

QUARANTINE SERVICE

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MALARIA MOSQUITO SURVEY

OF

Irrigation Areas in the Murray
River District.

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INTRODUCTION.

Owing to the return from military service abroad in New Guinea, Egypt, &c., of many men infected with malaria, it was considered to be a matter of fundamental importance that the irrigation districts, where preparations were being made to establish many returned men, should be examined in order that the absence or prevalence of the malaria-carrying species of mosquito should be determined. This decision was arrived at during a conference upon the question of malaria convened by Surgeon-General Fetherston, Director-General of Army Medical Services in Australia. This mosquito survey was intrusted to the Quarantine Service, and Mr. F. H. Taylor, of the Australian Institute of Tropical Medicine, was requested to carry out the work.

It was not possible during the time available to do more than examine the principal centres in the irrigation districts, but the results of the work in these centres are such as to be considered practically applicable to the whole irrigation area.

The survey was conducted immediately after a period of phenomenal rains over the whole area, and therefore abnormal flood conditions were existent. On the other hand, testimony was unanimous that there was at the time a much greater prevalence of mosquitoes than usual.

Mr. Taylor has established that *A. (Nyssorhynchus) annulipes*—the Malaria Mosquito—is to be found right through the irrigation area, and, with the possible exceptions of Mildura and Renmark, wherever present they were found in considerable numbers.

Not only was this so, but they were chiefly to be found close to human habitations, indicating that an increase in the human blood-supply available would probably be followed by an increase in the numbers of these species.

It is obvious, therefore, that no man should be allowed to settle in these areas whose record shows that he has suffered whilst on service from malaria, or in whose blood the malarial parasites are found.

Moreover, every endeavour should be made to create such conditions in these areas that malaria-carrying mosquitoes will not breed, as the casual introduction of infection may be productive of a serious outbreak of malaria.

The matter is sufficiently important for active measures to be taken.

J. H. L. CUMPTON, M.D., D.P.H.,
Director of Quarantine.

22nd January, 1917.

PREFACE.

Mosquitoes are small two-winged flies, belonging to the order Diptera, and are characterized by their small size, long proboscis and legs, and are clothed with scales. The adult, in addition to the long proboscis, possesses long antennæ, threadlike in the female and feathery in the male, two palpi or mouth feelers which are always long in the *Anopheles* and usually short in the *Culex*.

The eggs are deposited on the surface of water and in the case of *Anopheles* are laid singly, and usually in the form of a raft in the case of the *Culex*, a notable exception in this respect is *Stegomyia fasciata*, Fabr., which lays its eggs singly. The larvæ or wrigglers must have water for their development. They differ from most fly larvæ in that they have a well-defined head region, are more or less densely covered with long hairs, and breathe through a syphon, which is visible to the naked eye in the *Culex*, at their apical extremity. They are usually about a quarter of an inch in length, and are readily recognised by their wriggling movements. This is the feeding stage. The pupæ have the fore part of the body greatly enlarged so as to appear hunch-backed. They are also actively motile and live under similar conditions to the larvæ, though they do not feed.

The members of the sub-family *Anopheles* only transmit malaria. It is the *Culex* which spread yellow fever, filariasis, and dengue.

The main features of the *Anopheles* and *Culex* may be distinguished as under :—

Anopheles.

Adult.—Wings usually spotted. When at rest, body at an angle to surface.

Palpi as long as proboscis.

Eggs.—Laid singly.

Larvæ.—Minute breathing tube at apex of body.

When at rest, lies parallel to surface of water.

Breeding-places.—Usually small earth pools or edges of ponds and other such like places.

Culex (type).

Adult.—Wings generally clear.

When at rest, body parallel to surface.

Palpi shorter than proboscis in the female.

Eggs.—Usually laid in raft-like masses.

Larvæ.—Have a long breathing tube at apex of body.

When at rest, usually at an angle of about 45° to the surface of water.

Breeding-places.—Water tanks, barrels, old tins, foul water, swamps, &c.

LIFE-HISTORY AND HABITS OF *Anopheles*.

The *Anopheles* mosquito flies mainly about dawn and sunset, though it is to be found biting during the day and late at night. It is to be found in hiding during the daytime in dark secluded spots as under road bridges, houses, in hollow trees, &c. The female lives on the blood of man and other animals, whilst the male lives entirely on plant juices. The eggs are laid singly on the surface of the water. The larvæ or wrigglers emerge from the egg in a day or two and from this moment until they are fully developed

MALARIA MOSQUITO SURVEY.

KYABRAM.

It was unfortunate that the time spent here, from 12th to 21st October, 1916, embraced a period of weather unfavorable to the work which immediately followed some weeks of phenomenally heavy rain and flood conditions.

Situated in the Goulburn River Irrigation Area. Surrounding country, flat and sparsely timbered. Population, 1,800. Rainfall, 16.85 in. (average).

Irrigation Channels.—The nearest channel is about half-a-mile from the Post Office, in a westerly direction, and about a quarter of a mile in a northerly direction. The main channel is about a mile distant in a westerly direction.

The depth of the water in the street gutters and borrow pits varied from an inch or two to about a foot. The water in the small irrigating channels was usually only an inch or two in depth.

At the time of my visit there were numerous collections of flood water lying about. They may be divided as follows:—(1) More or less extensive collections in the ill-formed street water-tables and borrow pits; (2) water-holes on private property; (3) an extensive swamp adjacent to and inside the race-course; (4) the small irrigating channels in cultivated fields, which are used for irrigating them, and which contain water in a greater or less degree throughout the year. The banks of these channels are low, gently sloping, and are usually covered with grass and reeds. In some cases these channels are completely overgrown with herbage.

The irrigation channels, both main and secondary, have high gently sloping banks, which are overgrown with grass, thistles, and other rank growth, which occasionally extend into the water.

Most of the pools and other collections of water are in the sunlight all day. In the majority of cases the collections of water are muddy, very few being clear. The water in the main part of the swamp near the race-course is clear, but that along the roadside is muddy, owing to traffic going through it. There was a small quantity of drift on one side only (that adjoining the iron fence).

Most of the street collections are about a couple of feet wide and overgrown with reeds, docks, &c. There are some wider ones, which are clear of growth except at the sides. In a few cases they were covered with scum.

All the collections of water which are free from growing weeds and the irrigation channels are subject to wave action due to winds, which drown the mosquito larvæ.

Water beetles, predaceous insect larvæ, crustaceans (*Lepidurus* sp.) were found in some of the pools; on four occasions the crustacean, *Lepidurus*, was present in many hundreds.

All of the breeding places were found to be in close proximity to a constant source of blood supply, both human and animal, which insures continuous food for the adult mosquito.

pupæ, they live entirely in the water, obtaining the necessary air by means of the breathing tube already described, which is extended to the surface of the water. When the larvæ are fully developed they change to the pupal stage, from which the adult mosquito emerges. Under normal weather conditions the life-cycle is completed in from a week to ten days, but if the weather becomes unfavorable, this period may be considerably extended.

Anopheles is, generally speaking, a swamp-breeding mosquito, whereas the *Culex* will breed in almost any locality from a mine sump pit to old tins and foul water.

Anopheles prefers small earth pools containing either muddy or clear water. It will breed abundantly along the grassy banks of ponds, lakes, in street water tables, swamps, overgrown ditches and all such like situations.

Anopheles will also breed in comparatively arid areas, provided there is a sufficiency of water for the period of its life-cycle.

METHOD OF EXAMINATION.

The scoop used during this survey was a white enamelled kitchen ladle, holding about half a pint.

ILLUSTRATIONS.

Illustrations of the various stages of development of the *Anopheles* and *Culex* mosquitoes, and maps and photographs of the places visited, are shown in Appendices.

In many instances, the distance from residences and obstacles, such as trees, fences, &c., is only a few feet to the breeding place—that is, from the street gutter to the house. In other cases the distance would vary from a few yards up to half-a-mile.

Large numbers of *Culicine* larvæ were breeding in the swamp near the race-course—larvæ of all ages and also pupæ. Very large numbers of the adult insects were found sheltering in the long grass.

Anophele larvæ, the majority young, were found in small numbers amongst the grass growing in the water at the edges. On no occasion was more than one taken at each dip of the scoop; in some parts of the swamp none at all were found.

A small water-hole near by also contained large numbers of *Culicine* larvæ of all ages and pupæ. No *Anophele* larvæ were discovered here.

Larvæ and pupæ of *Culicine* type were found in the water-tables of Union-street.

Larvæ and pupæ of *Culex* type were very numerous in the water-tables of Allan-street, running east from where the railway line crosses it for about a quarter of a mile.

Small numbers of *Anophele* larvæ of all ages were also encountered in Allan-street, usually a single larva to a dip of the scoop every few feet.

These water-tables, on each side of the street, are ideal *Anophele* breeding places, being more or less heavily overgrown with docks and other kinds of weeds, which afford excellent protection to the larvæ and pupæ from wind and also good shelter for the adults when hatched.

Very few predaceous insects, waterboatmen, &c., were seen in these pools, and, judging by the number of mosquito larvæ and pupæ found in the pools, are quite negligible. No fish were seen.

Few *Anophele* larvæ were seen in the water-tables of Allan-street, west of the Post Office. *Culicine* larvæ were also scarce, which was probably due to the presence in the water of large numbers of crustaceans—*Lepidurus* sp.

The main irrigation channel, on the west side of the town, was examined for some distance, and none could be found, although the banks were in many places overgrown with reeds extending into the water, affording protection for larvæ.

This channel runs parallel with Rushworth road for some distance, along which is a ditch, containing muddy water, about a foot deep and five feet wide, which contained large numbers of *Culicine* larvæ, averaging forty larvæ and pupæ to a dip of the scoop every few feet. Travelling along this drain, in a northerly direction to its dead end, large numbers of *Culicine* and *Anophele* larvæ were encountered. The latter were not common, usually only one larva being taken amongst the dead grass on the sides, though occasionally two or three were found at each dip of the scoop.

Besides the dead grass on the sides, there were some dead tree branches covered with decaying vegetable matter in the water.

Then still proceeding along the main channel for about a quarter of a mile an irrigating channel was seen inside a cultivation paddock, overgrown with weeds and containing numerous small collections of water. These were searched and both *Anophele* and *Culicine* larvæ were found. The former were more numerous than had previously been found, as many as three and

four larvæ and sometimes a dozen larvæ being found in a single hole (these holes were mostly hoof marks made by horses and cattle, usually about four inches deep). These collections of water extended for about a couple of hundred yards. Search was made in another irrigating channel near by, but the water was, evidently, too much disturbed by animals, as neither *Anophele* nor *Culicine* larvæ were found in it till it left the field and entered the road, where both types were found. The latter were very common, the former were scarce, only an odd larva being found every few feet. *Anophele* larvæ were also scarce in a large sheet of water near by on the opposite side of the road. *Culicine* larvæ, however, were common.

Working in a southerly direction from where Allan and Rushworth roads junction to the road immediately behind the race-course, *Anophele* larvæ were found between these points in fairly large numbers in clusters of small pools in the ditch running alongside the road. They were present in the following numbers in the pools:—

- (1) Eighteen larvæ (all adult) in a small pool about a square foot in area.
- (2) Fifteen in a hoof hole; all these were adult.
- (3) Fifty in hole the area of which was about 18 feet by 8 feet; the majority of the larvæ were adult.
- (4) Nine in a hoof hole—mainly young forms.
- (5) Sixty-eight, nearly all adult, the remainder about half grown, were found in a pool about a square foot in area.
- (6) Twenty-eight larvæ, of varying ages, were found in a pool about 6 feet long by about 2 feet wide.
- (7) Sixteen in a hoof hole, of all ages.
- (8) Sixteen larvæ in a pool about 8 feet square in area; about two-thirds of them were adult.
- (9) Five larvæ were found in a hoof hole.
- (10) Nine were found in a pool about a square foot in area.
- (11) One was found in a hoof hole.
- (12) Two were found in a hoof hole.

In all 237 *Anophele* larvæ were found (the majority being adult forms) in these pools, which were protected by reeds and scattered over a length of about 30 yards, and were about 300 yards from the nearest dwelling.

Proceeding further along the drain no larvæ were seen until the cross road behind the race-course was reached on the left where the secondary channel leads off from the main one. Running alongside this channel is a drain, overgrown with weeds, which furnish excellent protection from the wind.

Everywhere along this drain *Anophele* larvæ were to be found in varying numbers. At each dip of the scoop, from one to six larvæ—mostly adult—were caught. The drain is about half a mile long and about 2 feet wide.

The average number of *Culicine* larvæ taken at a dip of the scoop was twelve.

There are two houses in this length of road.

No predaceous insects or larvæ were seen in any part of the drain where the larvæ were found. There were, however, some at the western end of the drain, but they were not common.

The water was, as in other cases, muddy and varied in depth from about 1 to 6 inches.

Following the first channel from the Post Office on the western side to where it crosses the road running parallel with Allan-street, a small pool of clear water a couple of inches deep was found. There were thirteen *Anophe-line* larvæ in it, all adult.

The street water-table, about 3 feet wide and a chain long, overgrown with grass and reeds, contained clear water, in which twenty-eight *Anophe-line* larvæ were found, about two-thirds of them being adult. They were not common, only a single larva being taken at a dip of the scoop every few feet—very rarely were two specimens taken at a time.

There were also a few *Culicine* larvæ present and, like the *Anophe-line*, they were not common.

The nearest house is about a chain distant.

The next place examined was a borrow pit, alongside the channel, after it crossed the above road, at one end of which were a few hoof marks with muddy water a couple of inches deep. *Anophe-line* larvæ were found in two of these holes—two larvæ in one and five in another. They were situated about 150 yards from the nearest house.

Passing further along the channel to where it turns at right angles and runs through a paddock to Union-street, about half-way between the bend and this street is a small swamp, well covered with grass. The water is clear, about 20 square feet in area, and averages about 3 inches in depth. *Anophe-line* larvæ were here in scanty numbers—only four being found alto-gether. *Culicine* larvæ were also scarce. The nearest house was only a few yards away.

Continuing along the channel through the field on the opposite side of the road, no larvæ were found till the channel turned north, where there is a borrow pit about 30 feet long and 6 feet wide—the water muddy—with reeds, &c., at one end. Nine *Anophe-line* larvæ were found here. From this point no larvæ were found till the channel turned east, where a borrow pit runs alongside the channel till nearly at the back of the State school, where five *Anophe-line* larvæ were found in a small hole. The distance to the school would be about 300 yards.

In no instance were mosquito larvæ found in the channel itself although some parts of it afforded excellent shelter, particularly the portion immediately behind the State school, where reeds and a kind of water lily were growing in it.

The next part examined was a wide drain alongside the railway line going east from the railway station, on the right hand side. The first part of the drain—about 100 yards in length—was cut off from the rest by a bank of earth across it. *Anophe-line* larvæ were very scarce indeed, only six larvæ being found in the drain. *Culicine* larvæ were, on the other hand, common. The water was clear, with a large amount of dead and decaying vegetable matter in it—mostly grass.

The next part of the drain was much freer of vegetable matter; the water was muddy and contained enormous numbers of *Culicine* larvæ and pupæ, but careful search failed to reveal any *Anophe-line* larvæ.

The drain gradually narrowed toward the mile peg from the town to about 18 inches wide, and was dry and heavily overgrown with grass and other herbage. As no water was found in it for the next half mile, search was discontinued.

The next portion examined was the channel on the northern side of the railway station, commencing near the butter factory. There is also a wide drain alongside the channel. No larvæ were found till the end of the street was reached, where the drain terminated. No *Anophe-line* and only a few *Culicine* larvæ were found in this dead end.

Continuing along the channel to where it runs into railway property, a small pool about 6 feet by 8 feet in area and only a few inches in depth was found, in which *Anophe-line* larvæ were taken in small numbers, nine being found altogether; only one larva was found to a dip of the scoop, except once, when two were taken. *Culicine* larvæ were common, being present in hundreds.

A short distance further along the channel several borrow pits were found but no *Anophe-line* larvæ and very few *Culicine* larvæ were seen.

The same channel was followed till another channel branching off this was met, and followed in a northerly direction for about a quarter of a mile, when small collections of water were found between the standing crops and the channel bank.

The majority of the holes were hoof holes made by horses and cattle, and contained up to 4 inches of water. *Anophe-line* larvæ were present in the first seven holes examined in the following numbers:—eight, five, two, one, eight, seven, and 34. The larvæ varied in age from very young to adult forms. Here the *Anophe-line* were more numerous than the *Culicine* larvæ.

