A PRELIMINARY ACCOUNT OF THE RESULTS OF SURVEYS FOR BREEDING-PLACES OF MOSQUITOES IN NORTH WALES

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INTRODUCTION

The present paper is an account of the results of an investigation into the biology of the species of CULICIDAE, or mosquitoes, present in various parts of North Wales. The work, which was carried out under the Department of Zoology and the Agricultural Zoology Laboratory of the Department of Agriculture, at University College, Bangor, was begun in October, 1920, and has since been prosecuted whenever circumstances have permitted; that portion of it chiefly dealt with here, viz., observations on breeding-habits, was carried out during the summers of 1921, 1922, and 1923.

In the summer of 1921, my attention was entirely confined to an area of CARNARVONSHIRE bounded by the MENAI STRAITS, the OGWEN RIVER, the SNOWDONIAN MOUNTAINS, and the GWYRFAI RIVER. The elevation of the area worked varies from a few feet above sea-level to about 480 feet at LAKE CWELLYN. The major part of the district is well above the 200-feet contour; the only low-lying land is along the shore of FORYD BAY, an arm of the Menai Straits. In this part there are a relatively large number of slow running ditches and brackish pools. In the rest of the area there are few ponds; drainage is largely by swiftly running natural streams.

The fields are for the most part bounded by stone walls without ditches. The area is moderately wooded; the preponderating trees are oaks and conifers; such tree-hole examination as has been done has yielded negative results (Blacklock and Carter (1920)).

In the summer of 1922, and again in 1923, I re-surveyed the North Carnarvonshire area, while I examined, in addition, streams and ground collections of water in the neighbourhoods of DOLGELLEY and DINAS MAWDDWY, MERIONETHSHIRE, and ABERFFRAW, ANGLESEY (this last in 1922 only).

In all, ten species of mosquitoes have been taken in the larval stage; viz., *Anopheles maculipennis*, *A. bifurcatus*, *Aedes* (*Ochlerotatus*) *detritus*, *A.* (*O.*) *caspius*, *A.* (*O.*) *punctor* var. *meigenanus*, *A.* (*O.*) *rusticus*, *Aedes* (*Ecculex*) *vexans*, *Theobaldia annulata*, *Theobaldia* (*Culicella*) *morsitans*, and *Culex pipiens*. The first three and last four have also been obtained as imagines. The nomenclature employed is that of F. W. Edwards (1921); since this differs from that employed previously (*e.g.*, Lang (1920)), I have thought it advisable to give both the authority for the name, and also, when Lang's specific or generic name differs from that of Edwards, that employed by the former author.

It may be mentioned that the weather varied during the period which this paper covers, from being very dry and warm (1921) to cold and wet (1923).

I have very great pleasure in taking this opportunity of acknowledging my indebtedness to Professor P. J. White, F.R.S.E., Department of Zoology, and Mr. C. L. Walton, Adviser in Agricultural Zoology at Bangor, for much valuable advice, assistance and encouragement; to Professor Warrington Yorke, Professor R. Newstead, F.R.S., and Miss A. M. Evans, of the Liverpool School of Tropical Medicine for valuable assistance in the matter of literature; to Professor Newstead, for helpful criticism also; to Mr. F. W. Edwards, of the British Museum (Natural History), for information as to literature, and for the identification of imagines of *Theobaldia morsitans*; and finally to numerous landowners and farmers, especially the Trustees of the Vaynol Estate and Mr. W. H. Jones, Plas Llanfaglan, Carnarvon, for affording me every facility for the 'field-work' involved in these investigations.

Anopheles maculipennis, Meig.

Anopheles maculipennis, Meigen. Syst. Beschr., Vol I, p. 11 (1818).

This species is everywhere common. In my experience, it will

breed in any moderately clean water containing vegetation. The presence of a moderate amount of current does not affect it; it will breed in swiftly running streams, provided there is enough vegetation to shield the larvae from the full force of the current. As for volume of water, it needs but little. In the laboratory, the larvae may be bred in shallow vessels, offering a large surface to the air, with low mortality; when the surface is small relative to the volume, there is considerable mortality, even if the water be daily artificially aerated.

According to Martini (1921), the Sanitary Staff of the German Army in Macedonia found that this species would not breed in water thickly covered with duckweed. I have obtained larvae from pools thickly covered with *Lemna minor*. I have also obtained larvae from water 'choked' with *Elodea canadense*.

