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FIELD STUDIES OF THE ANOPHELINE MOSQUITOES OF ALBANIA.[1]

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I. INTRODUCTION.

The present paper summarizes various field observations which were made in connection with the program of the laboratory for mosquito research in Tirana, between 1936 and 1939. The main emphasis of the laboratory work was on the study of the differential characters of the mosquitoes of the *Anopheles maculipennis* group, and the field work was almost entirely confined to these mosquitoes. A few observations on other anophelines are, however, included in this paper. A history and description of the laboratory will be found in a paper by Hackett and Bates (1939), and field work during the years 1934 and 1935 is covered in a paper by Lewis (1939).

The malaria situation in Albania seems to be essentially similar to that found in Greek Macedonia, which has been described in a series of papers by Barber, Rice, Balfour, and others. In Albania, as in Macedonia, the areas of most intense malaria are associated with *Anopheles sacharovi* (*elutus*). In Albania, however, malaria is often found in regions where *sacharovi* does not occur, and in most of these cases *Anopheles superpictus* seems to be the vector (the towns of Elbasan and Berat may be taken as examples). A third type of mosquito-malaria association is found in a very few places, notably in villages on the shores of Lake Malik, a large, shallow, marshy lake in the mountains near the Yugoslav frontier at an elevation of 800 meters (Lewis, 1939, pl. 1, fig. 1). In this area neither *sacharovi* nor *superpictus* is found, and the only common mosquitoes are three species of the *maculipennis* group (*maculipennis*, *messeae* and *subalpinus*), which are generally supposed not to be malaria vectors because of their non-anthropophilous food habits. The mosquitoes breed in immense numbers in the lake, and the villages are in close proximity to the breeding

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places. The resulting situation seems to be rather similar to that found in parts of Hungary (Lörincz, 1937), where malaria is also found associated with *Anopheles maculipennis* and *messeae*.

II. List of Species.

Ten species of *Anopheles* were found in Albania. The nomenclature of the following list is that of Edwards (1932), except in the case of the *maculipennis* group.

Subgenus ANOPHELES Meigen.

Anopheles algeriensis Theobald.

Adults of this species were found occasionally in stables (Bates, 1937), but never more than two or three at a time. Larvae were sometimes very numerous in Lake Terbuf; but although large numbers of mosquitoes were collected in stables near the lake shore, no *algeriensis* were ever found. Hence stable collections can not be taken as an index of the abundance or distribution of this species.

Anopheles claviger Meigen.

The seasonal distribution of this species in 1937 and 1938 was similar to that found in the four previous years (Bates, 1937): a large peak in November, and a smaller peak in April or May. Except at these times, adults were rarely found in stables. The species probably occurs in all parts of Albania.

Anopheles hyrcanus Pallas.

Albanian specimens would presumably be identical with Italian ones, and thus belong to the subspecies *pseudopictus* Grassi. The chief distinguishing character of this form, however, is said to be the white color of the fourth tarsal segment of the hind leg, and the coloration of this segment is variable in Albanian specimens. The species was quite common in the marshy border of Lake Terbuf, and larvae were occasionally found in other parts of the coastal plain. During the four years in Albania, we never found a single specimen resting during the day in either a stable or house. Barber and Rice (1935) found occasional specimens in stables and houses in Macedonia.

Anopheles maculipennis Meigen.

We use this name in the restricted sense, for the species called "*typicus*" in previous papers (Bates and Hackett, 1939). It is the commonest and most generally distributed of the Albanian anophelines: it was represented in every collection of adults made from stables.

Anopheles marteri Senevet and Prunelle.

Hadjinicolaou (1938) recently found this species in Greece, breeding in pools in heavily shaded mountain streams. We found it in the same situations in Albania, in streams in the Shkumbini Valley, at elevations between 500 and 600 meters; the larvae were common in July and August, and even more abundant in September.

Anopheles melanoon subalpinus Hackett and Lewis.

This species seems to be found in all parts of Albania, but it is common only in the vicinity of large marshes and lakes, which form the principal habitat of the larvae.

Anopheles messeae Falleroni.

In Albania this species was found only in the vicinity of the highland lakes of Malik, Ochrida and Presba (700–800 m. elevation). This seems to be the southernmost point of its range in the Balkans, the species called by this name in Greece (Rice and Barber, 1937) being *subalpinus*.

Anopheles plumbeus Stephens.