Working forward, successive areas of water were found containing *Anophe-line* larvæ. A pool about 20 feet long and about 2 feet wide contained very large numbers, as many as 30 *Anophe-line* larvæ being taken at each dip of the scoop. Counting those in a small area and estimating the rest, there must have been approximately 600 *Anophe-line* larvæ present. *Culicine* larvæ were also numerous but not so common as the *Anophe-line*.

Near by was a depression about 20 feet long and a few feet wide, which also contained large numbers of *Anophe-line* larvæ. Two hundred larvæ were counted in about half its length; estimating the number of *Anophe-line* in the remaining part the depression must have contained more than 400 specimens in addition to the *Culicine* larvæ which, however, were not so numerous.

Still further along the channel a narrow strip of water about 16 feet long contained considerable numbers of *Anophe-line* larvæ—150 were counted on the surface of the water. There were exceptionally few *Culicine* larvæ present.

About a chain further on were a few more collections of water, one of which—a hoof hole—contained 50 *Anophe-line*, besides numbers of *Culicine* larvæ. Another similar collection of water contained eight *Anophe-line* but no *Culicine* larvæ. Slightly further on in a narrow pool, about 9 feet long, nine *Anophe-line* and a few *Culicine* larvæ were seen. Close by were three small collections of water which contained respectively four, two and 23 *Anophe-line*, and small numbers of *Culicine* larvæ. The *Anophe-line* larvæ varied in age from very young ones to adults, but the latter were in the majority.

instance between standing crops and the channel bank, were protected from wind by the crops, the channel bank, and the grass and weeds growing in and around them, thus making them ideal breeding grounds.

Adult mosquitoes, particularly a fairly large one of *Culex* type, were extremely numerous, so much so that when walking through grass paddocks and along channel banks where the herbage is generally long, myriads were disturbed, which attacked one viciously.

In addition to the above species, there were two other species of *Culicinae* which were common. The Scotch or Hexham Grey (*Mucidus alternans*) was also found, but not commonly.

Notwithstanding the fact that large numbers of *Anophele* larvae had been found in various parts of the district, only two adult specimens of *A. (Nyssorhynchus) annulipes* (Walker) were found, the conclusion formed was that the mosquitoes were only just commencing to hatch out.

Weather conditions were somewhat unsettled for part of my stay. Light to heavy rain fell during two days, and high winds prevailed for five days. Nearly every day was more or less overcast for part of the time, some days entirely so.

Summary.

The most abundant mosquitoes at the time of my visit were a species of *Culicada* and a *Culex* sp. The Scotch or Hexham Grey (*Mucidus alternans*, West.) was also bred from larvae.

Notwithstanding the fact that large numbers of *Anophele* larvae were found in various parts of the district, only two specimens of *A. (Nyssorhynchus) annulipes* were found.

The conclusion formed was that the previous broods of adults had been killed by the almost continuous rain and wind prior to my visit, and that they were only just recommencing to hatch out.

It is evident from the number of larvae found that the *Anophele* mosquito is a common species in the Kyabram district, and that should it become infected with the malaria parasite it would probably be a serious matter for the district.

BAMAWM.

The weather, except for a couple of days, was on the whole considerably better during my stay from 24th October to 2nd November, 1916, than it had been at Kyabram.

Flood conditions still prevailed in many parts of the district, owing to the continuous heavy rains of September and early October.

Surrounding country flat and sparsely timbered, the trees being eucalypts and cypress pine. Population of district, about 1,000. Rainfall, 16.80 in. (average).

The irrigation channels are numerous and form a network through the settlement, which is entirely agricultural. The main channel, which also supplies the water for the Echuca settlement, some 16 miles further north, is about 3 miles from the Post Office in a southerly direction.

Weather conditions during my stay were, on the whole, favorable to the work. Rain fell during one night and part of one day. The Sunday

River to flood. The days were more or less cloudy in the morning, becoming warmer in the afternoon. The nights were usually chilly.

There were still large quantities of water lying at the sides of the roads. Part of the road, about a mile, from Rochester to Bamawm, still had a couple of feet of water on it, which would leave innumerable pools behind when the flood water receded. This flooding was due to the Campaspe River overflowing its banks at Rochester.

The average depth of the water on the road side and in the paddocks was only a few inches. The swamps, except one, were also shallow. The swamp near the Shire dam was deep.

The street collections of water were mainly formed by the borrow pits and ill-formed waterbodies.

There were also numerous waterholes in paddocks for the use of stock. In addition to these sources of water, there are also numerous small channels, sometimes two in each field, which are used for irrigating the crops with water drawn from the irrigation channels. These irrigating channels always contain a greater or less quantity of water throughout the year.

The banks of the main, secondary, and small irrigating channels are always covered with thick crops of grass, in some cases with dense growths of tall thistles and reeds, which afford excellent shelter for mosquitoes. In many instances the small irrigating channels are completely covered with reeds, &c., and thus when they contain water they form excellent breeding grounds, being well protected from wind. The borrow pits on the sides of the roads and waterbodies are also at times overgrown with reeds and grass.

There is, in addition to the above collections of water, a fairly large gravel pit, just off the road, about a quarter of a mile from the post office, which contained three pools of water about a foot deep in the deepest part.

The channels and the majority of other collections of water are in the sunshine the best part of the day. Some of the small irrigating channels and pools of water are protected from the sun for part of the day by the crops and by the growth of reeds and grass on their sides.

The water, in every case but one, in the irrigating channels, borrow pits, and pools was muddy; in the swamps it was clear.

In some cases the water on the sides of the roads was from 4 to 6 feet wide and extended for a considerable distance. The latter are only overgrown with reeds, &c., on their sides, in rare instances being covered with growth.

Only two of the small irrigating channels seen were covered with scum. Drift was also rarely seen.

The irrigation channels and collections of water on the road, unprotected by reeds, &c., are subject to wave action caused by the wind. The strongest wind in this district is the south-west.

All the breeding places are in close proximity to a constant source of blood supply, both human and animal, for the mosquitoes to feed upon.

In some cases the distance from houses and obstacles, such as outhouses, fences, &c., is only a few yards, while in others it perhaps extends to a quarter of a mile.

Mosquito larvae were found in the majority of the collections of water examined, usually in large numbers, while myriads of adults were starved while sheltering in the long grass and other such places.

Predaceous insects, such as water beetles, waterboatmen, and insect larvae were conspicuously absent in many places. On no occasion were they found to be common. The crustacean, *Lepidurus* sp., was only met with in one large collection of water. No mosquito larvae were found in this pool.

Bull frogs were, in some instances, comparatively common, and though it is probable they destroy large numbers of larvae, yet the latter are usually to be found in company with them in fairly large numbers.

Large numbers of *Culicine* larvae were found breeding in the street collections of water. In some cases they were extremely numerous, occurring in thousands along the edges of pools amongst the grass and reeds. It is in such places, sheltered from wind, that the *Anophele* larvae are to be found.

Commencing the examination of the road pools from near the post office, and working north, *Anophele* larvae were found in two collections of water, about 100 yards from the post office, in fairly large numbers by dipping with the scoop along the edge of the water, two or three larvae being taken at each dip.

A few yards further along, where the channel runs parallel with the road, *Anophele* larvae were found in similar numbers in the water on the road side.

This was an ideal situation as a breeding place, as it was entirely overgrown with reeds. The channel was crossed at this point, and the small irrigating channels and other collections of water amongst the crops were examined.

In an irrigating channel, between two cultivated paddocks, *Anophele* and *Culicine* larvae were found, the former in small numbers, rarely more than one larva being obtained at each dip of the scoop; on the other hand, the *Culicine* larvae were very common, as many as forty being taken at a single dip of the scoop.

Another small channel was found further back which proved an ideal breeding ground for mosquitoes, as in some parts it was entirely covered by a dense growth of grass on both banks.

It was possible, by lifting the grass aside gently, to capture three or four *Anophele* larvae at a time. On one occasion nine were taken at a single dip of the scoop. *Culicine* larvae were also very common, being present in hundreds.

Two waterholes on either side of the dead-end of the above channel were also similarly infested with both *Anophele* and *Culicine* larvae.

The nearest house was only a few hundred yards away. It was in a grass paddock near this channel that I saw the farm horses galloping about after their day's work in the vain endeavour to free themselves from the mosquitoes which were attacking them.

The mosquitoes, on this occasion, settled on one's face, hands, and clothes in hundreds. The day had been somewhat cloudy and warm with very little wind.

Following the channel, near the main road, in a northerly direction through cultivation fields, no larvae were found till the first cross road was met. Turning down this road and following it for some distance toward the Shire dam, mosquito larvae were found in the pools and borrow pits on the sides of the road.

Water was lying along the road from where the channel crosses it to beyond the Shire dam—a distance of about a mile and a quarter. Before the Shire dam is reached a road branches from the one in question towards the State school. Some of the pools were small, but others several feet wide and of considerable length.

Larvae were found in about 80 per cent. of the pools, the majority of which were fairly well protected from wave action by reeds and other herbage. In some no *Anophele* larvae were found and only very few *Culicine*, while in others, which were better protected by reeds, large numbers of *Culicine* larvae were found. *Anophele* larvae were found in varying numbers, from a single larva to five or six to a dip of the scoop.

Culicine egg rafts were also numerous, as many as half a dozen rafts being seen every few inches in some instances. Two rafts were broken up and the eggs counted—one contained 120 eggs, the other 185.

Adult mosquitoes were very abundant in the long grass inside the fences of the cultivation fields, and when disturbed flew up in clouds.

A waterhole, on private land near the road, with steep banks, well protected from the wind, had large numbers of *Culicine* larvae in it. *Anophele* larvae were scarce, as no more than a single larva was taken at each dip of the scoop.

Turning up the cross-road toward the school, similar conditions to those on the previous road prevailed, although the pools of water were not so numerous. Both *Anophele* and *Culicine* larvae were present in similar numbers. This was especially so in a collection of water alongside the channel where it crosses the road on its way toward the school. This pool was swarming with *Culicine*, while *Anophele* larvae were also common. On no occasion were less than three larvae taken at each dip of the scoop, while on one occasion no less than sixteen were taken.

No larvae were found in the waterhole situated between the school and the road, though careful search was made.

No *Anophele* and but few *Culicine* larvae were found in the State nursery, situated a short distance from the school, this being probably due to the fact that there was very little water lying about, and that the small irrigating channels had been cleaned out.

Working back, however, in a southerly direction along the channel, which passes through the nursery, *Anophele* and *Culicine* larvae were found a couple of hundred yards from the nursery. Both types were fairly numerous. Usually one or two larvae were taken at a single dip of the scoop, more often two were taken, on one occasion five specimens were captured. Working still further back, water was found in a small irrigating channel at the head of a lucerne field which contained numerous *Anophele* and *Culicine* larvae. The former were found in varying numbers, from a single specimen to half a dozen being taken at each dip of the scoop. The *Culicine* larvae were much commoner, the numbers taken at each dip of the scoop varying from twelve to 35.

There is a small shallow swamp of clear water in a paddock off the road leading to the Shire dam, and just beyond a long, high boxthorn hedge alongside the channel. Mosquito larvae were not common here. *Anophele* larvae were only found after a prolonged search, the average being about one larva to every half dozen dips of the scoop, and about six *Culicine* larvae to each dip of the scoop.

There is a swamp of considerable size adjoining the Shire dam. Large numbers of *Culex* larvae were found in it, often as many as a hundred being taken at each dip of the scoop. *Anopheles* larvae were also fairly common, usually one or two were taken at each dip of the scoop, but occasionally as many as half a dozen were taken.

Working south from the post office no larvae were found in the pools till the cross roads were reached—a distance of about a quarter of a mile—when turning to the right both *Anopheles* and *Culex* larvae were found; the former were scarce, only one larva to about every twelve dips, while nine was the average number of *Culex* larvae taken at each dip of the scoop.

Inside the fence of a cultivated field alongside the road was a small irrigating channel containing clear water—the only one found with clear water. *Anopheles* larvae were common here, each dip of the scoop capturing upwards of five larvae; in one case a dozen were taken. *Culex* larvae were also common, on an average 30 larvae being taken at a single dip of the scoop.

Anopheles mosquitoes were common on one farm, the numbers captured on six successive days being—65, 260, 83, 190, and 215; total 813. The number of males was 143; 65 per cent. of the females were gorged with blood.

The day on which the 260 specimens were taken had been warm, with scarcely any wind.

In every instance the mosquitoes were taken on the edge of crops near to, or not far removed from, their breeding places. The farm house was not more than a quarter of a mile distant.

On one occasion, between 3 and 4 p.m., 30 adult *Anopheles* mosquitoes were taken, sheltering in a cow shed and stable. All were gorged with blood.

Summary.

Considering the comparatively large numbers of *A. (Nyssorhynchus) annulipes* seen, it would appear that it was a common species in and around Bamawm. For although the larvae were not found in what might be considered large numbers, yet they were well distributed over the district. The majority of the breeding places furnish ideal conditions for the propagation of the adult mosquito.

It is quite possible that if this mosquito became infected with the malaria parasite, it would become a menace to the health of the district.

Numerous specimens of a small *Culex* were bred from larvae and pupæ, together with some *Anopheles* and a *Culex* species.

The mosquitoes found at Bamawm were—

Culex sp.—A large dark-coloured species, which was very common.

Culex sp.—A much smaller species; fairly common.

Grubbia sp.—A species with spotted wings and legs; very active, and fairly common.

A. (Nyssorhynchus) annulipes.—Common about sundown, and very active.

A fact to be borne in mind in connexion with the great prevalence of mosquitoes both at Kyabram and Bamawm is the relatively enormous quantity of water (flood waters) which was lying about everywhere, due to the excessive rains which fell in Victoria during September and early October.

All the pools thus caused, and the swamps, also increased in size, afford in many cases excellent breeding places for mosquitoes, which exist in normal years in a much less degree than at present.

The land in and around Bamawm is so composed that the excess of water does not readily drain through the subsoil and thus leave the surface quickly.

I was informed that there is always a greater or less quantity of water in the small irrigating channels throughout the year—in the winter from the rains, and in the summer from the water used to irrigate the crops and orchards.

ECHUCA.

This district had suffered from phenomenally bad weather conditions, which included two floods, prior to my visit from November 3rd to the 14th; the result being that a large part of the area examined by me was still under water, which made my work almost impossible in the inundated portions.

The surrounding country is flat, and more heavily timbered than Bamawm. Both the Murray and the Campaspe Rivers, the latter entering the former at Echuca, have their banks well covered with timber.

Population, 4,000 (circa). Rainfall 16.90 inches (average).

The irrigation and small irrigating channels were similar to those at Bamawm, but the small irrigating channels appeared to be more numerous.

Weather conditions were not at all favorable during my stay, as heavy rain fell on four days, and strong winds prevailed nearly the whole time—only two days being calm.

There were still extensive areas of flood water on the irrigation area and elsewhere in the district, with a depth of over 3 feet in some parts. The collections on the roadside were very numerous, and several feet wide, varying in depth up to a foot.

One large area of water was seen which was caused by the Murray River "backing up" on to some low-lying land. It was about 3 miles long, and in its widest part appeared about half a mile wide.

No mosquito larvae were seen in this swamp, but as the water gradually receded it would leave a large number of pools in which larvae would undoubtedly be found.

The street collections were composed of long drains and borrow pits on both sides of the streets.

There were also waterholes in the paddocks for stock purposes. Besides these collections of water, there were numerous small irrigating channels and some partially flooded cultivation paddocks. In some instances these irrigating channels contained considerable quantities of water; in others they were almost dry.

The banks of the main channels and irrigating channels were all more or less overgrown with grass, reeds, and thistles, the small channels being, in many instances, completely overgrown. The drains and borrow pits were also covered with reeds, though the wide ones were usually so only on their sides.

The water in the channels, drains, and borrow pits was in the sunshine the best part of the day, except in such cases where they were completely overgrown, notably, many of the small irrigating channels.

In every case the water was muddy, no collections of clear water being found.

In no instance was scum found on the surface of any of the collections of water, and there was but very little drift. On one occasion the water in the long wide drains on each side of the road was green and foul.

The channels, many of the street collections of water and portions of the swamps, are subject to wave action due to the winds.

The majority of the breeding grounds are in close proximity to, or not far distant from, a constant source of blood supply, both human and animal, for the mosquitoes to feed upon.

Larvæ were found in the majority of the places examined, usually in large numbers, while very considerable numbers of mosquitoes were disturbed from their shelter in the reeds and long grass along the banks of the channels, drains, &c.

Predaceous insects and larvæ were not generally numerous. In one street collection, however, waterboatmen were very numerous.

