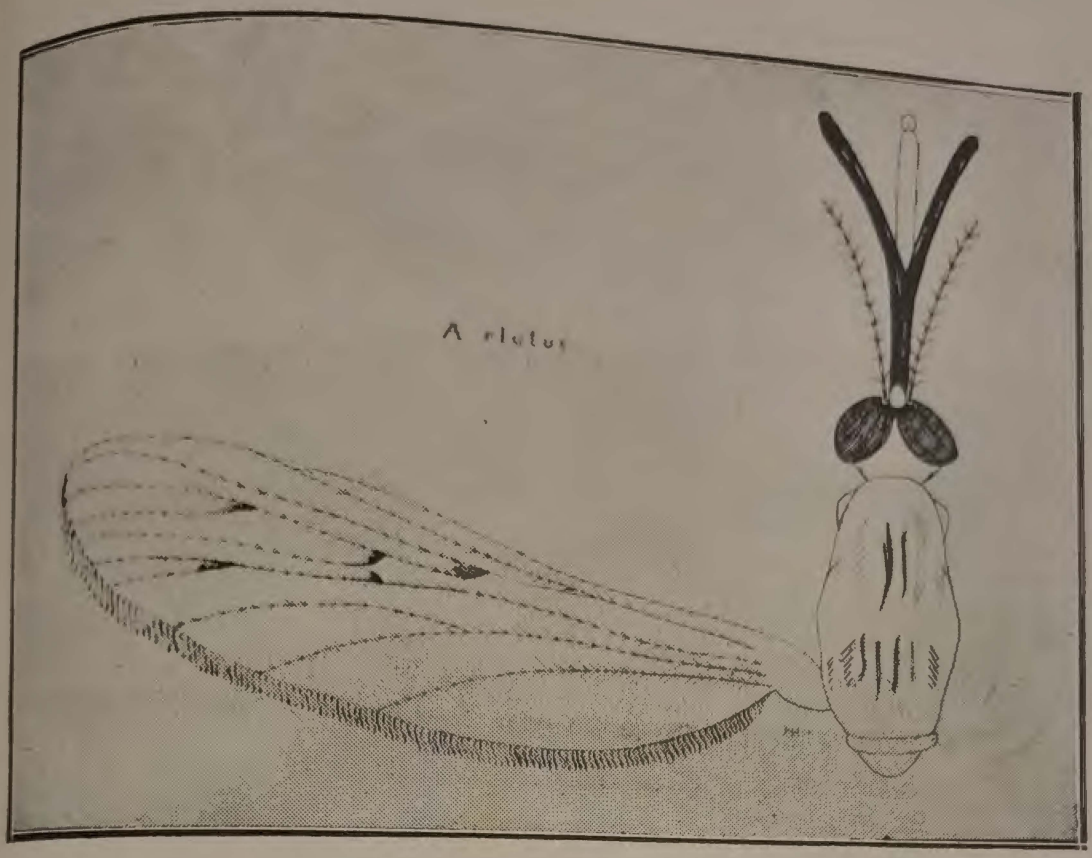


FIG. 3.—*A. elutus*

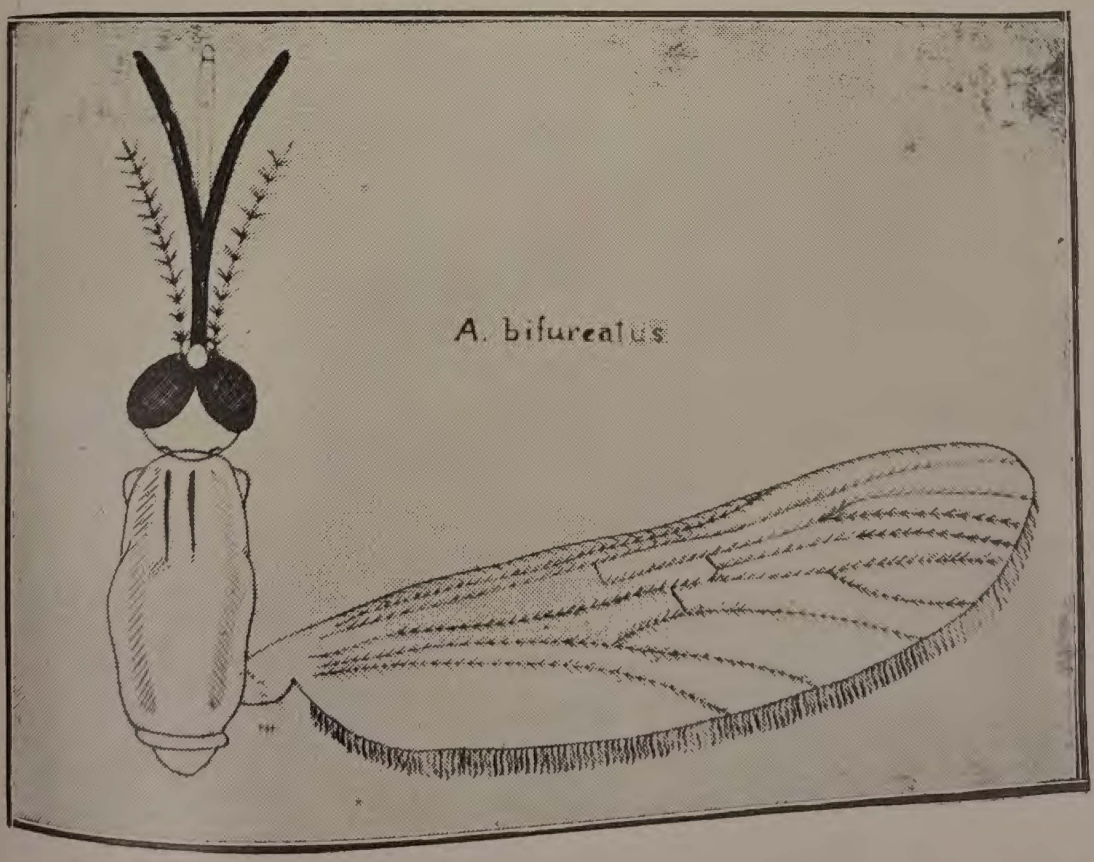


FIG. 4.—*A. bifurcatus*.