During 1936 we found this species quite commonly in one of the stables near Tirana (Bates, 1937); but although we continued to collect in this stable during the following years, no more *plumbeus* were found, so that its appearance in 1936 must have been due to some exceptional circumstance. Larvae were found in tree holes in various parts of Albania, and the species is probably generally distributed in the country.

Anopheles sacharovi Favr.

This species seems to be limited to the coastal plain in Albania, and we found it nowhere more than 40 kilometers from the coast, or at an elevation of more than 200 meters. We previously thought that the inland extension of the species was a purely summer phenomenon (Bates, 1937), but in 1938 we found hibernating adults in Tirana (24 km. from the coast in a straight line).

Subgenus **MYZOMYIA** Blanchard.

Anopheles superpictus Grassi.

This species is characteristic of the great river valleys, and it seems to be especially abundant in the region where these valleys enter the coastal plain. We attempted to establish its inward extension up the valley of the Shkumbini River in July, and failed to find any larvae at elevations above 500 meters. In

September, however, we found a few adults at Lubonik, in the Korça region, at an elevation of 800 meters.

III. Identification of Eggs.

The egg characters of the *maculipennis* group were discussed at some length in a paper by Bates and Hackett (1939), and the chief distinguishing characters of the Albanian populations are outlined in the key below. The eggs of all of the other Albanian anophelines have been included in this key, not so much with the idea that it would serve for the identification of the eggs—since in most cases this is more easily achieved by an examination of the adult mosquito—as in order to show the type of characters that seem to distinguish these various species. We did not examine the eggs of *Anopheles marteri*, and the species is included in the key on the basis of the description and figure published by Hadjinicolaou (1938).

We have found the field study of eggs to be the most useful way of defining the breeding places of the various species of the *maculipennis* group. We followed the method described by Barber (1935), except that we found it more convenient to use as a sieve, instead of the mitten, a piece of muslin stretched taut over an embroidery hoop (Fig. 2). By marking the cloth off into squares, the eggs can be counted without difficulty. *Sacharovi* eggs are easily recognized by the absence of floats and the uniform grey color; *maculipennis* by the two prominent black bars; and *subalpinus* and *messeae* by the general mottling of the egg surface. We have not been able to distinguish between *subalpinus* and *messeae* in the field, but this does not seriously interfere with the utility of the method, since *messeae* has a very limited distribution in Albania. Of the other species, *superpictus* and *claviger* can quite readily be recognized in the field, and it would probably also be comparatively easy to distinguish *hyrcanus* and *algeriensis* with a little patience.

Key to Eggs.

1. Eggs without floats or floats rudimentary 2
– Eggs with well developed floats 4
2. Egg diamond-shaped .... *plumbeus*
– Egg elongate 3
3. Ground color of upper side dark (black) .... *superpictus*
– Upper side light, silver grey (early spring eggs with rudimentary floats) .... *sacharovi*
4. Upper side of egg with a pattern of light and dark spots 5
– Upper side of egg uniformly dark 7
5. Intercostal membranes of floats smooth .... *subalpinus*
– Intercostal membranes rough (finely corrugated) 6

6. Pattern of two transverse black bars at ends of floats, sharply contrasted with the light ground color .... *maculipennis*
– Transverse bars part of a diffuse dark pattern .... *messeae*
7. Floats very large; viewed from above the two floats are wider than the dorsal surface of the egg exposed between them 8
– Floats smaller, the combined width less than the width of the dorsal surface of the egg between them 9
8. Intercostal membrane of float smooth .... *claviger*
– Intercostal membrane moderately rough .... *marteri*
9. Float membrane extending on to the dorsal surface of the egg at the ends of the floats, making four membranous patches on this surface .... *algeriensis*
– Membrane not extending on to surface in four distinct patches, but visible on the dorsal surface along the entire float length .... *hyrcanus*

IV. Identification of Fourth Stage Larvae.

In a previous paper (Bates, 1939–b) we published statistics on the variation in the antepalmate hairs of larvae in the *maculipennis* group, showing that the larvae could in many cases be distinguished by the branching of these hairs. The results have been incorporated in the following key. We have found no means of distinguishing between the larvae of *maculipennis* and *messeae*, and the distinction between *sacharovi* and *subalpinus* is not absolute, although by making hair counts it should be possible to determine the relative abundance of these two species in any particular breeding place. The key is in all cases based on Albanian larvae; it is possible that widely distributed and little known species like *marteri* and *algeriensis* will be found to show geographical variation in larval characters.

Key to Larvae.