No specimens of the crustacean, *Lepidurus* sp., were seen. Bull frogs were very numerous on some occasions. They, however, do not seem to aid in the destruction of mosquito larvæ to any material degree, as it was always possible to find both larvæ and bull frogs in the same pools in this district.

Large numbers of *Culicine* larvæ were found breeding in the street collections of water, especially when they were well protected by reeds, &c., from the wind.

It was in these well-protected collections of water, and in the small irrigating channels, that the *Anophele* larvæ were found. They were numerous in some cases.

The examination of the drains and borrow pits along the road leading from the town to the irrigation area revealed the presence of both *Anophele* and *Culicine* larvæ. The latter were very common in every collection of water along the whole distance of the road. *Anophele* larvæ appeared only at odd intervals in these collections of water, and always along the edges among the reeds. It was only possible to obtain occasional specimens every few yards after careful search, though on a few occasions the larvæ were found in greater numbers. Nine larvæ were taken on one occasion at a dip of the scoop, and on two other occasions six. At no other time was more than one larva found to a dip of the scoop at every few yards.

Although *Culicine* larvæ were found in pools unprotected by reeds along this road, I was unable to discover any trace of *Anophele* larvæ in these situations.

Turning to the right on reaching the cross road in which the school is situated, *Culicine* larvæ were found to be extremely numerous, as many as 100 larvæ and pupæ being taken at each dip of the scoop in the drains at the side of the road.

Anophele larvæ were not common in some parts of the drain, only one to a scoop being found, but in other parts as many as five to a dozen larvæ were taken at each dip of the scoop.

This drain was an ideal breeding place, as the water was well protected by reeds standing about 2 feet high, thus making it difficult to get to the larvæ without disturbing them by the movement of the reeds.

Proceeding still further along this road to the next cross road, *Anophele* and *Culicine* larvæ were met with, the former frequently and the latter abundantly. As many as five *Anophele* larvæ were taken to each dip of the scoop,

while on one occasion seventeen were taken; the average number of larvæ taken being eight to a scoop. On no occasion were less than three taken at a time. *Culicine* larvæ were abundant, some parts of the water being black with the larvæ and pupæ.

Adult *A. (Nyssorhynchus) annulipes* were found here sheltering on the edges of the growing crops. Five were taken, the time being a little before noon.

The small irrigating channels in this part were somewhat heavily infested with *Anophele* larvæ. Twelve of these channels were searched in various parts, and it was always easy to find the larvæ sheltering amongst the grass and reeds growing in the water. One of these channels in particular contained large numbers of *Anophele* larvæ, six consecutive dips of the scoop, in about 100 yards of channel, capturing larvæ in the following numbers:—7, 19, 11, 41, 27, and 32. Only once were less than ten larvæ taken at each dip of the scoop in these channels, and on one 59 were taken. This channel, which was on the edge of a standing crop, was well protected from the wind both by its banks and by the growth of herbage all over it. The nearest house was about a quarter of a mile distant.

Culicine larvæ were not in such numbers as the *Anophele*. Here also two adult *Anophele* were taken during the afternoon.

Somewhat further down the road both *Anophele* and *Culicine* larvæ were found in the drains on each side of the road. The *Culicine* larvæ were much the commoner, and were taken in numbers varying from fifteen to over 100 at each dip of the scoop. The *Anophele* larvæ were found in numbers varying from one to eight larvæ to each dip of the scoop.

Similar conditions to the above prevailed in all other parts of the area examined in regard both to *Anophele* and *Culicine* larvæ and the quantity of water lying about.

Culicine egg rafts were also moderately common in most of the channels, drains, &c., three or four being found every foot or so wherever examined.

Adult mosquitoes of the *Culicine* group were extremely common, rising in clouds when disturbed from their shelter amongst the reeds, grass, &c., on the sides of the channels and other collections of water.

A. (Nyssorhynchus) annulipes was not so common as at Barnawm. Being a frail mosquito, easily buffeted by the wind, it is probable that the strong winds were a determining factor in the smallness of the numbers taken. The number of specimens captured on seven consecutive evenings indoors being—5, 32, 10, 14, 9, 25, and 19, total 114; average per evening 16. The number of males was 22. 58 per cent. of the females were gorged with blood.

Summary.

It is necessary to state that weather conditions were very adverse to the work in hand during my stay in Echuca, as heavy rain fell on several occasions and strong winds prevailed almost continuously. Under these conditions it was not surprising to find that the *Anophele* adults were scarce.

Culicine adults were rarely seen on the wing, but were abundant amongst the long grass and reeds. However, judging from the number of *Anophele* larvæ seen, it is, I think, reasonable to assume that *A. (Nyssorhynchus) annulipes*, Walker, is a fairly common mosquito in the Echuca North Settlement.

The mosquitoes found in the district were *A. (Nyssorhynchus) annulipes*, *Culiseta* sp. and *Culex* sp.

SWAN HILL.

The weather conditions were, with the exception of a few sharp showers, good during my stay from 17th November to the 25th, being mostly warm clear days.

This district did not appear to have suffered from the phenomenally heavy rains which fell during September and early October, as the levee bank had withstood the flood waters of the Murray River.

Surrounding country flat and very sparsely timbered. Population, 6,000. Rainfall, 13 inches (average).

Irrigation Channels.—The Swan Hill pumping station is situated on the northern edge of the town.

The nearest channel (the western) runs on the outskirts of the town. This channel divides, when it reaches the railway line to Nyah, sending a channel in a northerly direction. It does not divide again till about 3 miles from the town, when it bifurcates, one channel in a southerly, the other in a northerly direction.

The remaining channels (the one on the river bank and its branches), borrow pits, &c., were next examined. There are few swampy areas on the settlement as far as seen.

Algae were found on several of the borrow pits, and in one instance the pit was completely covered.

In many instances the distance from residences and obstacles, such as fences, shrubs, &c., was only a few yards to the breeding places. In other cases the distance would extend up to about half-a-mile.

Channel stops and bridges over the channels were found to be common sheltering places of the adult mosquito. The bridges and some of the channel stops are in close proximity to dwelling-houses.

There were very few street collections of water. Numerous extensive borrow pits existed along the railway line and channels. The borrow pits were in some instances about 20 feet wide and correspondingly deep. Those along the channels were narrower, usually about a foot deep, and were overgrown with grass and reeds.

Generally speaking, the banks of the channels and borrow pits are gently sloping, though in some cases those of the borrow pits are steep. The edges of the borrow pits, especially those on the railway line, are extensively covered with reeds and other growth, which extend into the water for 2 or 3 feet.

The water has, in some cases, extended from the borrow pits on to the adjoining land, thus forming a swampy area. In some cases also the channels are overgrown with tall reeds, while a small yellow-flowering hyacinth and other aquatic plants are also relatively common.

The majority of the channels, borrow pits, and swampy areas are unprotected from the sun. The channels, borrow pits, and swamps are subject to wave action, caused by the wind, except those overgrown with reeds.

The water is, generally speaking, muddy, but some of the swamps contain clear water.

There are numerous predaceous insects and larvæ in the water—water beetles, dragonfly larvæ, waterboatmen, &c. Large numbers of very young Murray cod were seen on some occasions in a channel near the river. Yabbies, or young Murray River crayfish, were also common in the channels, but the part which young Murray cod and yabbies play in mosquito destruction is unknown.

The number of *Anophele* adults and larvæ, in contrast to those of the *Culicine*, was very marked. In this district the former predominate, this being contrary to what has been found in other districts visited.

Large numbers of *Anophele* larvæ were taken in some small pools of water near the entrance to the pumping station, the number of larvæ varying from 30 to as high as 91 to each dip of the scoop.

Culicine larvæ were not so common, as on no occasion were more than sixteen taken in one dip of the scoop.

All along the western channel *Anophele* larvæ were easily found in numbers varying from one to as many as 43 larvæ to each dip of the scoop. Then working across along the channel to the railway line *Anophele* larvæ were found in numbers from one to five larvæ to each dip of the scoop along the small irrigating channel inside the cultivation field.

Culicine larvæ were more or less common along this channel, from the point where it left the western channel to the railway line. They were very common in one small pool, as many as 100 larvæ being taken at each dip of the scoop.

All the larvæ, both *Anophele* and *Culicine*, ranged from very young to adult forms.

The channel "stops" proved to be a very fruitful source of adult mosquitoes, particularly *A. (Nyssorhynchus) annulipes*, large numbers being found sheltering in them. Six "stops" were examined in the length of channel, the following number of *N. annulipes* being taken in them:—100, 34, 63, 22, 74, and 51; total 344; average for each, 57.3. The number of males was 62, and 71.6 per cent. of the females contained blood.

Specimens of *Culex* sp. were also found in the same shelters, but were not nearly so common as *N. annulipes*.

Extending the examination over further portions of the irrigation area, both *Anophele* and *Culicine* larvæ were readily found, although on a few occasions the latter were only found after long search.

Anophele larvæ were sought with varying success along the margins of the borrow pits, in the small irrigating channels, and street collections of water. They were also found on two occasions in the channel, where there was a considerable growth of aquatic plants. The larvæ were found in numbers varying from 3 to 84 to each dip of the scoop in this area, and ranged from young to adult forms.

The case of heaviest infestation was about 2 miles from town in a small irrigating channel alongside the road which follows the Murray River. Here also the adult mosquito was common, 60 specimens being taken in a channel stop, 38 of which were gorged with blood. There was a farm house on the opposite side of the road.

MILDURA.

The undulating, almost hilly, nature of the district, combined with the porous nature of the soil, does not appear to lend itself to the general breeding of mosquitoes, as extremely few pools of water were found during my stay from 26th November to 6th December, notwithstanding the fact that several sharp showers fell during that time.

The township and settlement are situated on undulating ground, which appears to be naturally well drained, and are well above river flood level.

The surrounding country is covered with mallee scrub, saltbush, and bluebush. Population, 4,000 (approximately); rainfall, 10.94 in. (average).

There are extensive billabongs along the river frontage, but as these were flooded to a depth of several feet, no idea of their size or of whether they are extensive mosquito breeding grounds under normal conditions could be obtained. That mosquitoes do breed in them is borne out by statements of local residents.

Mildura is served by several pumping stations, the water being raised in one case to a height of 90 feet above river level. The irrigated area comprises about 12,000 acres of a total of 250,000 acres, the remainder being given over to dry farming, &c.

Irrigated orchards and vineyards occur right in the town, and extend for some miles on three sides, the fourth being the river frontage.

A noticeable feature of Mildura, not seen on previous irrigation areas, is the concrete irrigation and small channels which have been constructed to prevent seepage from the channels into the irrigated land. Exceptionally few earth channels were seen—only one large one and but few small ones were met with. The channels when not in use generally contain very little, if any, water.

The water was slightly muddy in all cases, except in some street collections, where it was clear.

All the breeding places found were in close proximity to a constant source of blood supply, both human and animal, for the adults to feed upon. The distance was in no case more than about a quarter of a mile, in some much less, from the breeding ground to the dwelling-house.

During the greater part of my stay, practically all the small channels were quite dry, and the large ones almost so, since the pumping stations were not working, as the crops were not then being irrigated.

There were few street collections of water, and these only in outlying parts, this being due to some heavy rain which fell during my stay. These collections were free from larvae and other insects. I was informed that water does not generally lie about long on account of the loamy nature of the soil.

Only two street collections of water were found in the town—the largest, a borrow pit in Deakin-avenue, near 15th-street, overgrown with reeds and grass, contained large numbers of *Culex* but no *Anopheles* larvae. It was an unlikely breeding place for the latter, as it contained large quantities of decaying grass and other vegetable matter, such localities, as a general rule, not acting as breeding places for *Anopheles* larvae. The other street collection was an overflow from a small irrigating channel (on the western side of the town) into a small drain which leads on to a piece of ground. Larvae were found here.

Eight channel "stops" were examined in this section, and all mosquitoes in them were caught. The numbers were—8, 28, 45, 26, 60, 41, 47, and 26; total 281; average per stop, 35.12. Thirty-two were males, and 64 per cent. of the females were gorged with blood. All were *Anopheles*.

Going further afield *Anopheles* larvae were found in similar numbers to other parts examined. Adults were also commonly found as before in the channel stops. Ten channel stops were examined and the following *Anopheles* caught:—4, 75, 44, 7, 28, 16, 35, 54, 9, and 25; total, 297; average per stop, 29.7. The number of males was 35; 60.3 per cent. of the females were gorged with blood.

Owing to the height of the water in the channels, it was impossible to obtain the adults of *A. (Nyssorhynchus) annulipes* from beneath a section of the bridges, to estimate the numbers in shelter in these situations. They were, however, seen to be common. On one occasion, however, 60 specimens were counted on the edge of one bridge, and many more were seen further under, so that there must have been some hundreds present.

Attention was paid to the number of adults *A. (Nyssorhynchus) annulipes* found indoors, the site selected being the hotel where I stayed. Certain rooms and outhouses were examined, morning and evening, with good results, particularly in the evening if the day had been hot. The total number of specimens taken each day being 100, 84, 210, 52, 97, and 62; total 605; average each day, 100.83. The number of males was 162; 97 per cent. of the females were gorged with blood.

The two bath-rooms were always the most heavily infested with the adults, as they were much darker than the other rooms examined.

N. annulipes could, with little trouble, always be found indoors any time of the day or night.

The nearest breeding grounds to this locality were two swamps of considerable size on the New South Wales bank of the river, about a quarter of a mile away, which were the result of the overflowing of the river bank during the recent floods, owing to the absence of levee banks on that side of the river. These swamps will drain away as the river falls, but as this will be very gradual it will take some time, and even when the surplus has drained back into the river innumerable pot-holes of water will remain, which will continue to breed mosquitoes for a considerable time.

These swamps, like some of the borrow pits and other collections of water on the irrigation area, are excellent breeding places, as they are well covered with herbage, which protects the water from wave action, at the same time affording good cover for the adults when hatched.

Summary.

In view of the number of adult *A. (Nyssorhynchus) annulipes* taken and larvae seen in various parts of Swan Hill, it may be safely considered that the *Anopheles* concentration is sufficiently strong, and that if they at any time become infected with the malaria parasite, they would in all probability be a menace to the public health of the district.

The mosquitoes found were *A. (Nyssorhynchus) annulipes*, *Culex* sp., *Culiseta* sp., and *Scutomyia notoscripta* (Skuse) (one specimen only).

The borrow pits along part of the railway line examined near Irymple are narrow and shallow, containing little water. There were also some borrow pits along a channel in the eastern section, which was raised a few feet above the level of the surrounding ground.

Few predaceous insects and larvæ were seen, which may have been due to the small quantities of water met with, the only places where they were found being the borrow pits in Deakin-avenue and those alongside the raised channel, and a street drain in the eastern section.

The contour of the channels is such that after the land has been irrigated very little water remains in the main channels, whilst the small ones are entirely dry.

In many instances several miles were traversed without any water being seen.

The construction of concrete channeling has, at least in some parts of Mildura, been a material factor in mosquito destruction.

It is also worthy of note that the channel "stops" afford practically no shelter to mosquitoes, as they are not covered in as at Swan Hill, being simply a piece of boarding let into slots at the entrance of the small irrigating channel into the larger channel.

The bridges over the channels were also not so productive of adult specimens, which was due to the lack of breeding places, as the shelter they afforded differed in no wise from that at Swan Hill.

Specimens of very young Murray cod and also yabbies, or young Murray River crayfish, were seen in some of the main channels. They were, however, not common.

On the western side of the town *Anophele* larvæ were found in a short drain leading across a footpath on to a block of land in numbers varying from one to two larvæ to each dip of the scoop.

Culicine larvæ were more numerous, occurring in numbers up to twenty larvæ to each dip of the scoop.

Anophele larvæ were also found in a small pool of water in an overgrown channel junction. Forty-five larvæ were taken, the majority of which were adult. *Culicine* larvæ were more numerous, 30 larvæ being taken to each dip of the scoop—these were also mostly mature forms. The area of the pool was about 1 foot by 2 feet 6 inches and about 6 inches deep.

Anophele larvæ were also found in a small irrigating channel in numbers varying from one to three larvæ to each dip of the scoop. *Culicine* larvæ were numerous, as many as fifteen being taken to a dip of the scoop. The collection of water was about 6 feet long by about 1 foot wide and a couple of inches deep.

Adult *Anopheles* (*Nyssorhynchus*) *annulipes* were taken only in six channel stops, the numbers being 2, 5, 1, 9, 3, and 7; total 27, eight being males. Sixty-one per cent. of the females were gorged with blood. They were also found under four road bridges in the following numbers:—16, 5, 8, and 1; total 30. Twelve were males, and 38 per cent. of the females were gorged with blood.