FIG. 5.—*A. hyrcanus.*

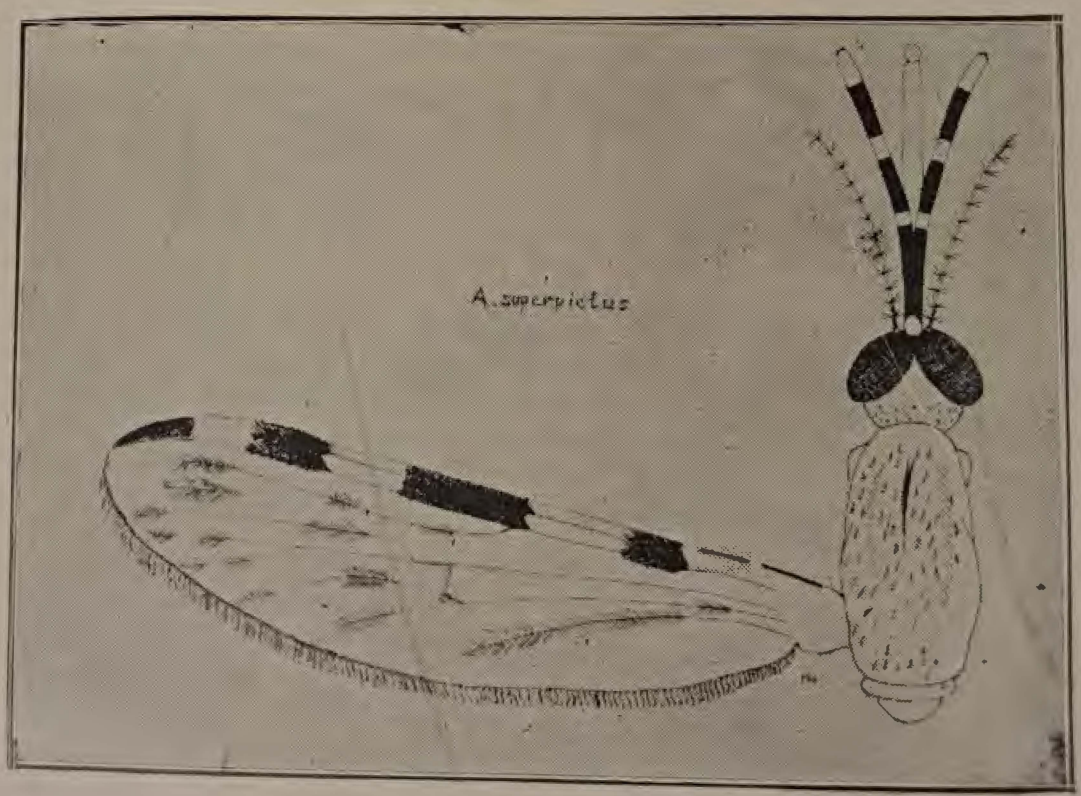


FIG. 6.—*A. superpictus.*

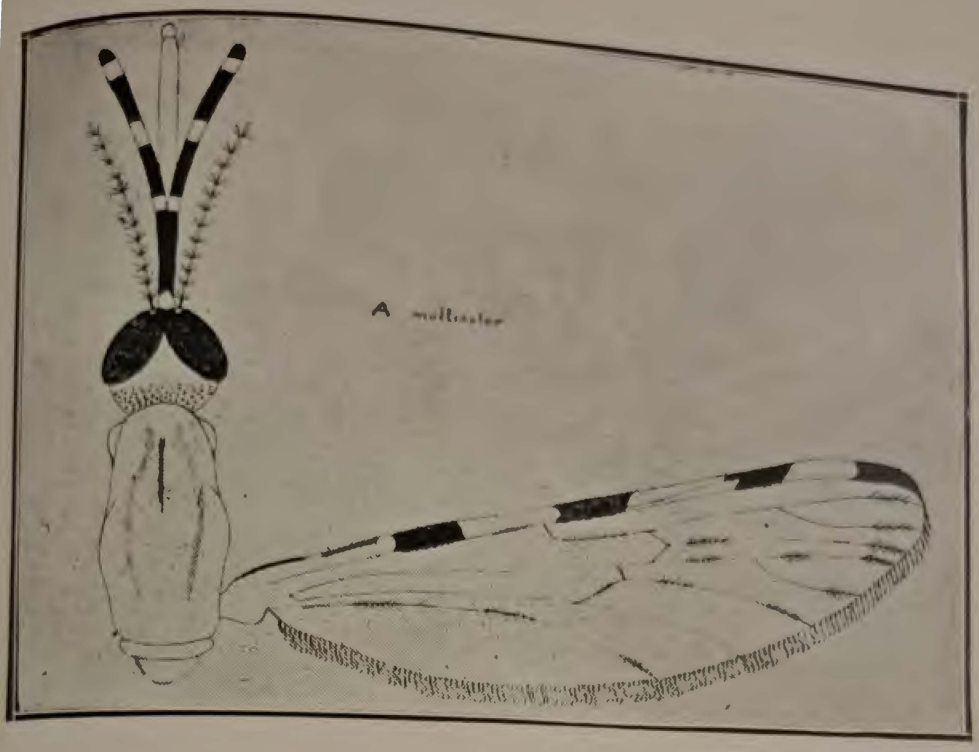
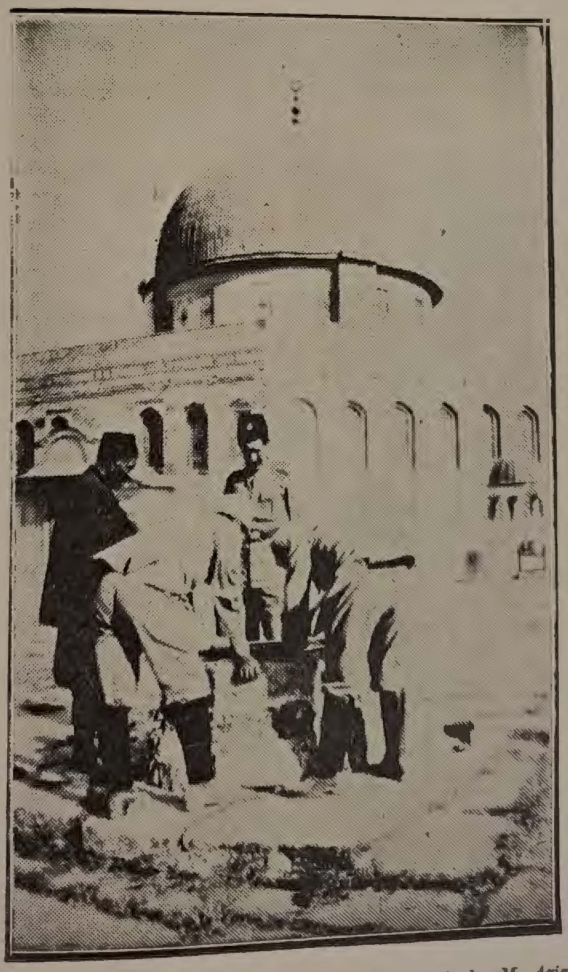


FIG. 7.—*A. multicolor.*



[*Photo by M. Aziz.*]

FIG. 8.—Breeding place of *A. bifurcatus*, a cistern in the yard of Mosque of Omar, Palestine.

[*Photo by M. Aziz.*]

FIG. 9.—Breeding place of *A. elutus* and *A. hyrcanus*, Syrianokhori.

[*Photo by M. Aziz.*]

FIG. 10.—Breeding place of *A. hyrcanus*, Syrianokhori.