1. A row of six large plumose hairs across middle of head 2
– These hairs vestigial, simple .... *plumbeus*
2. Antepalmate hair of segments IV and V simple, or long stalked, with a terminal bifurcation 3
– These hairs with three or more branches, the branches arising near the base of the hair, not from a long stalk 5
3. Antepalmate hairs of segments IV, V and VI always simple; hair of antennal shaft simple .... *superpictus*
– Some of the antepalmate hairs on IV, V and VI bifurcate at tip, or double: hair of VI especially apt to be double; hair of antennal shaft bifurcate 4
4. Branches of palmate hair of segment II well developed, sharply divided into a broad basal portion and a narrow terminal portion .... *marteri*
– Branches of palmate hair of segment II lanceolate, narrowing gradually toward tip .... *algeriensis*
5. Outer clypeal hair simple .... *claviger*
– Outer clypeal hair branched, dendriform 6

6. Hair of antennal shaft prominent, long, many branched (longer than width of shaft)........................*hyrcanus*
– Hair of antennal shaft small, inconspicuous, with two or three branches (shorter than width of shaft)........................7
7. Antepalmate hairs of segments IV and V normally with three branches, the total count of the branches of the four hairs varying between 11 and 17........................*maculipennis*, *messeae*
– These hairs always with more than three branches, the total count being more than 17........................8
8. Count of antepalmate hairs of segments IV and V usually 26 or less; antepalmate hair of segment I usually larger than the palmate hair, and with 5 or more branches........................*subalpinus*
– Count of antepalmate hairs of segments IV and V usually more than 26; antepalmate hair of segment I minute, usually smaller than palmate hair, and with 3 or 4 branches........................*sacharovi*

V. Larvae of the Maculipennis Group.

The distribution of the antepalmate hair count of larvae from three Albanian breeding places is given in Table 1, to show the application of this method of identification to field material. The straight lines on the table indicate the range of variation of each species, as determined by a study of bred material (Bates, 1939–b).

Lakes Malik and Presba are located in the southeastern corner of the country, at an elevation of about 800 meters. *Maculipennis*, *messeae*, and *subalpinus* eggs were found in marshy areas along the lake margin (Fig. 3). *Sacharovi* did not occur in this region, hence larvae with high counts must in all cases be *subalpinus;* the modes at 12 and 15 in the hair count distribution may represent *maculipennis* and *messeae* respectively. In Vorra Pond (a marshy area between Tirana and Durazzo) we found eggs of *maculipennis*, *subalpinus* and *sacharovi*. The hair count of *maculipennis* larvae is distinctive, but it is more difficult to be sure of the separation of *subalpinus* and *sacharovi;* from an examination of other characters it seemed that only the two larvae with counts of 30 and 33 were *sacharovi*. In Yrshek Pond (Fig. 6) we found only *maculipennis* eggs, and the larval hair count is typical for this species.

VI. Larval Habitats.

In studying the factors limiting the habitats of anopheline larvae, it is interesting to reverse the usual procedure, and list the types of habitat in which larvae of a particular species are not found. Extended field work in Albania was confined to the species of the *maculipennis* group; and of these, *subalpinus* seemed to have the most sharply limited habitat (marshes and ponds). If any natural accumulation of water is regarded as a

TABLE 1.

Counts of the branches of the antepalmate hairs of the fourth and fifth abdominal segments of larvae from three types of habitat in Albania.

	Eggs present	Total hair counts 11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
maculipennis		———	———	———	———	———	———																	
messeae			———	———	———	———	———	———	———	———														
subalpinus									———	———	———	———	———	———	———	———	———	———	———	———	———	———		
sacharovi															———	———	———	———	———	———	———	———	———	———
Lakes Malik and Presba (69 larvae)	*maculipennis* *messeae* *subalpinus*	2	15	6	3	12	4	3	1	2	3	4	2	1	3	3	1	2	–	1	1	–	–	–
Vorra Pond (41 larvae)	*maculipennis* *subalpinus* *sacharovi*	4	10	3	2	1	2	–	–	1	1	2	6	1	3	1	1	1	–	–	1	–	–	1
Yrshek Pond (25 larvae)	*maculipennis*	2	13	4	4	2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

potential anopheline breeding place, the larvae of *subalpinus* were not found in:

1. Heavily shaded situations (forest pools).
2. Habitats with a small surface area (pools, ditches).
3. Water without vegetation.
4. Water subject to strong surface movements (waves, current).
5. Water with a high nitrate content.
6. Water with an appreciable salinity (more than 0.001 NaCl).