On the eastern side, both *Anophele* and *Culicine* larvæ were found in small numbers—one larvæ to a dip of the scoop—in a borrow pit alongside the railway line near Irymple.

Further over toward the Murray River, *Anophele* were found, one to a dip of the scoop, and *Culicine* larvæ from 17 to 60 to a dip of the scoop, in a grass-covered drain on the side of the road.

Anophele and *Culicine* larvæ were found in a borrow pit on the side of a raised concrete channel. The pit was about 8 feet wide, 1 foot deep, and of considerable length. *Anophele* larvæ varied in numbers up to five to a dip of the scoop, the average being two. *Culicine* larvæ were very common, the number taken varying up to 86 to each dip of the scoop. Pupæ were also numerous.

A drain on the roadside near by also contained *Culicine* larvæ in small numbers, four larvæ being taken to a dip of the scoop. No *Anophele* larvæ were found in this drain.

A borrow pit in Deakin-avenue, near 15th-street, completely overgrown with reeds and grass, contained large numbers of *Culicine* larvæ and pupæ, the average being 57 to each dip of the scoop. No *Anophele* larvæ were found here.

A considerable distance further out on the avenue *Culicine* larvæ were found in varying numbers in the drain on both sides of the road, 7 to 23 larvæ being taken to a dip of the scoop. *Anophele* larvæ were scarce, only a single specimen being taken at odd intervals.

Adult *A. (Nyssorhynchus) annulipes* were found in small numbers in the bath-room of the house where I stayed, the number taken being 12, 7, 19, 14, 6, and 11; total 69; average per day, 10.9. Twenty-four were males. All the females were gorged with blood.

In addition to *A. (Nyssorhynchus) annulipes*, specimens of *Stegomyia* sp., *Culicada* sp., and *Culex* sp. were taken.

Summary.

Anopheles (*Nyssorhynchus*) *annulipes* was practically absent from Mildura at the time of my visit, but whether this condition is maintained throughout the year is unknown. This apparent scarcity of adults and larvæ may, perhaps, be accounted for by the lack of suitable breeding places in the settlement, concrete channeling, which became necessary on account of seepage on to the cultivation blocks, having replaced earthen channels.

Should this species be as scarce during the rest of the year as during my visit, it is extremely improbable that it would ever be a source of danger to Mildura.

The controlling influence of predaceous insects would appear to be limited, judging from the comparatively small numbers seen.

The commonest mosquito was a *Culex* sp. somewhat similar to *C. fatigans*, Wied. A few specimens of a *Culicada* were bred, apparently the same species which was found abundantly in the Goulburn Valley. A small delicate *Stegomyia* was bred from a mixed lot of larvæ. This species, which was rare, bears no relationship to *S. fasciata*, Fabricius.

REMARK.

Similar conditions to Mildura prevailed here during my visit from 8th to 16th December. It was unfortunate that it was irrigating week at the

Renmark settlement is situated on undulating country. The outlying parts are covered with gums, cypress pine, saltbush, and bluebush.

The irrigation channels, the main ones mostly earthen, are numerous. The smaller channels are of concrete. Some of the small channels are carried overhead, in which case they are constructed of galvanized iron.

The creek which separates the town from the settlement is much broader than in normal years, owing to the large increase of flood water from the Murray River. This creek is connected at the present time, both above and below the town, with the river, and is used in irrigating the land, the water being pumped into it from the Murray, and then to the higher levels of the settlement.

Weather conditions were far from satisfactory during my stay, as there were heavy scattered showers nearly every day. High winds also prevailed during the whole of my visit.

All the collections of water on the road side were fresh and were due to the recent rains.

There are three swamps on the edge of the settlement, two on the eastern side (one of which was dry) which are extensively covered with reeds and water grasses, and one on the southern side of the town, of considerable size. This swamp was flooded by the overflow of the river. It is apparently little overgrown and is subjected to wave action. These swamps were, apparently, negative.

My visit to Renmark unfortunately coincided with an irrigation, which necessarily washes out all larvæ from any of the channels which might have contained small quantities of water from a previous irrigation, besides dispersing larvæ from odd collections of water on the edges of cultivated areas.

Large numbers of predaceous insects, mostly waterboatmen and water beetles, and in a lesser degree dragonfly larvæ, were found in the swamps.

Algæ were common on parts of the swamps, the creek, and in some of the street drains where they enter the creek.

The banks of the channels are gently sloping and are generally free from thistles, docks, &c., which afford shelter for the adult mosquito.

There are two disused channels in the Eastern Section overgrown with reeds. A narrow channel, completely overgrown with reeds, a short distance from one of the swamps in the Eastern Section, which serves to drain a section of land, contained considerable numbers of mosquito larvæ.

All the borrow pits, of which there are a considerable number alongside the roads, and some of the channels, were dry.

The water in the swamps, the creek, and the drains into the latter was only slightly muddy.

The breeding places in all cases were in close proximity to dwellings, sometimes only a few yards and rarely more than a quarter of a mile away, thus assuring a constant source of blood supply, both human and animal, for the adult mosquitoes to feed upon.

The channel stops in the Renmark settlement are similar to those at Mildura, thus affording but scanty shelter to adult mosquitoes.

Considerable numbers of *Culicine* egg rafts and larvæ were found in a small sheltered washaway in the bank of the channel leading from the No. 1 Pumping Station to the creek. The average number of larvæ taken to each

No *Anophele* larvæ were found in this locality.

A trap hole in a concrete channel in the Eastern Section of the area contained small numbers of *Anophele* larvæ, ten in all being found. *Culicine* larvæ were more numerous, up to twenty being taken to each dip of the scoop.

The backwater of the creek in a street drain also contained larvæ, two *Anophele* and seven *Culicine* larvæ being taken to a dip of the scoop. An examination of the drain on the other side of the road failed to reveal any larvæ.

The narrow channel on the Eastern Section, overgrown with reeds, contained *Anophele* larvæ in fairly large numbers, as many as sixteen being taken at a dip of the scoop. On no occasion were less than five larvæ taken at each dip of the scoop.

Small numbers of *Anophele* and *Culicine* larvæ were found on the margin of the creek near the bridge in Renmark-avenue; the former averaged two specimens and the latter seven to a dip of the scoop.

Anophele larvæ were found in small numbers in the disused channels in the Eastern Section, the average number being one larva to a scoop at odd intervals. *Culicine* larvæ varied in numbers from one to sixteen to each dip of the scoop, the average being six. Adult *A. (Nyssorhynchus) annulipes* were found in only three channel stops and under one bridge; the numbers taken in the former were 5, 14, and 8, 13 of which were males. All the females were gorged with blood. There were 22 specimens under the bridge, five were males, and of the seventeen females twelve were gorged with blood.

Mr. Showell, president of the Renmark Water Trust No. 1, informed me that the time of my visit was unfortunate, as about a week later there probably would have been more breeding places, there being always a fair quantity of water lying in and around the channels for some time after an irrigation.

Summary.

Adult mosquitoes, both of the *Anophele* and *Culicine* were scarce in Renmark, on account of the then great lack of breeding places, and also the inclement weather. But judging from the fact that the *Anophele* mosquitoes prefer small shallow pools, and also taking into consideration the very porous nature of the soil in the irrigation area, it is improbable that *A. (Nyssorhynchus) annulipes*, Walker, would ever be prolific enough over an extended period to become a source of danger. It is not at all improbable that the predaceous insects in the swamp areas play an important part in mosquito control.

Three species of mosquitoes were found:—*A. (Nyssorhynchus) annulipes*, *Culex fatigans*, and *Culex* sp.

OVERLAND CORNER.

My visit, from 16th to 20th December, embraced ideal weather conditions, but notwithstanding the heavy rains which were experienced during the latter part of the year, there were no casual collections of water, the nature of the soil being such that it does not hold water above a few days.

Situated on the Murray River, about 30 miles from Renmark, by road, down the river. Population, 30 (approximately). Rainfall, 10 inches

The river flats had been inundated for some months, and will remain so for some time, as there were several feet of water on them. There are high banks back from the river bank, which divide the river flats from the Mallee land. The flats are covered with river (red) gums.

Mallee, pine, and sandalwood are the chief timbers growing on the high land.

The high banks facing the flats are intersected with numerous creeks which contain considerable quantities of water in the wet season, but are waterless in the dry season. They were dry at the time of my visit.

About a mile from the settlement up the river are three lagoons, but owing to the flats being flooded, they were completely hidden by several feet of water.

I should judge that these lagoons would be excellent breeding places for mosquitoes in the dry season, in the absence of flood waters, from what Mr. J. Hunter told me. He said they were fairly well sheltered, and that mosquitoes were fairly common near them. The river is unusually high this year.

Although careful search was made in the sheltered backwaters of the flood on the flats no *Anopheles* larvæ were found.

The only larvæ found were those of *Culex fatigans*, in a water tank, and some dead *Culex* larvæ in a small pool of water in an old abandoned house which had been in the flood waters.

Search was also made for *Anopheles* adults in the house where I stayed, in a stable, and in a cellar, but without result.

Summary.

Notwithstanding the apparent absence of *Anopheles* mosquitoes, I am sure they are to be found at Overland Corner, as the local conditions differ in no wise from those at Renmark. That they are there is proved by the fact that Dr. J. B. Cleland gave me, some time ago, several specimens of *A. (Nyssorhynchus) annulipes* which he had taken there and which were common at the time of his visit to Overland Corner.

I consider their temporary absence is due to the lack of suitable breeding places at the time of my visit.

LAKE BOGA.

The weather conditions here were ideal from 26th to the 27th December, the days being fine and warm, and very favorable to the work.

A parasitic fly is said to be attacking mosquitoes in this district. I expected on arriving at Lake Boga to find some small *Hymenopteron* or a parasitic *Dipteron* attacking the adult mosquito. This, however, was not the case, for Mr. Noske, a gentleman who has followed the question closely, told me that the insects which had kept the mosquitoes in check at Lake Boga were dragonflies. He said, on driving through the district, large numbers of mosquitoes were disturbed from amongst the grass which surrounded their breeding places, and that almost immediately after rising they were attacked by large numbers of dragonflies, with the result that at the time of my visit (about a month after he had made his observations) although careful search was made for mosquitoes, only one wild one and three *Culex fatigans* were found—the wild one was *A. (Nyssorhynchus) annulipes*.

In addition to the almost total absence of mosquitoes, the great scarcity of bush flies was also very marked when compared with other districts visited.

That the dragonflies played the part attributed to them was borne out by the fact that when I caught large numbers of them many were found which held between their jaws specimens of *Chironomida* and muscoid flies.

The commonest dragonfly, *Xanthagrion erythroneurum*, Selys, was a red and black species with blue apical abdominal rings. The next commonest was a metallic green and blue species, *Austrolestes annulosus*, Selys; the former was exceedingly abundant, but the latter was less common.

Little is known at present of the habits and food of the *Odonata*, but a recent paper* by Alfred Warren throws considerable light on their food habits. His paper deals with the life history and food habits of the cosmopolitan *Pantala flavescens*, Fabr.

The following passages may be quoted as bearing on the mosquito question at Lake Boga:—

"During this research, quite a number of specimens when caught were found to have some insects or portions of insects still in their mouth parts."—p. 30. And again on p. 35—"One day while watching a half-dozen or more yellow dragonflies darting back and forth in a sunny corner of a rice field hedged in by high bushes where a swarm of minute Chironomids or midges were basking in the sun, the writer could see that these flies were captured in great numbers. Four of these dragonflies were caught and on dissection every one of the four was found full, from the oesophagus to rectum, of the remains of these minute Diptera. A comparison of the bulk of the entire contents of the alimentary canal of one dragonfly with the bulk of one of these Chironomids would indicate that at a conservative estimate there must have been at least fifty of these flies."

Mr. Warren found that Dipterous larvæ and adults were the favorite food of the nymphs and adult dragon flies.

It was very evident when comparing the great scarcity of mosquitoes and other Dipterous insects in the Lake Boga district with their prevalence in other districts visited, that the relatively enormous numbers of dragonflies in the Lake Boga district (it was possible to catch them without the aid of a net) have played an important economic rôle in the destruction of both mosquitoes and other Diptera there.

Summary.

It may reasonably be inferred from the information given me by Mr. Noske, and from the fact that many specimens of captured dragonflies held portions of Dipterous insects between their jaws and also from Mr. Warren's findings, that dragonflies play an important rôle in the destruction of soft-bodied insects, such as mosquitoes and many other Dipterous insects.

COBDOGLA.

Ideal weather prevailed during my stay here, from 6th to 11th January, 1917, as the days were hot and dry, with the exception of one afternoon, on which rain fell. The soil is very loamy, and except for the flooded polygonum flats, practically no water was seen.

Population, 100 (approximate). Rainfall, 10 inches (approximate).

The greater part of the Cobdogla area is composed of limestone country, timbered with mallee and cypress pine for the most part. It is undulating.

loamy country, except on the river flats, which are of a heavier type of soil and fairly heavily timbered with redgum and polygonum bushes.

Cobdogla area, which has absorbed the old station of that name, situated on the northern bank of the River Murray, 20½ miles by river from Murray Bridge and about 30 miles by road from Renmark, comprises a total acreage of 141,000, of which 33,000 acres are irrigable. The old station had a river frontage of 90 miles.

Lake Bonney, 4,000 acres in extent, is situated within the Cobdogla area. It fills from the Murray through Chambers Creek, which branches from the river about 10 miles above Overland Corner, pursuing a tortuous course through the flats for some 6 miles before it enters the north-west corner of the lake. The present capacity of the lake is approximately 24,862 million gallons.

When the Cobdogla area is completely surveyed it will extend from near Overland Corner to the Beri settlement, which almost adjoins the Renmark settlement.

There are no permanent creeks on the area. Chambers Creek, which branches from the Murray, is at the present time submerged by flood water. This creek gradually becomes dry as the river falls to summer level, but when the weir across its mouth is erected, the depth of water in it will be controlled.

There are only a few channels constructed so far—the majority of concrete—and all were dry except the main one, for a short distance from the pumping station, situated on the river bank, and one leading from the Lake Bonney pumping station. The water in the former was old and only a few inches deep, and contained very little insect life—chiefly waterboatmen—but no mosquito larvae were found in it. This water was exposed to the sun and was wind swept. The water in the channel (an earthen one) from the Lake Bonney station, was fresh, the crops being irrigated during my visit. There is little doubt that if the water remains sufficiently long in this channel, it would become a breeding ground as it is fairly well protected, by growth on its banks, from wind.

The proximity of the breeding places to dwellings is very marked, being in many places only a few yards away, thus insuring a constant supply of blood, both human and animal, for the adults to feed upon. There are practically no barriers between the breeding places and the dwellings.

Predaceous insects and larvae were not common, being found only occasionally in the sheltered parts of the flood waters on the river flats and in the main channel.

Dragonflies were almost absent, though judging from the numerous nymphal casts on the tree stems they had apparently been common in the early summer.

Young and adult frogs were, on the other hand, extremely common.

Lack of permanent water has driven the mosquitoes to breed in sheltered parts of the flood waters on the river flats round the polygonum bushes. They were, however, not present in large numbers in any particular spot, as on no occasion were more than six larvae of *A. (Nyssorhynchus) annulipes* taken at a single dip of the scoop, the average being two larvae to a dip.

Adult *A. (Nyssorhynchus) annulipes* were found in two outhouses, the numbers taken on four consecutive mornings being 168, 87, 151, and 173, total 579, of which 95 were males. 89 per cent. of the females were covered

Culicine larvae were also found in small numbers—eleven larvae being the most taken at a dip of the scoop, while seven was the average.

The adult *Culicine* mosquitoes taken were *Culex fatigans*, and a species resembling *C. sitiens*, Wied.

Summary.

It is evident that, though the larvae of *A. (Nyssorhynchus) annulipes* were not found in any considerable number in one particular spot, the mosquito is nevertheless sufficiently common to be found in fairly large numbers in outhouses, as is shown by the daily average of 145 adults over a period of four days. There was also a large preponderance of females over males.

The *Culicine* mosquitoes were not as common as the *Nyssorhynchus annulipes*, as very few *C. fatigans* were found, and only 100 specimens of the species which is apparently *C. sitiens*.

POMPOOTA.

13th to 16th (afternoon).

The weather conditions were good during my stay here, from 13th to 16th January, 1917.

The general local conditions as regards soil, rainfall, and flood water were similar to what I found at Cobdogla.