It is a well-known fact that in the later years of last century, and the earlier years of this, there was a continued decrease in the amount of endemic malaria ('ague') in Great Britain and also in other parts of Northern Europe (Wesenburg-Lund, 1921). Various theories have been put forward to account for this, the latest being that independently proposed by Wesenburg-Lund and Roubaud, that a change has taken place in the mode of nutrition of *Anopheles maculipennis*. It has been suggested by Nuttall (Lang, 1918) that unfavourable breeding seasons, by temporarily exterminating *Anopheles* spp. in the ague zones, may have broken the 'chain of infection,' and thus brought about the observed disappearance of the disease; he suggests that very wet seasons may bring this extermination about by washing-out larvae from the localities in which they normally breed. I doubt if this cause would operate in such country as is found in North Carnarvonshire, where there are few ditches, the majority of the Anopheline breeding in isolated pools, etc., not liable to 'wash-outs.' Ague was formerly endemic in parts of the North Carnarvonshire littoral; I have met several farmers who remember a time when it was often difficult to conduct agricultural operations owing to ague among the farm labourers. At the present time, there are thousands of Anophelines in the area, and many imported cases of malaria, but so far as I am aware, there have been no locally contracted cases of malaria within the last few years.

The observations of Macgregor (1921) and James (1922) in

Surrey, and my own in North Carnarvonshire, suggest that a dry season is not likely greatly to affect the Anopheline mosquitoes.

This species generally breeds in the least shaded situations, so that in pools or streams it may be expected on the North side, unless this be shaded, deep, or without vegetation. I have occasionally obtained it from quite shady spots.

On 13th September, 1922, I obtained larvae of this species from a rainwater tank at PLAS LLANFAGLAN, near Carnarvon.

Larvae in all instar, and pupae, may be obtained throughout the summer.

The females hibernate in the warmer farm buildings.

Anopheles bifurcatus (Linn.).

Culex bifurcatus, Linnaeus. Syst. Nat., Ed. X, p. 603 (1758).

This species is the commonest mosquito in North Carnarvonshire. It breeds in the same types of water as does *A. maculipennis*, and also in extremely foul pools in marshes. I have often obtained larvae of the two species together. This species may be bred in the laboratory under the same conditions as *A. maculipennis*.

Feytaud and Gendre (1919) state that, while *Anopheles maculipennis* 'develops above all in stagnant water, clean and sunny (clear pools, lagunes, marshes, etc.), with abundant vegetation, variable temperature,' etc., '*Anopheles bifurcatus* likes pure water . . . cold, with little vegetation. We especially see it in fresh springs, streams through woods . . . wells.' The results obtained by Boyd (1922) and myself are not in agreement with this; Boyd remarks that 'the dyke in which the greatest number (of larvae) were found has the banks overgrown with weeds, and is almost stagnant in parts. The bottom is covered with leaves and decaying vegetation, into which the larvae appear to burrow at times.'

Larvae may be found throughout the year in all instar, and pupae throughout the summer.

The larvae of both species of Anophelines commonly bear a greater or less number of ectozoic Ciliates, very similar in appearance to *Vorticella*. These occur but rarely on Culicine larvae.

The larva hibernates.

Theobaldia annulata (Schrank).

Culex annulatus, Schrank. Beit. Z. Naturg., p. 97 (1776).

This, the largest and most ornamented of our mosquitoes, is common everywhere.

I have never found the larvae except in clean currentless water, but it has elsewhere been found breeding in foul rainwater (R. Newstead). It may be found in both natural and domestic collections.

Normally, this species hibernates as the adult female, in cellars and lofts.

Larvae of this species hibernated, in the winter of 1921-22, in a tank at UNIVERSITY COLLEGE, BANGOR, attaining the adult condition at the end of March, 1922. During the winter the water in the tank was once frozen almost—if not quite—solid, while it was frozen on the surface only, on two other occasions. Boyd (1922) has made similar observations.

Wesenburg-Lund (1921) states that in Denmark this species is exclusively domestic.

Theobaldia (*Culicella*) *morsitans* (Theo.).

Culex morsitans, Theobald. Mon. Cul., Vol. II, p. 5 (1901).

Culicella morsitans (Theo.). Lang. Handbook, p. 102 (1920).

I have obtained this species from one locality only, in a wood near GLAN-RHYD FARM, PENTIR, near Carnarvon (altitude slightly over 350 feet), where I found numerous first and second instar larvae in pools in a ditch, partly filled with fallen leaves and similar debris, on 21st September, 1922. I visited this pool on several later occasions. During the winter, fourth instar larvae were found; these pupated during May and June, 1923. Imagines bred in the laboratory from larvae were sent to Mr. F. W. Edwards, and identified as this species. After May, no larvae of this species were found until 11th October, when I obtained a few. The ditch was full of water most of the time.