From the point of view of the ovipositing mosquito, the first two of these factors might be called "visual" (landscape), the second two "physical," and the third two "chemical." If this list of restrictions is applied to the other species of the *maculipennis* group, we find the following differences:

The limitations of *Anopheles messeae* seem to be identical, except that in addition the geographical range of the species is very restricted in Albania (effect of maximum summer temperature on adult?).

Anopheles sacharovi seems not to be subject to the second (area) and sixth (salt) limitations: although typically a marsh breeder, it was occasionally found in pools and ditches; larvae were sometimes found in water with a sodium chloride content of slightly above 20 parts per thousand. The geographical range of *sacharovi* was also limited, again perhaps because of factors affecting the adult (minimum winter temperature?).

Anopheles maculipennis was found in all parts of Albania, and in a remarkably wide range of habitats. In general, however, the limitations were the same as those for *subalpinus*, except for the second (area). The contrast at this point is striking. *Subalpinus* and *maculipennis* are often found in the same locality, and adults may be present in a particular stable in almost equal numbers. Egg dips in nearby breeding places, however, will disclose only *maculipennis* in the ditches, streams and small pools, and both *maculipennis* and *subalpinus* in the marshes. This difference is brought out clearly in the figures published by Lewis (1939, Table 3). The wide range of *maculipennis* habitats is illustrated in Figures 3 to 7. In Yrshek and Ipja Ponds (Figs. 6 and 7) only *maculipennis* was found in the middle of the summer. The spring-fed pool illustrated in Figure 4 is the sort of place where one would normally expect to find only *maculipennis*, but at the time the photograph was taken (September 2d), *sacharovi* and *superpictus* eggs were also found. The habitat illustrated in Figure 5 is most unusual for *maculipennis*, since normally only *superpictus* is found in this sort of situation; this habitat forms an exception to the third limitation (vegetation), since only a sparse algal growth was

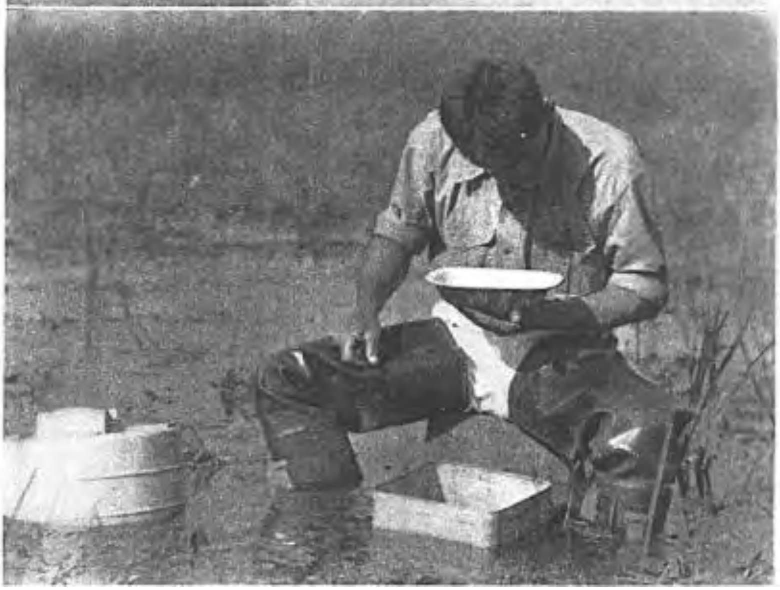

Fig. 2. Sieve made of cheese cloth spread over an embroidery hoop for the field study of anopheline eggs.

Fig. 3. Method of fencing off part of a larval habitat with a bottomless gasoline tin for making measurements of the larval population. The habitat illustrated is the marginal zone of Lake Presba (800 m.), where *Anopheles maculipennis*, *messeae* and *subalpinus* were found.

Fig. 4. Spring-fed pool in the coastal plain of Albania: eggs of *Anopheles maculipennis*, *sacharovi* and *superpictus* were found here in September.

Fig. 5. Detail of the bed of the River Dhrino in southern Albania. Eggs and larvae of *Anopheles maculipennis* were found in this particular place, although such locations are normally the habitat of only *Anopheles superpictus*.

Fig. 6. Yrshek Pond, near Tirana: made by damming a small stream: only *Anopheles maculipennis* eggs and larvae were found here, although *A. subalpinus* adults were also common in a nearby stable.