Population, 140. Rainfall, 12 inches (approximately).

Pompoota, situated on the eastern bank of the Murray, comprises undulating limestone country and reclaimed swamp land. There are approximately 4,000 acres in the settlement, of which 560 are reclaimed swamp. The total irrigable land comprises some 800 acres. As elsewhere on the Murray, there are two types of country on the river at Pompoota—the undulating loamy soil, which does not hold the water, and the black soil swamp lands, which retains the water well.

The channels, on the undulating ground, are of concrete and, except when in use, do not contain water.

Those on the swamp land are of earth. I did not see these, however, as the whole area was under water.

There is a concrete water storage tank for domestic purposes situated about half-a-mile away on some rising ground. There is also a small water-hole on the settlement, but it was dry at the time of my visit.

The river flat, which I was unable to examine, contains about 20 miles of channeling, some 10 miles of which contains permanent water and 4 miles have more or less permanent water which varies in depth according to the depth of water contained in the main channels. The remaining 6 miles of channels have purely temporary water in them.

This river flat is unsheltered from the prevailing winds and in consequence is subject to considerable wave action while in its flooded state.

The distance from the only breeding place found on the settlement to the nearest dwelling would be about half-a-mile without any barriers such as trees and fences intervening.

Larvae of *A. (Nyssorhynchus) annulipes* were found only in one locality—

Although several outhouses and one bedroom were searched each day for adult *A. (Nyssorhynchus) annulipes*, only three specimens were found during the four days of my visit.

Considerable numbers of dragonflies were found on the levee bank which separates the river from the swamp land, where they are breeding in the water among the reeds on the river side of the levee. Waterboatmen were also comparatively common. Although conditions appeared favorable for the breeding of mosquitoes in this locality—an extensive one in length—no larvae could be found after prolonged search. The only Dipterous larvae found belonged to the family *Chironomidae*.

The lack of mosquito larvae was in all probability due to the presence of the dragonfly nymphs and waterboatmen.

It is worthy of note that though this levee bank is in no place more than half-a-mile from the settlement, I did not see a single dragon fly in the settlement, this being probably due to the lack of shelter for them.

After completing the investigations at Pompoota I paid a hurried visit to Mypolonga, a neighbouring settlement a couple of miles down the river, where, contrary to Pompoota, the levee bank had stood the strain of the flood.

There are some 1,500 acres of reclaimed swamp land in the Mypolonga area, which has about 18 miles of main channels and about 40 miles of secondary channels. Twelve miles of the main channels contain permanent water and the 40 miles of the secondary channels have temporary water in them.

There are in addition to this channel water some small areas of swamp water near the landing at the north end where I found as many as ten *Anopheles* larvae to a dip of the scoop. *Culex* larvae were also very numerous, 50 larvae being taken at a single dip of the scoop.

This locality was an ideal mosquito breeding place, as the water was not deep and it was well sheltered from wind by the channel bank and reeds.

The channels were examined at several points and somewhat similar conditions were found to those described above, although the larvae—*Anopheles*—were not so numerous as at the landing place, usually three or four being taken at a single dip of the scoop.

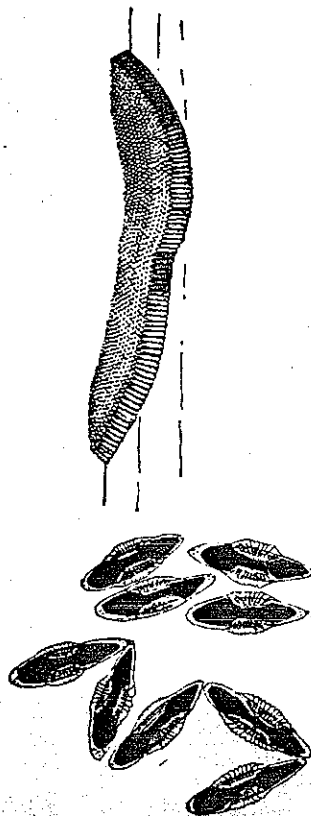
The importance of finding the larvae of *A. (Nyssorhynchus) annulipes* not uncommonly at Mypolonga cannot be under-estimated in regard to the Pompoota settlement, which is only a couple of miles further up the river on the opposite bank. This short distance makes it possible for the adult *Anopheles* to be blown over by the wind to Pompoota.

Both Mr. Grace, Pompoota, and Mr. Gray, Mypolonga, informed me that local conditions were similar in both settlements and that had the levee bank at Pompoota held against the flood I should have found the mosquito larvae in the channels there as at Mypolonga.

Mr. Gray also informed me that the reed bed at Wall Swamp (opposite Pompoota) usually has about 6 inches of water over it in normal river. Such being the case, it would probably be a mosquito breeding locality, as reed beds are, generally speaking, good breeding places.

22nd January, 1917.

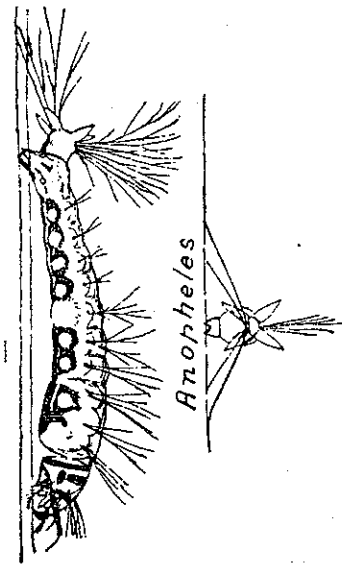
FRANK H. TAYLOR.



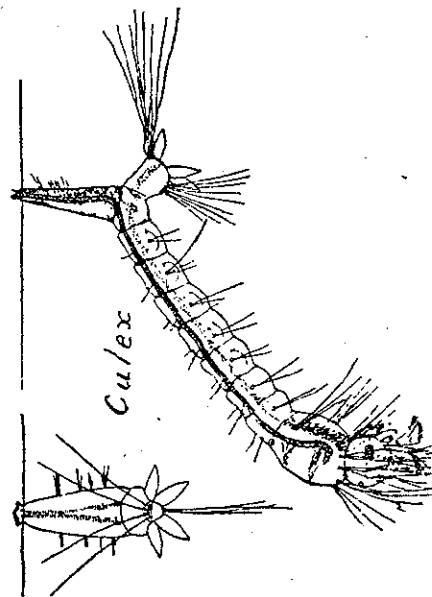
1.

1a.

1. *Anopheles* eggs. 1a. *Culex* egg raft. Greatly enlarged. (After Howard, U.S. Department of Agriculture).

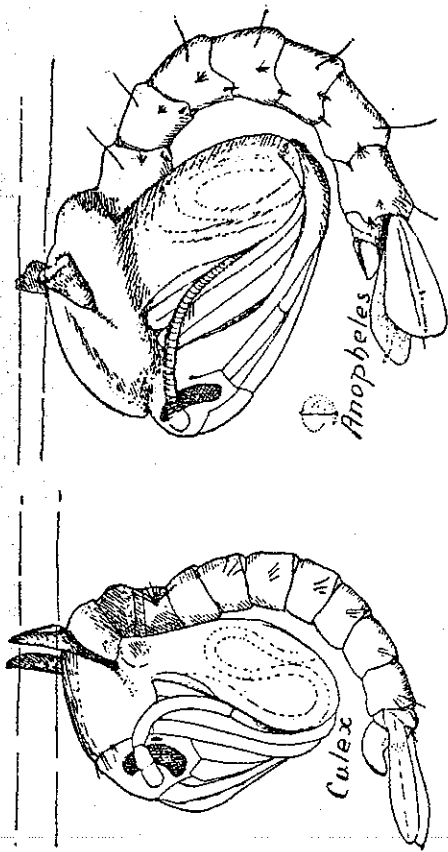


Anopheles

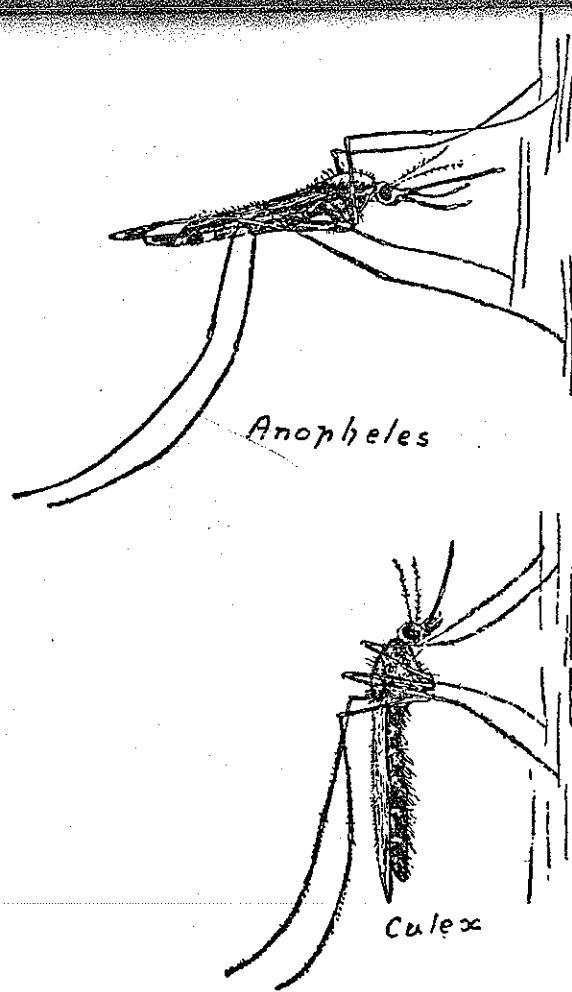


Culex

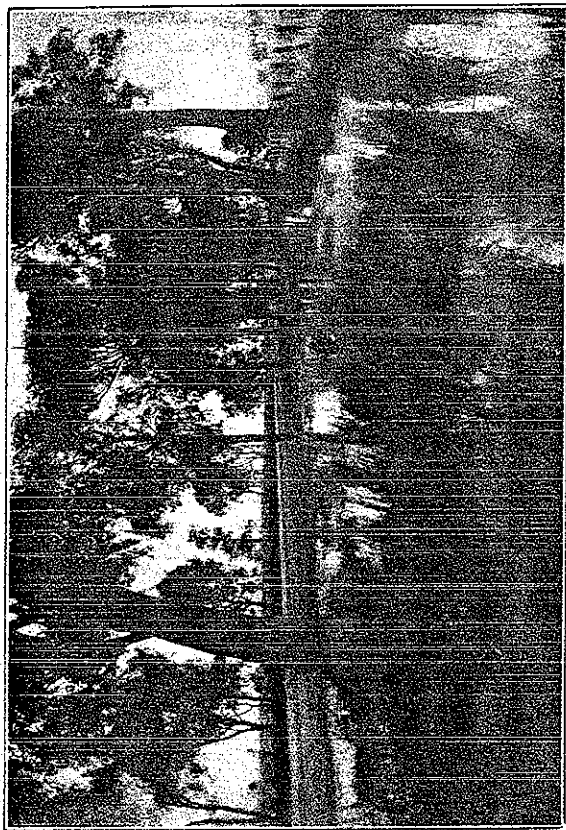
2. Mosquito Larva in resting position, just beneath surface of water. *Anopheles* above, *Culex* below. Greatly enlarged. (After Howard, U.S. Department of Agriculture)



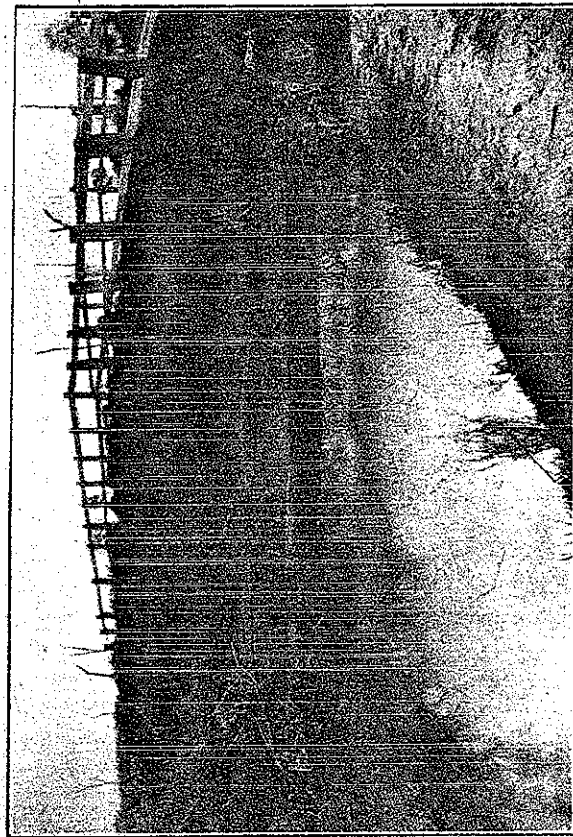
3. Mosquito Pupae. *Culex* at left, *Anopheles* at right. Greatly enlarged. (After Howard, U.S. Department of Agriculture).



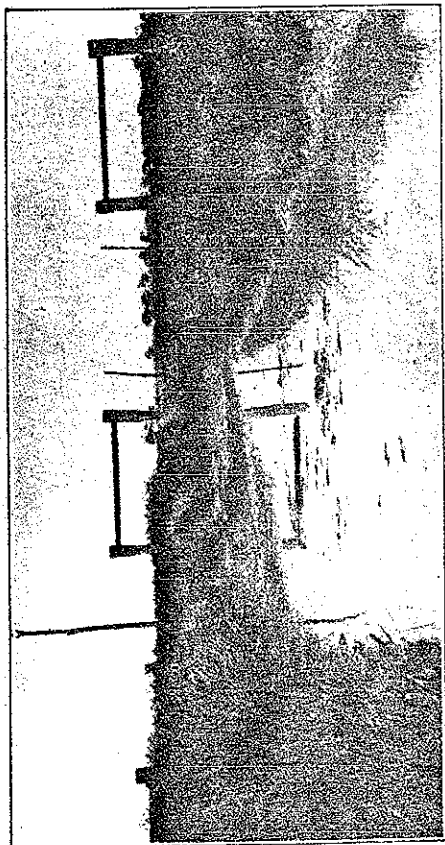
4. Adult mosquitoes in resting positions. *Culex* at left, *Anopheles* at right. Greatly enlarged. (After Howard, U.S. Department of Agriculture).



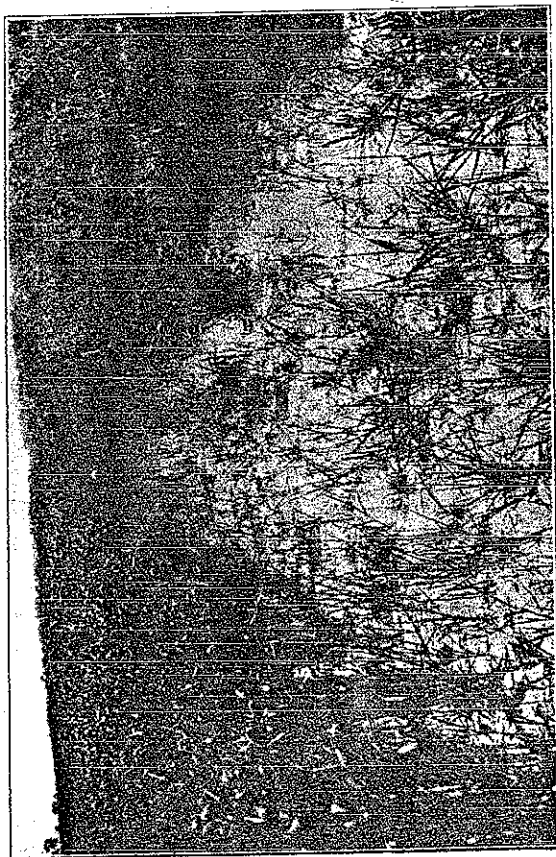
5. KYABRAM.—A roadside swamp in which *Anopheles* and *Culicine* larvæ were found.