According to Wesenburg-Lund (1921), the eggs are deposited on dry earth during July and August. These hatch out in September, the larvae proceeding to the fourth instar during the period 1st October to 1st December. The winter is passed as fourth instar larvae.

Aedes (*Ochlerotatus*) *detritus* (Hal.).

Culex detritus, Haliday. Entom. Mag., Vol. I, p. 151 (1833).

Ochlerotatus detritus (Hal.). Lang. Handbook, p. 89 (1920).

This species has been obtained from the low-lying part of the Parish of LLANFAGLAN, bordering on FORYD BAY, and also from similar land near ABER, Bangor, in late August, 1923.

The larvae occur both among vegetation and in open water; in pools the large fourth instar larvae may often be seen in the clear water towards the centre. Usually it is found in brackish or salty water, but I have taken it from inappreciably saline water and also from slowly running fresh water. In the laboratory, the larvae are easy to breed; they can be kept in shallow dishes filled with water from their original breeding-place, fresh water being occasionally added to compensate for evaporation. I have kept larvae in two cubic centimetres of water apiece, with no losses. By gradually diluting the brackish water, the larvae may become accustomed to, and thrive in, fresh water.

Under laboratory conditions, larvae pupated at various times between 11 a.m. and 6 p.m. on 12th July, 1922, the first imago emerging about 4 p.m. on 16th July. The maximum temperature in the interval was 66° F., the minimum 58° F.

On 29th June, 1923, I placed some dry mud from a ditch in which this species had bred the previous year, in a large dish of water. On 5th July, I noticed a larva swimming in the dish. This cast its skin on the following day, and pupated on the 11th. On the 14th, a female emerged from the pupa. The mean temperature was slightly over 60° F.

The imagines spend the day in the vegetation, around the breeding-places; they may often be beaten out in large numbers. The females are vicious biters, both in nature and under laboratory conditions; the swelling after the bite is, in my experience, more painful than that of any other of our North Wales species. In the laboratory, the females will attempt to feed shortly after emerging from the pupae, before the chitin of the mouth-parts has become rigid enough to allow of piercing the skin.

According to Lang (1920), there are 'at least two generations in the year.' In 1922, I believe there were three in this area. In

late June and early July, and again in late August and early September, larvae were abundant; in the interim there were none. The major part of the second brood had attained the last larval instar at least by 13th September, 1922, when I found only fourth instar larvae and pupae. On 25th November, 1922, I visited several of the pools where I had found larvae during the summer, with the object of obtaining data regarding the hibernation of this species. All pools and ditches were covered with ice; on breaking this and dipping near the margin, I everywhere obtained numerous larvae. All four instar were taken, the first two predominating. This suggests that in the interval between my two visits (13th September and 25th November) the females of the second brood—*i.e.*, females hatched from the larvae and pupae of August-September—had oviposited and that from the eggs emerged the larvae found on 25th November, these being a third generation. Larvae in all instar continued to abound until June, 1923, when they disappeared. In July the pools and ditches dried up. In August they again filled, and larvae were found until 2nd October, 1923. On 31st October no larvae could be found anywhere after a careful search. James (1922) records that larvae were found throughout the year.

According to Wesenburg-Lund (1921) and Lang (1920), this species hibernates as the egg; apparently it can hibernate also as the larva. It survives drought as the egg.

Aedes (*Ochlerotatus*) *punctor* (Kirby) var. *meigenanus*, Dyar.

Culex punctor, Kirby. Fauna Boreali-Amer., Zool. Ins., p. 305 (1829).

Aedes meigenanus, Dyar. *Insecutor Inscitiae Mens.*, Vol. IX, p. 72 (1921).

Ochlerotatus nemorosus (Theobald). Lang. Handbook, p. 91 (1920).

I have obtained larvae of this species from pools in a marsh near LLANELLTYD BRIDGE, DOLGELLEY (altitude well under 50 feet), in company with larvae of *Culex pipiens*, 27th July, 1922; and also nearer DOLGELLEY in company with *Aedes vexans*, 27th July, 1923.

Aedes (*Ochlerotatus*) *caspius* (Pallas).

Culex caspius, Pallas. Reise versch. Prov. Russ. Reich, Vol. I, p. 475 (1771).

Ochlerotatus caspius (Pallas). Lang. Handbook, p. 81 (1920).

I obtained larvae of this species in a pool on FAIRBOURNE (South of Barmouth, Merionethshire) Golf Links, 25th July, 1922; and with *Aedes vexans*, near DOLGELLEY, 27th July, 1923. This species has previously been recorded from Merionethshire (Tal-y-bont, North of Barmouth, see Lang, 1920) by Mr. F. W. Edwards.