Fig. 7. Ipja Pond, near Tirana, formed where a small stream spread over a mud flat. Only *Anopheles maculipennis* was found here.

present; and to the fourth (current). *Maculipennis* larvae were, however, frequently found in protected spots in ditches and streams, where there was a slight current.

Anopheles superpictus, as is well known, breeds typically in the small pools in gravelly river beds (Figure 5), and is thus not subject to the third and fourth of the *subalpinus* limitations. The current in the pools where *superpictus* breeds is usually slight, but the larvae are nevertheless exposed to a steady change of water. Late in the season, when the adult population of *superpictus* has reached its peak, the eggs may sometimes be found in all sorts of habitats, including small pools (Fig. 4) and rice fields.

Hyrcanus and *algeriensis* were found most abundantly in the great marsh at Lake Terbuf (Lewis, 1939, Pl. 2). Five species of anophelines (*maculipennis*, *subalpinus*, *sacharovi*, *hyrcanus* and *algeriensis*) were, at one time or another, found breeding in this marsh. We found *plumbeus* larvae only in tree holes. *Claviger*, in the summer, was found only in shaded spring-fed pools, but in the winter and early spring the larvae could be found in many types of habitat, so that it looks as though low temperature were the important factor. The breeding places of *marteri* (pools in mountain streams) were characterized by heavy shade, low temperature, and clear fresh water.

In general, we have found a close correlation between the species of eggs and of larvae found in a given habitat, and we are convinced that the ecological distribution of anophelines depends on selection of oviposition site by the adult mosquito. In the laboratory, it is possible to demonstrate selection by ovipositing adults for both chemical and visual factors (Bates, 1940), and from the list of limitations that seem to affect the selection of breeding places in nature, it looks as though both types of sensory perception might be operative. It is particularly difficult to explain the marked "landscape" differences in anopheline habitats, except by the operation of a visual factor in the oviposition reaction.

VII. Seasonal Distribution of Anopheles Maculipennis.

In a previous paper (Bates, 1937) we published a summary of data collected during four years on seasonal variation in the number of adult mosquitoes collected in stables in the vicinity of Tirana. We found that in the case of *Anopheles maculipennis* the population seemed to build up to a peak somewhere about the first of July, and then to fall off fairly rapidly although maintaining a moderately high level, and sometimes increasing again, in August. We thought that it might be interesting to try to compare this distribution of adults with the distribution of larvae. The breeding places in the vicinity of Tirana vary considerably in extent during the summer, many ponds and marshy areas drying up during July and August, and our first impulse was to attribute the summer decline in *maculipennis* to this drying up of breeding places. If this were true, it seemed likely that the larval population in a breeding place that could be maintained at a constant level through the summer might not show a decline corresponding to the decline in adult population.

There was a small permanent stream about 200 meters from the stable at Yrshek where we collected adult mosquitoes, and in the spring of 1937 we built a dam across this stream, making a small shallow pond that could be kept at a permanent level all through the summer (Fig. 6). The dam was built in May, and observations on larvae were begun five weeks later, when conditions in the pond seemed fairly stable. To get data on the larval population, we used a method that we had developed during the previous summer, and which we referred to as the "gasoline tin technique." The idea was to fence off a sample unit of the breeding area, and make a complete count of the larvae found in that area. We find that a convenient method of doing this is to remove the top and bottom from a gasoline tin, leaving a frame which can be thrust quickly over the spot to be

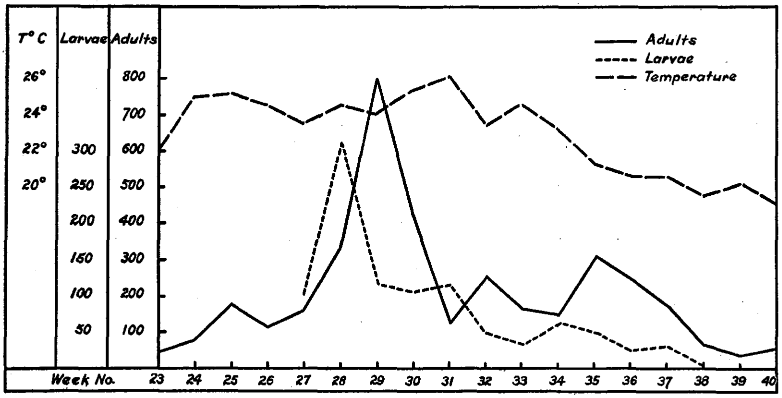

Fig. 1. Relationship between adult *Anopheles maculipennis* population (no. of mosquitoes in stable), larval population (total no. of *A. maculipennis* larvae per 500 cm² of surface in Yrshek Pond) and temperature (mean stable temperature), near Tirana, Albania.