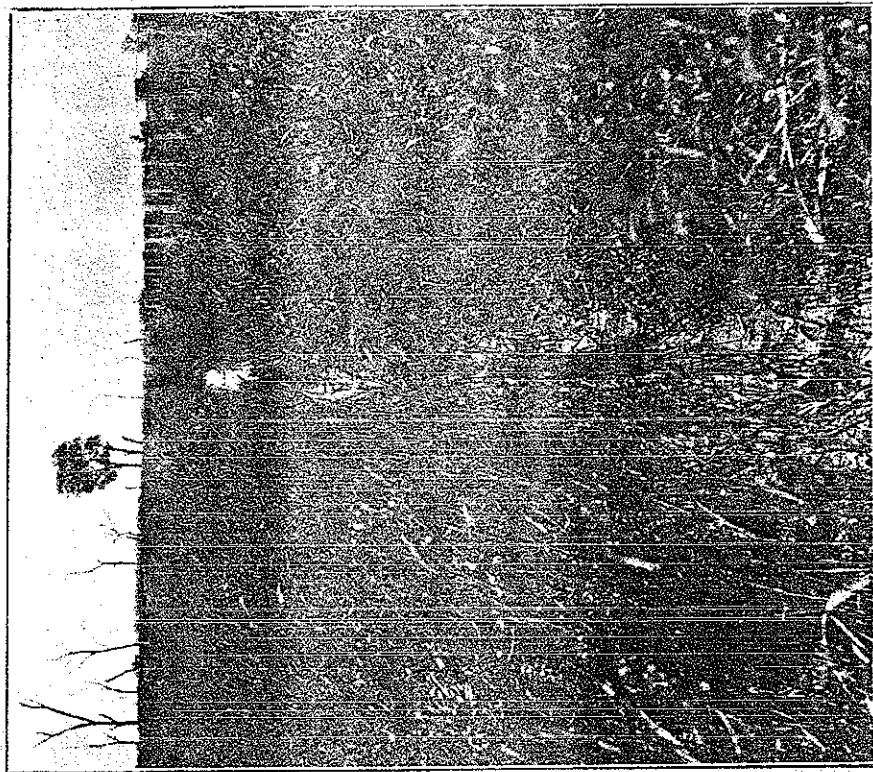
6. KYABRAM.—The dead-end of a ditch. A typical *Anopheles* and *Culicine* breeding ground.



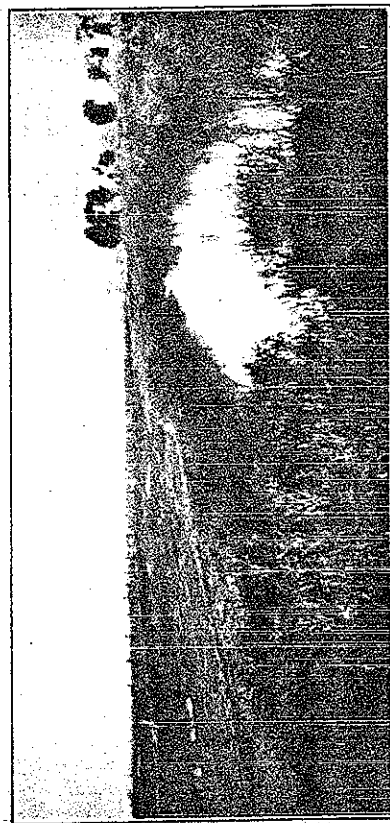
7. KYABRAM.—An irrigation channel.



8. KYABRAM.—An *Anopheles* breeding ground between a standing crop and a channel bank.



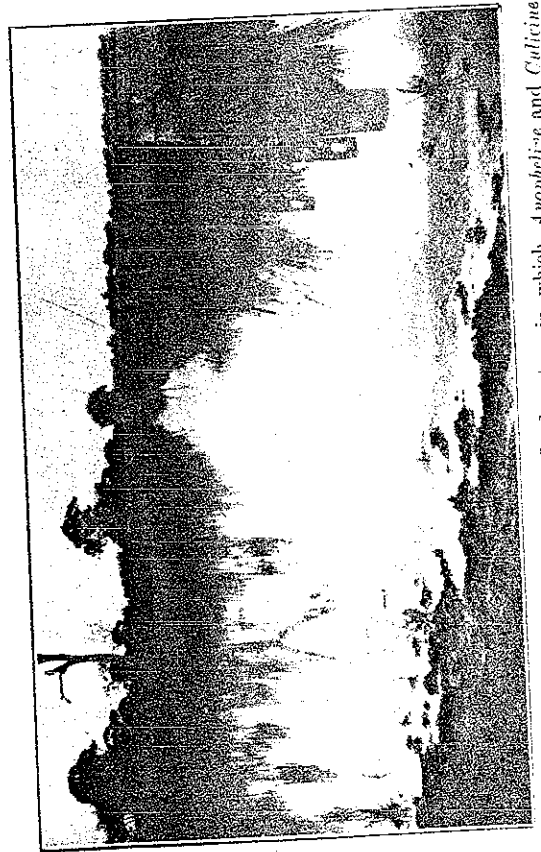
9. BAKAWM.—An overgrown irrigating channel, in which numbers of *Anopheles* larvae were found.



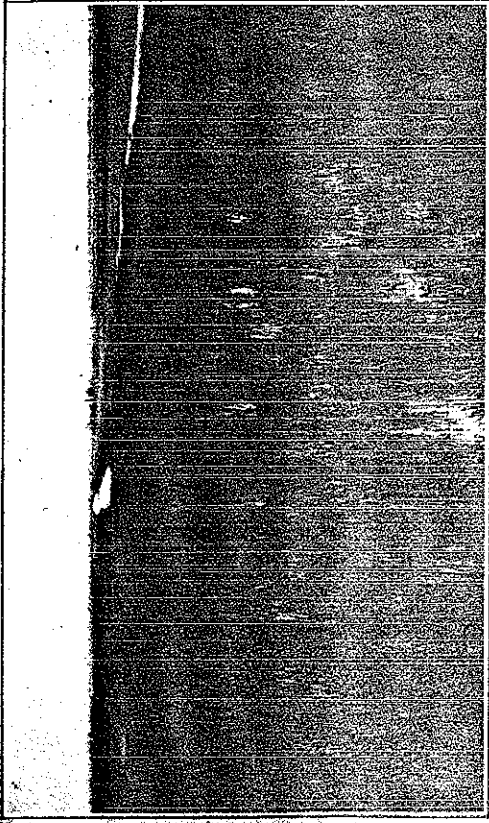
10. BAKAWM.—On roadside near State School. A borrow-pit where *Anopheles* and *Culex* larvae were found.



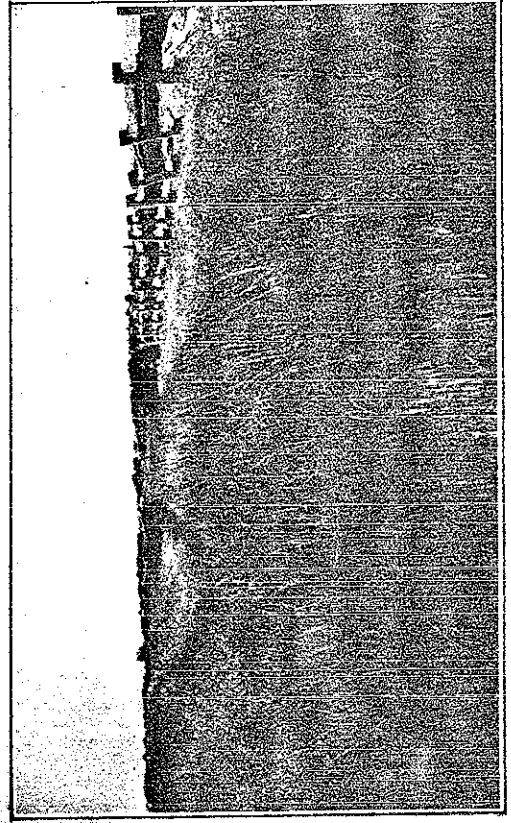
11. BAMAWM.—Near the Shire dam. A swamp in which *Anopheles* and *Culex* larvae were found.



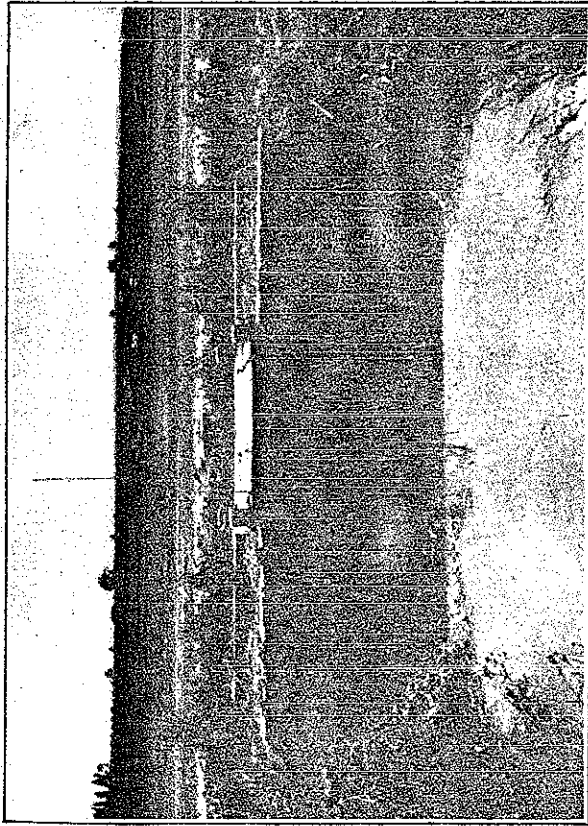
12. EQUICA NORTH.—A channel and flood waters in which *Anopheles* and *Culex* larvae were found.



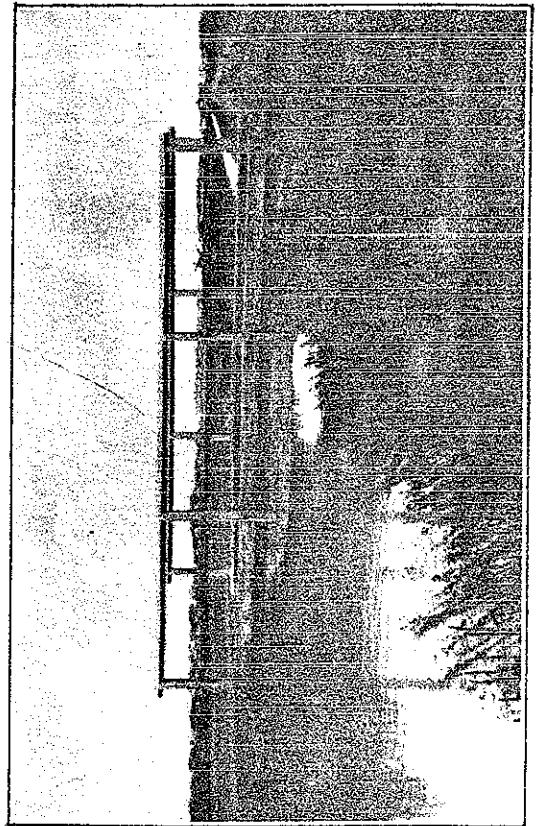
13. SWAN HILL.—A disused channel in which *Anopheles* and *Culex* larvae were breeding.



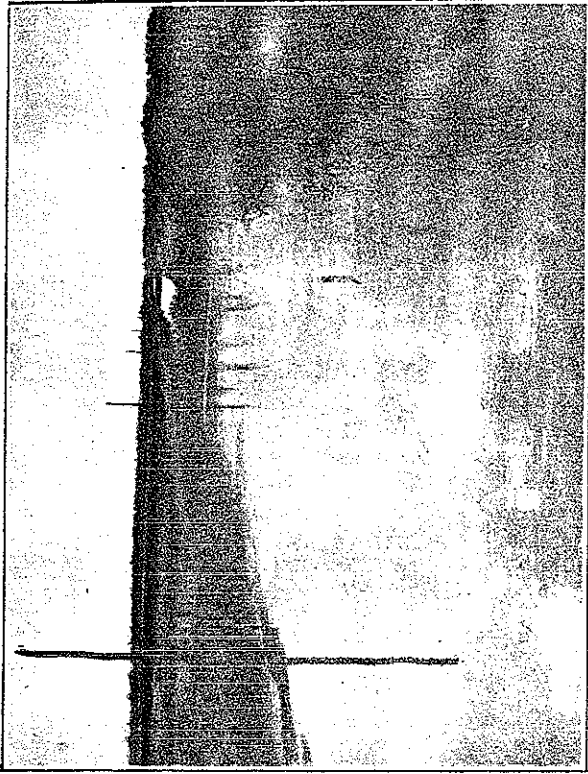
14. SWAN HILL.—A borrow-pit near a channel. A typical *Anopheles* breeding ground.



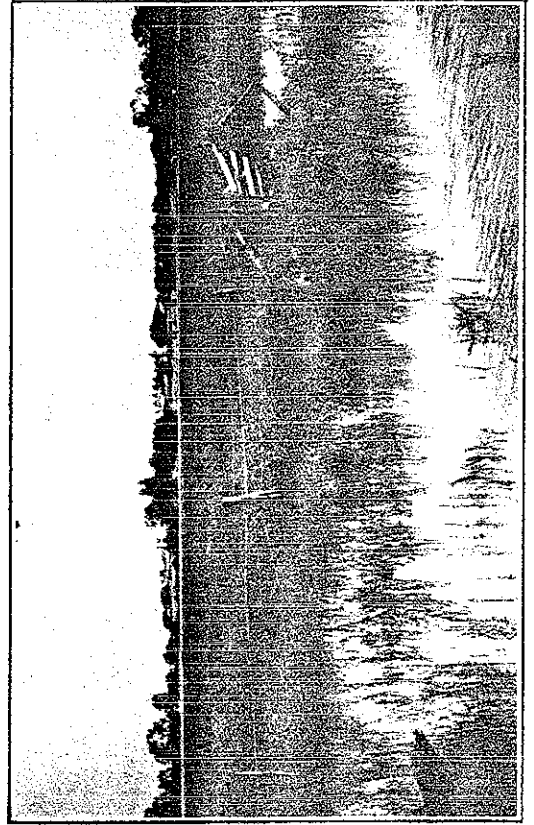
15. SWAN HILL.—A channel-stop and pool of water. The former is an excellent sheltering place for adult mosquitoes, and the latter is a good breeding ground, as it is well sheltered from wind.



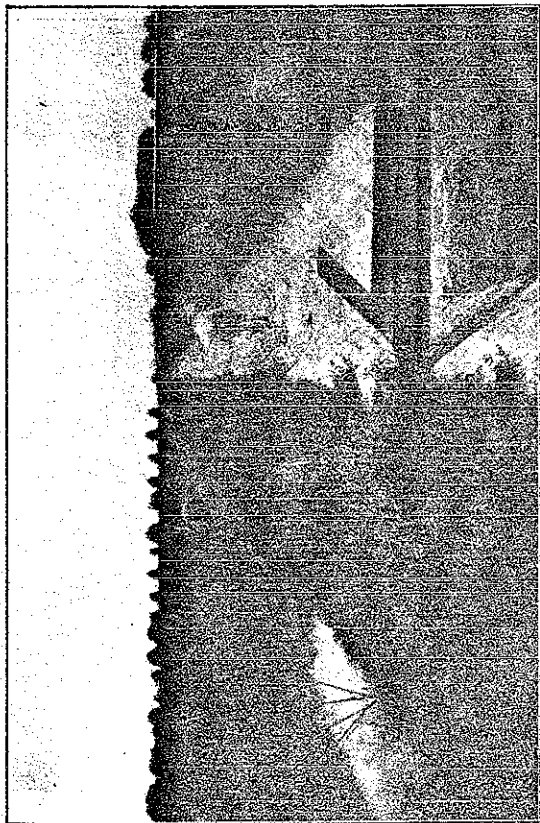
16. SWAN HILL.—The under surface of bridges affords good protection for adult mosquitoes.



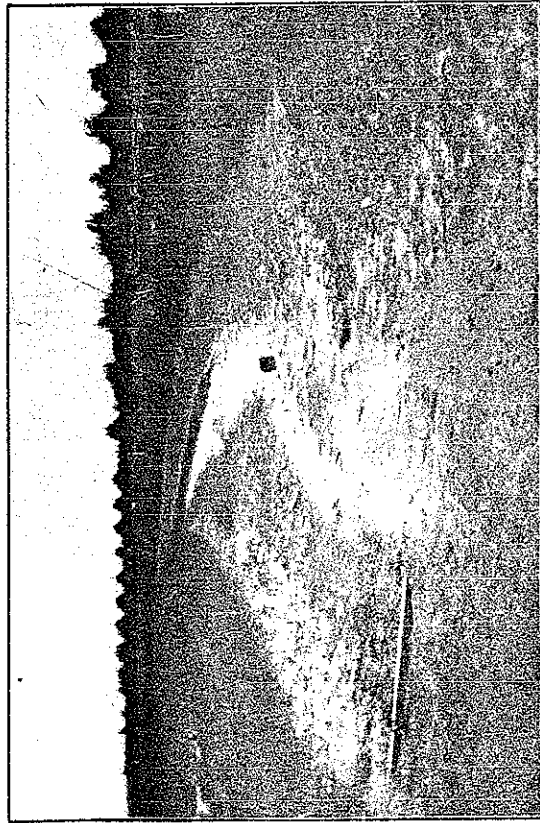
17. SWAN HILL.—Borrow-pits along the railway line. Both *Anopheles* and *Culex* mosquitoes were breeding here.