Aedes (*Ochlerotatus*) *rusticus* (Rossi).

Culex rusticus, Rossi. Fauna Etrusca, Vol. II, p. 333 (1790).

Ochlerotatus rusticus (Rossi). Lang Handbook, p. 94 (1920).

Near DOLGELLEY, with *Aedes vexans*, 27th July, 1923.

Aedes (*Ecculex*) *vexans* (Meig.).

Culex vexans, *Meigen*. Syst. Beschr., Vol. VI, p. 241 (1830).

Ochlerotatus vexans (Meig.). Lang Handbook, p. 85 (1920).

This species has been obtained from one locality; in a field on the right hand of the River Wnion, about half a mile below DOLGELLEY (altitude under 50 feet).

On the evening of 22nd July, 1922, I captured a number of imagines while beating a patch of rushes. On 24th July, a careful search led to the discovery of the larvae, in a small ditch.

In July, 1923, I again visited DOLGELLEY, and found this pool dry. On Monday, 22nd July, the pool was filled as a result of a flood. On Friday, 27th July, I obtained a large number of larvae. An attempt to breed the imagines failed, all the larvae dying, though one pupated. Most of the skins cast were preserved and mounted; a careful examination of this material showed it to contain, besides *Aedes vexans*—in all instar save the first—*Aedes caspius*, *Aedes punctor meigenanus*, *Aedes rusticus*, *Culex pipiens*, and *Theobaldia annulata*.

The imagines, apparently, spend the day among the vegetation. The females attack man.

Apparently, since larvae appear soon after the pool fills with water, it hibernates as an egg; no larvae could be found in the late autumn of 1922.

Culex pipiens, Linn.

Culex pipiens, Linnaeus. Syst. Nat., Ed. X, p. 602 (1758).

This species is everywhere common. It breeds, in my experience, in any type of water, natural or domestic. I have obtained the larvae from streams, ponds, pools in marshes, water in hoof marks, and all sorts of rainwater receptacles. It will breed in very foul situations. It is easy to breed in the laboratory.

The female hibernates in dark, cool cellars or lofts.

It rarely, if ever, attacks man. I have never succeeded in getting it to bite under experimental conditions.

REFERENCES

Blacklock, B., and Carter, H. F. (1920). On the Results Obtained from Surveys for Breeding-Places of Tree-Hole Mosquitoes in Liverpool and Neighbourhood. *Ann. Trop. Med. & Parasit.*, Vol. XIV, p. 115.

Boyd, J. E. M. (1922). The Botany and Natural History of the Dyke-land near Sandwich, Kent, as far as they concern Medical Entomology. *Journal R.A.M.C.*, Vol. XXXVIII, pp. 41 and 117.

Edwards, F. W. (1922). A Revision of the Mosquitoes of the Palaearctic Region. *Bull. Ent. Research*, Vol. XII, p. 263.

Feytaud, J., and Gendre, E. (1919 i). Sur la Répartition des Gîtes d' *Anopheles maculipennis* et d' *A. bifurcatus*. *Bull. Soc. Path. Exot.*, Vol. XII. 1919.

——— (1919 ii). Sur la Répartition des Gîtes d' *Anopheles* et d' *A. bifurcatus*. *Procès-Verb. Soc. Linn. Bordeaux*, Vol. LXXXI. p. 24 (Cited by Boyd. Summary in *Rev. App. Ent.*, B. Vol. VIII, p. 211).

James, S. P. (1922 i). Mosquito Life in Surrey during 1921. *Bull. Ent. Research*, Vol. XII, p. 427.

——— (1922 ii). Notes on the Eggs of Culicine Mosquitoes found in England. *Trans. R. Soc. Trop. Med. Hyg.*, Vol. XVI, Dec. 1922.

Lang, W. D. (1918). A Map of the Known Distribution in England and Wales of the Anopheline Mosquitoes. British Museum (Natural History), London. 1918.

——— (1920). A Handbook of the British Mosquito. British Museum (Natural History), London. 1920.

MacGregor, M. E. (1921). The Influence of Drought on Mosquito Life in Surrey. *Bull. Ent. Research*, Vol. XII, p. 205.

Martini, E. (1921). Die biologische Malariabekämpfung in Mazedonien. *Leitschr. angew. Ent. Berlin*, Vol. VII, p. 225. (Summary in *Rev. App. Ent.* B. Vol. IX, p. 91).

Wesenburg-Lund, A. (1921). Contributions to the Biology of the Danish Culicidae. *D. Kgl. Danske. Vidensk. Selsk. Skrifter Nat. Math. Afd.*, 8 *Raekke*, Vol. VII, p. 1. 1921.