tested, and pushed into the bottom so that it is firmly placed. The larvae are then collected from the enclosed area by dipping, and counted one by one as they are picked out of the dipper with a pipette. If the man doing the counting has had training in the laboratory with larvae of different stages, he can estimate the stage of a particular larva quickly and accurately by noting the relative size and shape of the head. This method of counting larvae is somewhat tedious; it requires two men, one to count the larvae and the other to note down the results as they are called to him, and a single trial may take half an hour, if it is carefully made. Gasoline tins are approximately 23 cm. on a side, so that in a single trial about 500 square centimeters of surface are enclosed; to cover a square meter, twenty trials would be necessary. We made up a series of frames of different height, for use in different depths of water, as counting is greatly facilitated if the surface of the water is only slightly below the edge of the tin. Fig. 3 shows the method of operation. Cambournac (1939) has obtained interesting results by applying this method to the estimation of larval populations in rice fields in Portugal.

TABLE 2.

Seasonal distribution of *Anopheles maculipennis* at Yrshek station near Tirana: number of adults in stable and number of larvae per 500 cm² in Yrshek Pond.

Week	Month	Stable temp.	Adults	Larvae per trial	Stage (percent)			
					I	II	III	IV
20	May	18.8	18	—	—	—	—	—
21	May	21.4	15	—	—	—	—	—
22	May	19.8	115	—	—	—	—	—
23	June	22.1	50	—	—	—	—	—
24	June	25.1	81	—	34	32	23	11
25	June	25.2	180	—	—	—	—	—
26	June	24.6	118	—	37	21	16	26
27	July	23.6	163	100	22	47	23	8
28	July	24.6	335	311	50	35	7	8
29	July	24.1	798	119	36	29	22	13
30	July	25.4	426	104	28	43	20	9
31	July	26.1	123	115	38	37	19	7
32	Aug.	23.4	251	48	6	29	28	37
33	Aug.	24.6	167	31	26	30	12	32
34	Aug.	23.1	149	61	33	28	19	20
35	Aug.	21.6	306	49	47	29	14	10
36	Sept.	20.6	244	24	31	41	16	12
37	Sept.	20.6	171	29	43	32	16	9
38	Sept.	19.8	62	1	0	0	69	31
39	Sept.	20.2	34	0	—	—	—	—
40	Sept.	19.1	50	—	—	—	—	—

The results of the 1937 study at Yrshek Pond are given in Table 2, and the figures for larval population, adult population and temperature are plotted in graph form in Fig. 1. The mean stable temperature (calculated from thermograph records) corresponds quite well with the mean outside temperature;

the temperature range was, however, very much less. It was unfortunately impossible to continue these observations in the following year, so the results of this single year of work can not be taken as more than suggestive of the utility of this line of attack. From these results, and from various other observations, it seems to us that the midsummer drop in *maculipennis* population is quite possibly in large part due to a high mortality in the adult population—probably the result of high temperature and low humidity. It is interesting that in each of the four years from 1933 to 1936, the peak of *maculipennis* preceded the peak in mean temperature (Bates, 1937, Figs. 2 and 10), as it did in 1937 (Fig. 1). The peak in larval population preceded the peak in adult population, and there was no great increase in the population of first stage larvae following the peak in adults, as one would expect if the adults lived and started laying eggs.

VIII. Larval Stage Ratios.

We started collecting data on the relative numbers of larvae in different stages of growth in various breeding places, on the theory that the ratio between stages might turn out to be fairly constant during the period of continuous breeding, and that variation in the ratio might throw light on seasonal population changes. We found that in fact the larval stage ratio varied considerably from one breeding place to another, and from the data collected in Albania it looks as though this ratio might be even more useful as an index of differences between breeding places than as a tool for the study of seasonal variation.