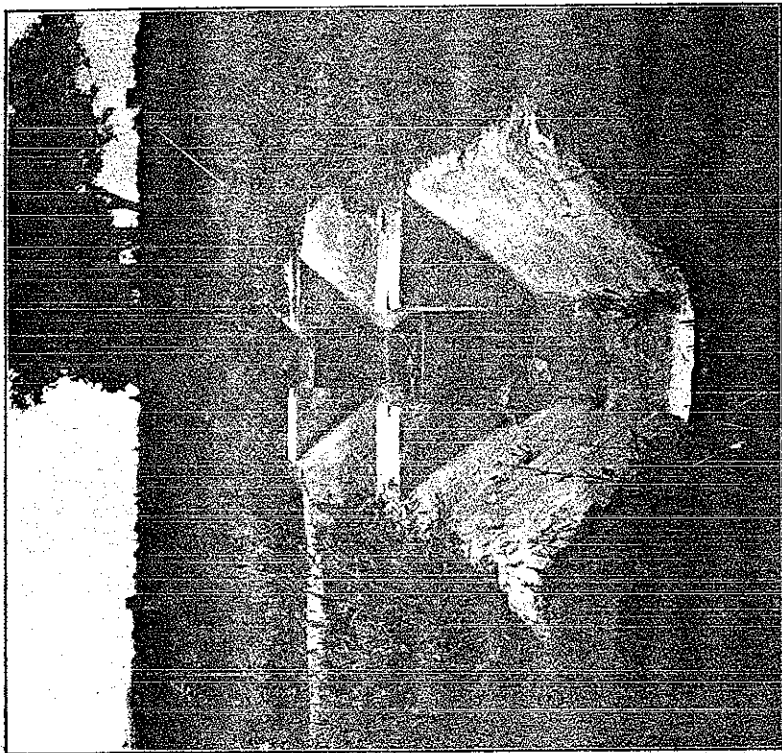
18. A swamp on the New South Wales side of the Murray River, showing Swan Hill in the distance. Both *Anopheles* and *Culex* larvae were found here.



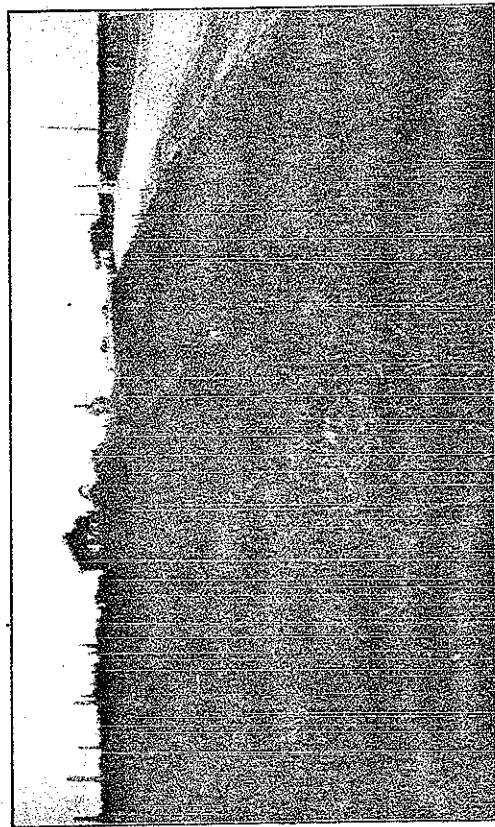
19. MILDURA.—Showing a borrow-pit on the left, where *Anopheles* and *Culex* larvae were found, and a concrete channel on the right.



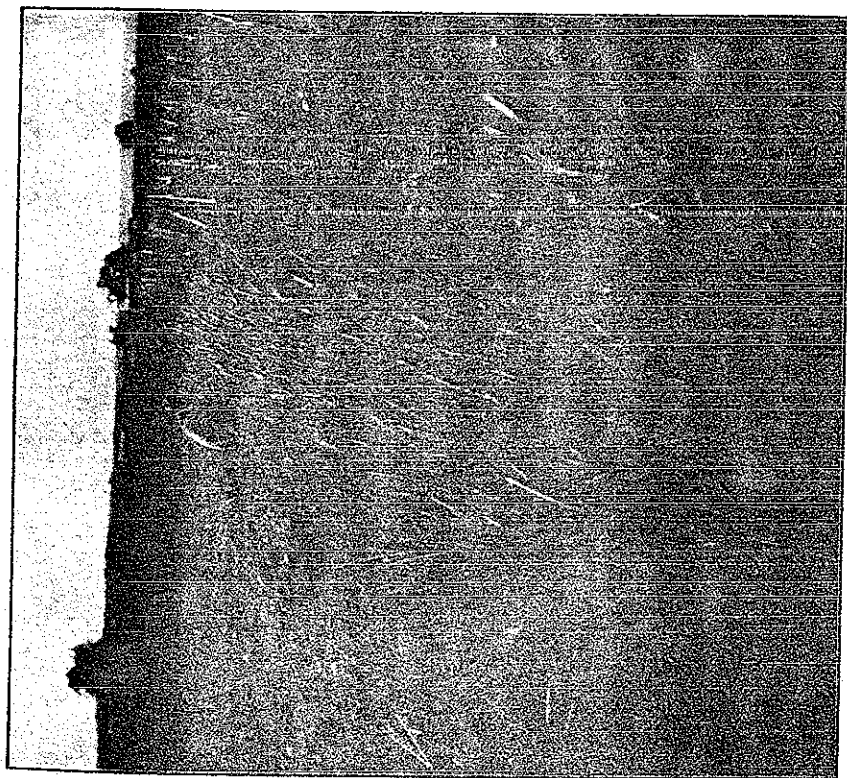
20. MILDURA.—An earthen channel. Note pools of water remaining in the channel.



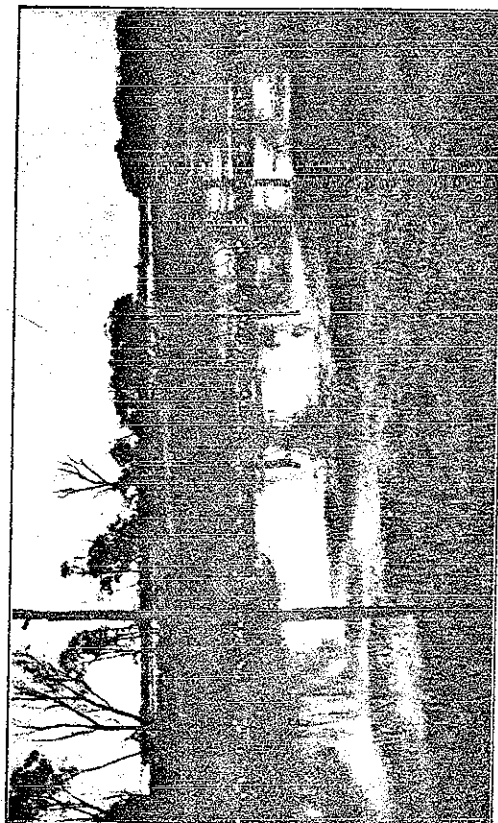
21. The type of channel-stop employed at Mildura. These stops afford practically no shelter to the adult mosquito. Contrast with Fig. 15.



22. MILDURA. A borrow-pit in Beakim-avenue. In its present condition a prolific breeding ground for *Culex* mosquitoes.



23. REMARK.—A drain overgrown with reeds. This is a typical *Anopheles* breeding ground.



24. REMARK.—On the banks of Remark Creek, where both *Anopheles* and *Culex* larvae were found.



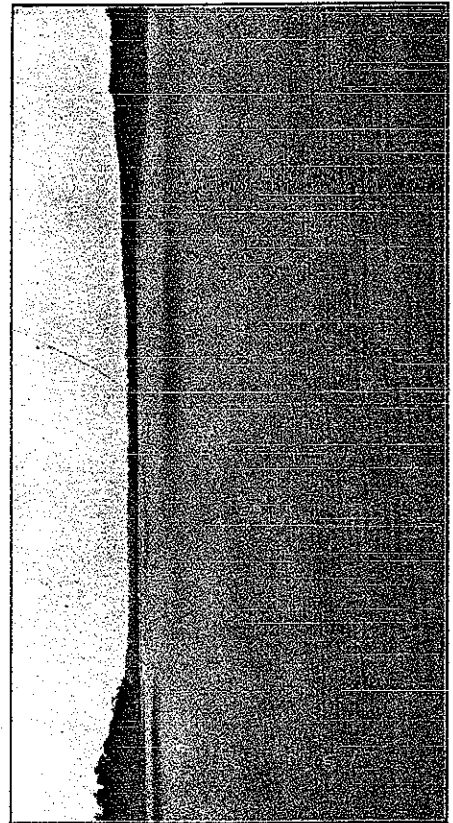
25. Type of country at Overland Corner between the river flats and the high land.



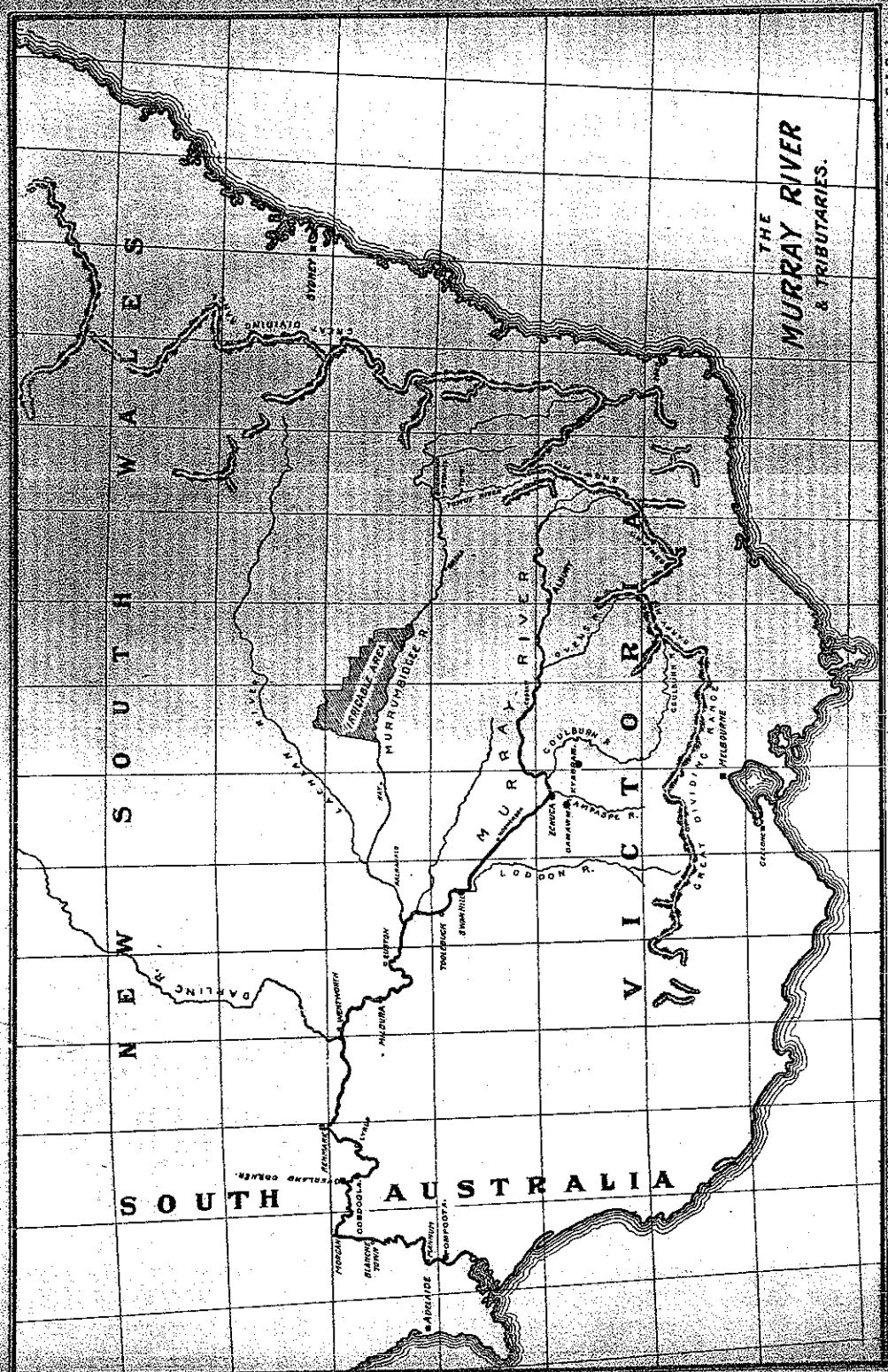
26. Showing the river flats inundated with flood water at Overland Corner.



