KENTUCKY AGRICULTURAL EXPERIMENT STATION

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BULLETIN NO. 159.

Bulletin (Kentucky Agricultural Experiment Station)

A Preliminary Study of Kentucky Localities in which Pellagra is Prevalent, having Reference to the Condition of the Corn Crop and to the Possible Presence of an Insect or other Agent by which the Disease Spreads.

LEXINGTON, KENTUCKY,
January 15, 1912.

Kentucky Agricultural Experiment Station.

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KENTUCKY AGRICULTURAL EXPERIMENT STATION,
LEXINGTON, KENTUCKY.

BULLETIN NO. 159.

A PRELIMINARY STUDY OF KENTUCKY LOCALITIES IN WHICH PELLAGRA IS PREVALENT.*

By H. Garman, Entomologist and Botanist of the Station.

The suggestion somewhat recently made by European investigators that pellagra is in Italy and other European countries conveyed by a small fly belonging to the genus Simulium has aroused a good deal of interest on the part of the American medical practioner, and the question has been raised as to whether or not the insect species charged with the mischief occurs in this country, and if not whether we may have as intermediate host some related species of the genus. None of the species found by Dr. Sambon in regions in Italy in which the disease is prevalent occurs in the United States. *Simulium reptans,* said to have been accused more positively than others, does occur, however, in Greenland, and may possibly yet be discovered in the northern portion of the continent.

The disease is now prevalent in sections of the southern states, and within the past two years has attracted attention in some of the mountain counties of Kentucky, from which counties a number of cases have been sent to the Eastern Kentucky Asylum for the Insane at Lexington. The recognition of these cases in the Asylum has perhaps more than anything else served to concentrate attention on the disease as a danger in the State, and led to a conference of our

*The writer has not at any time committed himself to the "Insect theory" of the spread of pellagra. He is not satisfied with the evidence, and intends in this bulletin simply to present facts which may bear upon the problem.

medical men who met at Corbin some time ago with a view to considering the matter and if possible devising means of checking the further spread of the ailment.

At this meeting it was requested that the writer of this bulletin visit the region in which pellagra is prevalent and determine if any fly occurs there that might serve to convey the disease.

In response to this request I spent several days at Corbin in the latter part of August and in early September, and again in October at Pineville, studying the localities in which pellagrous cases are located, and giving special attention to the streams in the region as breeding places of the flies.

It may be explained at this point that I was aware that Fall is not the most favorable season to look for the flies. The late Dr. Riley, who studied the buffalo and turkey gnats (*Simulium pecuarum* and *S. meridionale*) some years ago, declared indeed that the species were one-brooded. It was known to me, however, that some of our species produce more than one annual brood, and in any case it seemed best to study the locality and familiarize myself with the disease in order that I might not lose time in the Spring when the flies of the genus generally appear in great numbers.

Two species of the flies were known to me to occur in Kentucky at this time. The buffalo gnat (*S. pecuarum*) was years ago very abundant periodically in April and May along the Ohio and Mississippi Rivers in Western Kentucky. This gnat still occurs locally some seasons in that part of Kentucky, attacking stock and sometimes, it is claimed, invading the nostrils of men, causing sneezing, but no other annoyance. The larvæ of a second species (*S. pictipes*) were collected by me in 1893 in large numbers in small rills running into Kentucky River about 14 miles from Lexington. This gnat is said not to sting and hence may be eliminated from the problem. I have also a few specimens of Simulium larvæ, not yet studied, collected at Lexington in a small stream, August 5. 1889.