The larval stages are of unequal duration. From data collected in rearing experiments (Bates, 1939, Table 1) it looks as though in *Anopheles atroparvus*, at a constant temperature of 27°, stage I lasted 2 days; stage II, 2.5 days; stage III, 3 days; and stage IV, 5 days; making a total of 12.5 days. The length of stage IV varies greatly, but five days seems to be about the average at this temperature in favorable media. The period of growth in unfavorable media is greatly prolonged, and in some experiments we have had larvae of *Anopheles atroparvus* remain in stage II, for instance, for as much as seven days (at 27°). The figures quoted above for the various stages are based on experiments in "Medium S" (Bates, 1939), which was the most favorable of our artificial media. As a check, we tried growing larvae in bolting-cloth enclosures in the open, at Yrshek Pond. The experiment was carried out in July, and the mean water temperature (calculated from thermograph records) during the experimental period was 26.7°, so the field and laboratory results should be comparable. The first pupa was formed in 11 days, and half of the larvae had pupated on the 13th day, which would seem to indicate that the laboratory results with "Medium S" were reliable.

Martini (1923, p. 155) gives the following lengths for the larval stages of *Anopheles maculipennis* at temperatures between 24° and 27°: I, 2 days; II, 1¼ days; III, 2½ days; IV, 4¼ days; making a total of 10 days. Hadjinicolaou (1938) gives the following figures for *Anopheles marteri* (at temperatures between 19° and 24°): I, 3; II, 5½; III, 3½; IV, 6. The discrepancy between the relative lengths of the larval stages is curious: it may be that this is a specific characteristic, but that would hardly explain the differences between Martini's figures and ours. Our figures are estimates based on counts of fifty larvae grown together; much more accurate figures could be obtained by following the development of a number of individual larvae, which may be the system that Martini used. The need for accurate figures on this point for the interpretation of field larval ratios did not occur to us until after the Albanian work had been stopped.

On the basis of our figures for the relative length of larval stages, the larval stage ratios in an area of continuous breeding where there was no mortality should be: I, 16 percent; II, 20 percent; III, 24 percent; and IV, 40 percent. In actual breeding places, these ratios are practically always reversed—there are more Ist stage than IInd stage, and so forth. The weekly ratios for the summer of 1937 in Yrshek Pond are given in Table 2, and ratios for various breeding places in Table 3. Of the breeding places listed in Table 3, Yrshek Pond, Ipja Pond, and Shën Vllash had only *maculipennis;* Lakes Presba and Mali had a mixture of *maculipennis*, *messeae* and *subalpinus* (cf. Table 1); while the Portuguese rice fields had only *atroparvus* (Cambournac, 1939).

TABLE 3.

Larval stage ratios in different habitats in Albania.

Place	No. larvae	Stages (per cent) I	II	III	IV
Theoretical ratio, no mortality	—	16	20	24	40
Yrshek Pond, 1937, 14 weeks in summer	4,464	37	33	16	14
Ipja Pond, 1937, 9 weeks in summer	1,565	57	28	12	3
Lake Presba (June)	106	47	29	17	7
(September)	402	53	30	12	5
Lake Malik (June)	110	33	31	24	12
Shën Vllash, 19 May, 1937	39	18	20	26	36
8 June, 1937	107	74	17	6	3
Portugal, rice field (Cambournac, 1939)					
June	73,130	66	15	9	10
July	19,320	32	31	30	7
August	11,400	49	26	13	12

Our figures are too incomplete to warrant any very detailed analysis or discussion, and they are given here principally because they suggest what may prove to be a very interesting line of attack on some of the problems of larval ecology. In the figures for Yrshek Pond (Table 2) it is interesting that the proportion of Ist stage larvae tends to be higher at the beginning and end of the summer: it falls fairly steadily between weeks 29 and 32, between the peak of adult population and its lowest point, during the period of highest summer temperatures. This is what one would expect if the adults during this period should die before eggs are matured. The increase in the percentage of IVth stage larvae in the latter part of the summer may be due to the lower larval population density at this time, which might result in an increased survival rate. Figures of this sort would gain greatly in value if they could be compared with statistics on other variable factors in the pond, such as variations in the density of the predator population and variations in the physical and chemical environment.

The figures for the collection of May 19th at Shën Vllash (Table 3) are interesting, since they probably represent the first spring generation of mosquitoes: larvae from eggs laid by hibernating females have reached IVth stage, and the overlapping of generations which results in a general preponderance of Ist stage larvae for the rest of the summer has not yet started.

The differences for the summer period between Yrshek Pond and Ipja Pond, two *Anopheles maculipennis* habitats in the vicinity of Tirana, are striking. Apparently Yrshek Pond was a much more favorable breeding place than Ipja Pond, a fact that we did not realize until we started to analyze the larval data, after we had left Albania. The two ponds (Figs. 6 and 7) both seemed excellent breeding places and supported approximately the same larval population per unit of area.