27. COMODA.—A flooded polygonum flat in which *Anopheles* larvae were found.

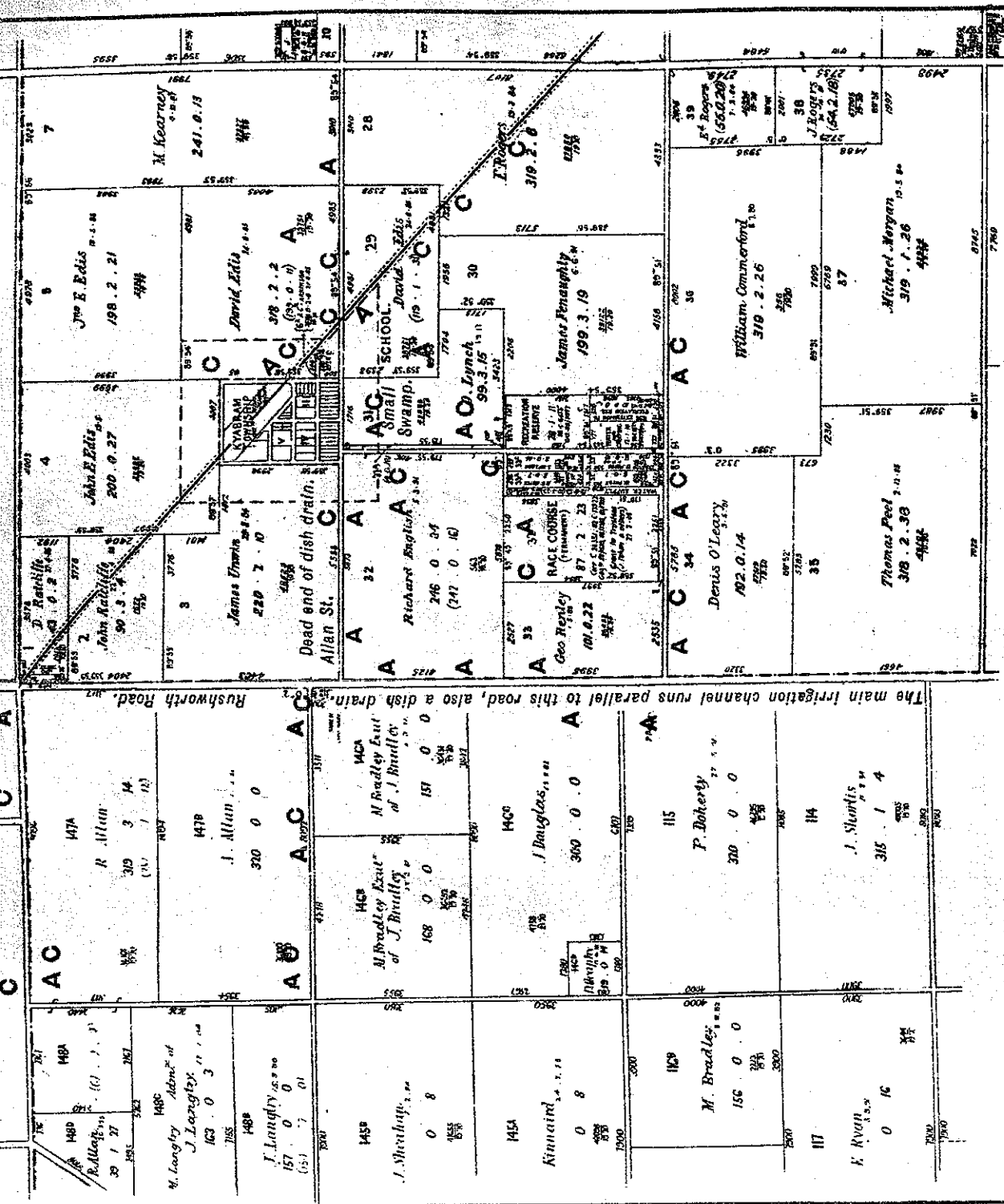


28. POMPOTA.—The river flat flooded out. There are approximately 20 miles of channels on this flat.



Reproduced from *Fيدر Rogers* by E. J. Brady

MAP of Murray River District showing Places visited thus far

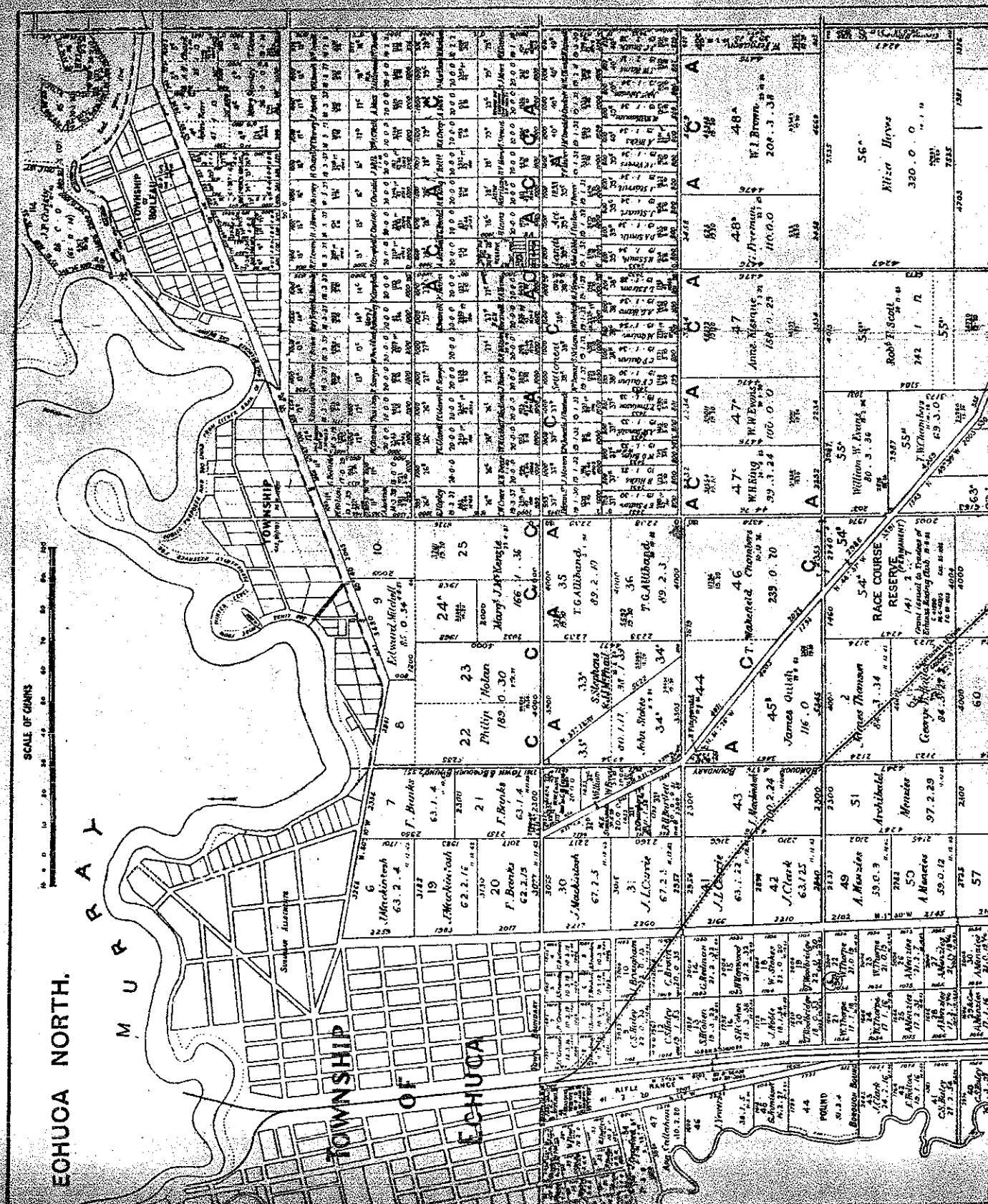


KYABRAM.

Reference A denotes the presence of the Anopheles mosquito.

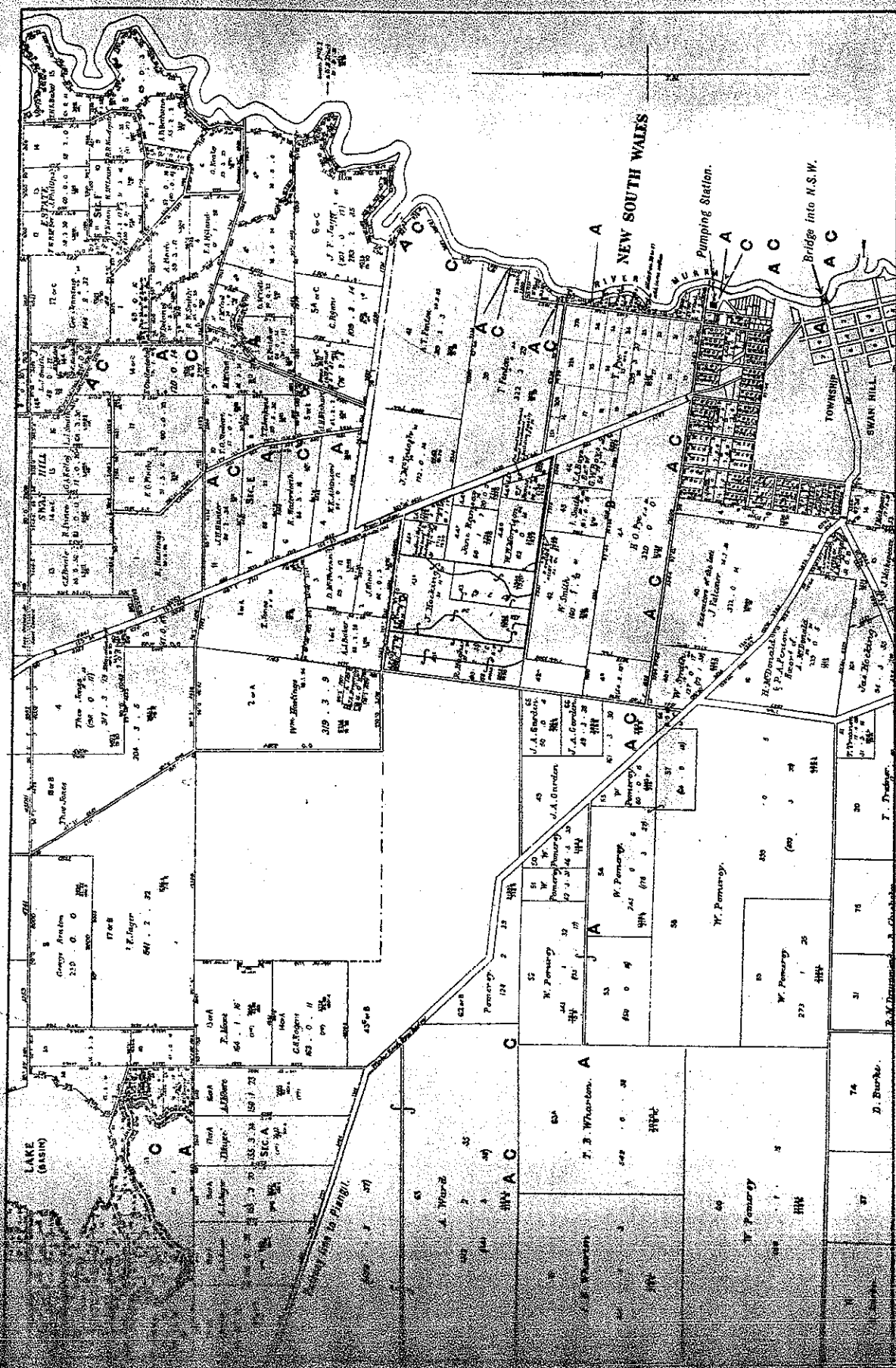
Reference C denotes the presence of the Culex mosquito.

SCALE OF CHAINS



References A denotes the presence of the Anopheles mosquito.

References C denotes the presence of the Culicine mosquito.



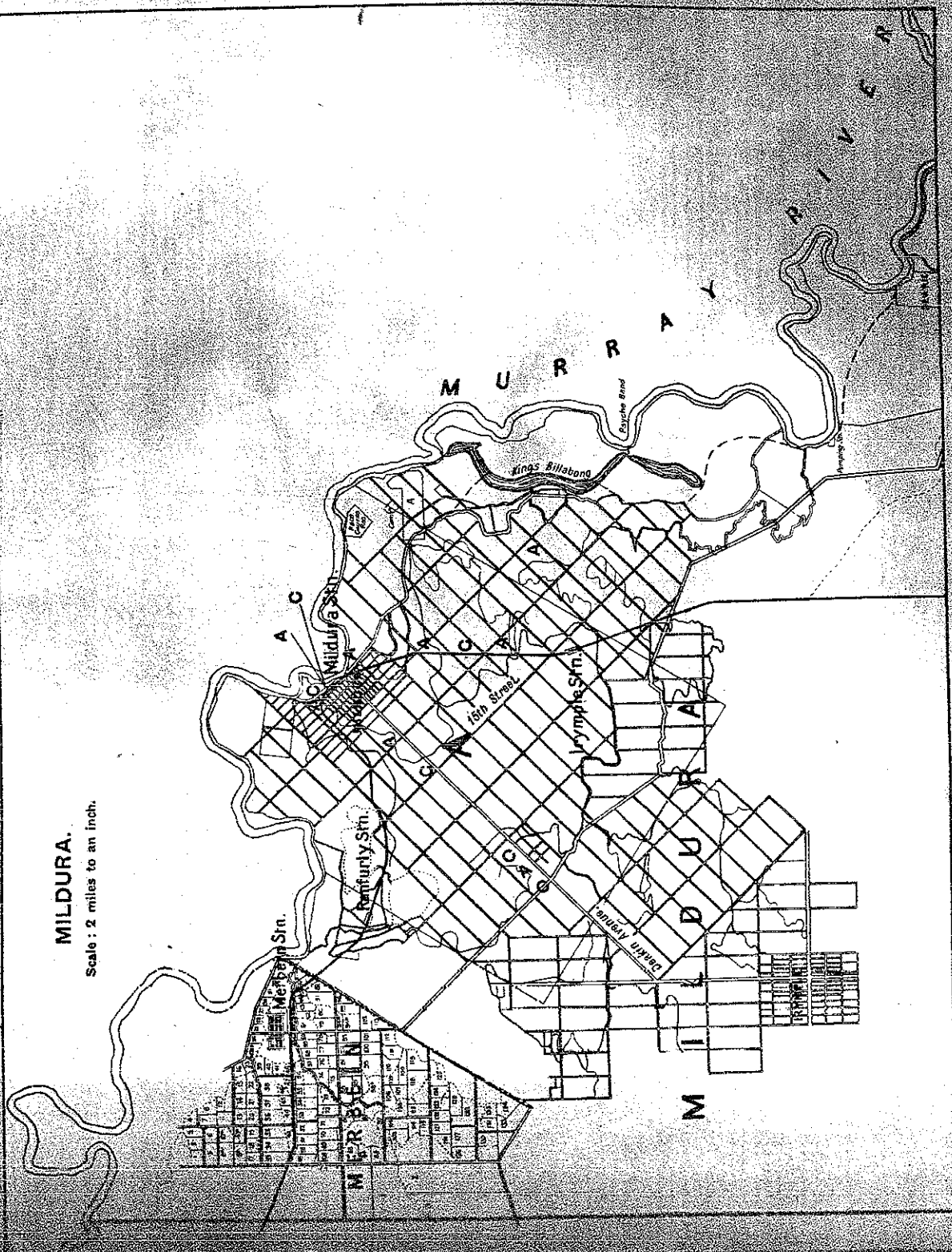
Reference **A** denotes the presence of the *Anopheles* mosquito.

Reference C denotes the presence of the *Culiseta* mosquito.

SECOND ISSUE

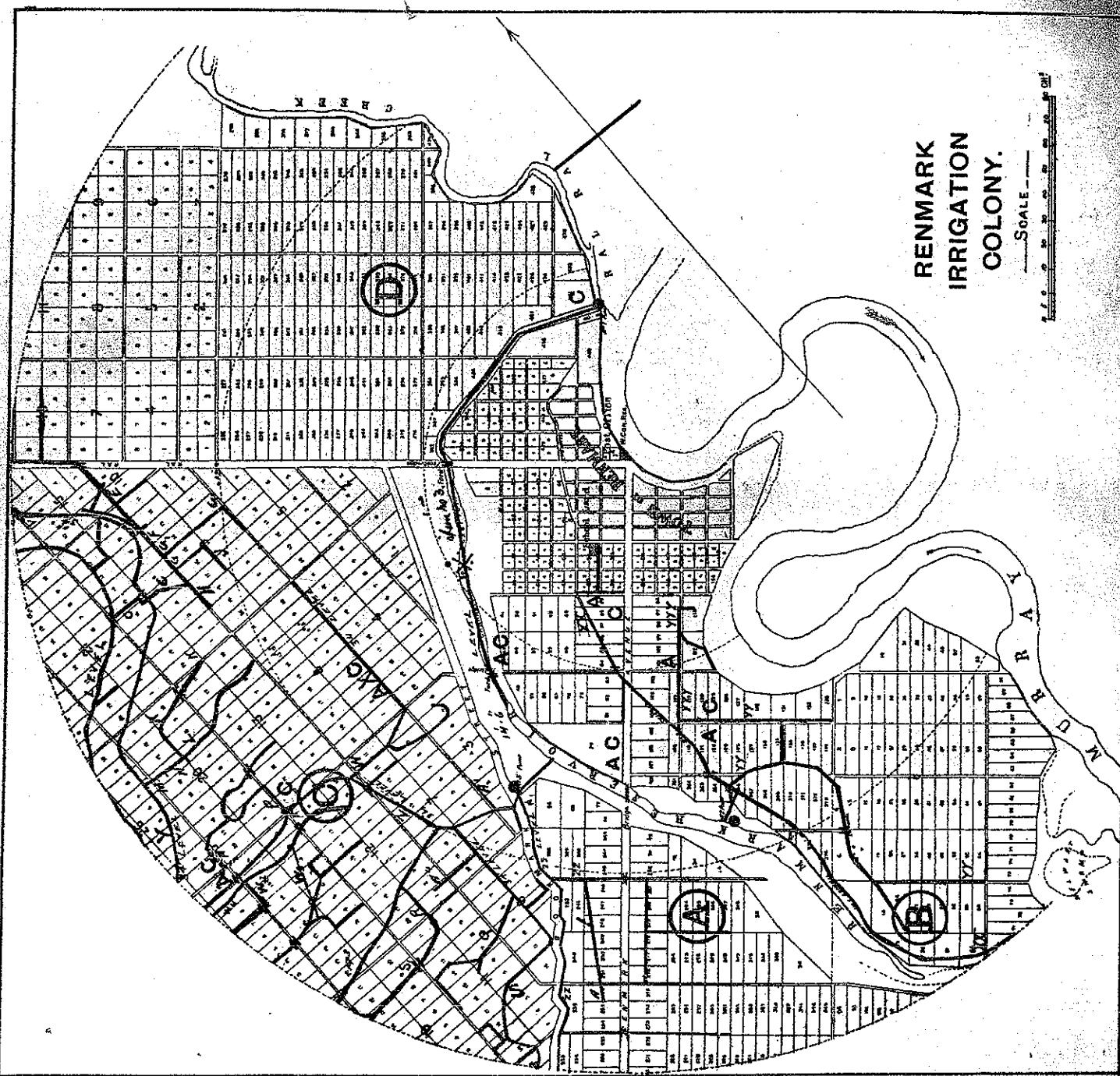
MILDURA.

Scale : 2 miles to an inch.



Reference A denotes the presence of the Anopheles mosquito.

Reference C denotes the presence of the Culex mosquito.



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COLONY.



Reference A denotes the presence of the *Anopheles* mosquito. Reference C denotes the presence of the *Culiseta* mosquito.