IX. Summary.

Ten species of *Anopheles* were found in Albania: *algeriensis*, *claviger*, *hyrcanus*, *maculipennis*, *marteri*, *messeae*, *plumbeus*, *sacharovi*, *subalpinus* and *superpictus*. Keys for the identification of the eggs and larvae of these species are given. Larvae of the *maculipennis* group can in most cases be identified by means of the variation of the antepalmate hair. Larval habitats were studied in detail only in the case of the four species of the *maculipennis* group; of these *messeae* and *sacharovi* were limited geographically, while *maculipennis* (s.s.) and *subalpinus* were found in all parts of the country. The chief distinction between the habitats of the latter two seemed to be of landscape nature: *subalpinus* was found only in large accumulations of water (marshes, ponds), while *maculipennis* was found in a wide range of habitats, including small as well as large water bodies (ditches,

pools, slow streams). The habitats could be accurately defined by means of the field study of eggs, which seems to show that the oviposition habits of the adult mosquito must be the controlling factor in determining specific differences in larval distribution.

From a study of the seasonal variation in adult and larval populations of *Anopheles maculipennis* in a locality near Tirana, it seems likely that the midsummer drop in population is due in large part to factors affecting the adults rather than the larvae: the peak of larval population preceded the peak of adult population, and there was no great increase in the population of first stage larvae following the peak in adults. Figures on the relative proportions of larvae in different stages of growth were collected for various breeding places and seasons, and it was found that the larval stage ratio was characteristic not only of the season, but of the breeding place. The collection of data on this point may serve as a useful index in determining the relative importance of different types of breeding place.

X. References.

Barber, M. A.

1935. A method of detecting the eggs of *Anopheles* in breeding places and some of its applications.
Riv. Malariol., **14**, pp. 146–149.

Barber, M. A., and Rice, J. B.

1935. Malaria studies in Greece. The malaria infection rate in nature and in the laboratory of certain species of *Anopheles* of East Macedonia.
Ann. trop. Med. & Parasit., **29**, pp. 329–348.

Bates, M.

1937. The seasonal distribution of anopheline mosquitoes in the vicinity of Tirana, Albania.
Riv. Malariol., **16**, pp. 253–264, 12 graphs.

1939. The use of salt solutions for the demonstration of physiological differences between the larvae of certain European anopheline mosquitoes.
Amer. J. trop. Med., **19**, pp. 357–384, 4 figs.

1939–b. Variation in the antepalmate hairs of larvae of the *Anopheles maculipennis* complex.
Riv. Malariol., **18**, pp. 299–312.

1940. Oviposition experiments with anopheline mosquitoes.
Amer. J. trop. Med. [in press].

Bates, M., and Hackett, L. W.

1939. The distinguishing characteristics of the population of *Anopheles maculipennis* found in southern Europe.
Verh. VII int. Kongr. Antom., 1938, vol. **3**, pp. 1555–1569, 3 figs.

Cambournac, F. J. C.

1939 A method for determining the larval *Anopheles* population and its distribution in rice fields and other breeding places.
Riv. Malariol., **18**, pp. 17–22, 3 figs.

EDWARDS, F. W.
1932. Diptera : Fam. Culicidae.
in Wytsman, Genera Insectorum, fasc. 194, 258 pp., 5 pl.
HACKETT, L. W., AND BATES, M.
1939. The laboratory for mosquito research in Albania.
Third Int. Congr. trop. Med. & Malaria (1938), Amsterdam, vol. **2**, pp. 113–123, 4 figs.
HADJINICOLAOU, J.
1938. Observations on *Anopheles marteri* S. and P. (Diptera, Culicidae).
Riv. Malariol., **17**, pp. 44–50, 2 figs.
LEWIS, D. J.
1939. The seasonal and geographical distribution of *Anopheles maculipennis* in Albania.
Riv. Malariol., **18**, pp. 237–248, 9 figs.
LÖRINCZ., F.
1937. Malaria in Hungary.
Riv. Malariol., **16**, pp. 465–479.
MARTINI, E.
1923. Lehrbuch der medizinischen Entomologie.
xvi + 462 pp., 244 figs. Jena, Gustav Fischer.
RICE, J. B., AND BARBER, M. A.
1937. The varieties of *Anopheles maculipennis* in a region of Greek Macedonia.
Bull. entomol. Res., **28**, part 3, pp. 489–497.