At Corbin I inspected the surroundings of cases in charge of Drs. M. W. Steele and J. H. Parker. The weath-

er was very unfavorable for my work, rain keeping the water of streams roiled and making a search for insects in them difficult. The cases of pellagra were located, as I had been led to expect, near streams, some of them only a few hundred feet away from the water, though as a matter of fact most of those living in the country in these mountain counties are near springs and streams for obvious reasons. When questioned it was found in some instances that the patients had not contracted the ailment where they were then living. One had not had good health where she formerly resided and had moved "up here" where she thought her condition was improved. In several cases observed the disease had in all probability been contracted where the patients then lived. This seemed true of three individuals, a mother and two boys, living on the banks of Laurel River north of Corbin. The mother had been very severely affected early last spring about garden making time at which time she was confined to her bed. Her face, hands and feet still showed the effect of the disease, though she was about the house when I saw her. One of the boys was affected on the calves of the legs quite extensively, the dusky cuticle being visible as he walked beside the buggy. The second boy showed only a small area on one of his legs, and was said to have contracted the ailment a week or so later than the others. All seemed to have become affected in the spring of 1911 at the place where they were seen. Excepting for the diseased skin neither boy seemed to be in bad health. None of them showed signs of mental derangement. The house in which the family lived was a mere shed that had been abandoned by sawmill men on the bank of Laurel River. The water of the river where nearest the house was at a much lower level, having cut its bed so as to leave rather steep banks, but is only a few hundred feet away. Several hundred yards below the dwelling is a ford where the stream is more rapid and shallow, running over and among large rocks consisting of a red sandstone which blackens on exposure to the weather and gives the river a rather forbidding appearance. I was able to cross here on the rocks, and spent some minutes looking for in-

sects among them. The situation is an excellent one for Simulium, but the weather was threatening and dark and with the limited time at my disposal I was compelled to give up the search without finding larvæ, though I secured a number of other insects from among the rocks. I am confident that Simulium larvæ can be found here in the spring of the year.

At Pineville I searched the rapids of Cumberland River with care, and explored Clear Creek between the Pine and Log Mountains, giving special attention to the creek because a case of pellagra, in charge of Doctor Foley, of Pineville, was located on its banks. The dwelling in which this patient lives is on the banks of the creek in much the same position relative to the water as the one on Laurel River at Corbin, yet from what I learned by conversation with the patient it was probable that she had contracted the ailment at another place, though similarly situated with reference to the stream. The stream was inspected at intervals above this dwelling and below it down to its junction with the Cumberland. Numerous insects were found in it, and situations exactly suited to the breeding of Simulium, yet none were found.

In the Cumberland River as it flows through the Gap of the Pine Mountains I spent some hours on two days and found a few Simulium larvæ in its rapids among a scant growth of Nitella, with many other insects characteristic of swift-flowing, rocky streams.

At Cary, three miles north of Pineville, is a mining camp on the left Fork of Straight Creek. In company with Doctor J. H. Hendren of Cary I visited here some of the most interesting cases seen on my trip. At the outskirts of the settlement, perhaps one hundred and fifty feet from the stream, is a dwelling in which were four cases of pellagra, which, judging from Dr. Hendren's statements, had originated at this place. The stream was shallow at the time of my first visit (September 1) and consisted of stretches of quiet water a few feet in depth, in which some fishing with hook and line was going on, alternating with rocky rapids

in which the water was not much over one's shoe-tops and where it was possible to cross by stepping from rock to rock. One of these rapids just below the dwelling seemed to me an ideal place for Simulium larvæ, and a few minutes search here brought to light some larvæ and pupæ. They were not very common, however, and were so small that I felt some hesitation about committing myself until they could be more carefully examined. Examination, and in some cases dissection, made since my return to the University, leaves no doubt as to their identity.

On October 21, during a second visit to the region about Pineville, I examined the Left Fork of Straight Creek well up toward its source. Above the Coleman mining camp were found larvæ and pupæ of the same Simulium collected on my previous trip. They were scattered and difficult to find, and although not nearly so common as I have seen similar larvæ in the spring of the year at other places, yet judging by the frequency with which I found a few here and there many of them must be now hibernating in the creek. Most of the pupa cases were empty. Other specimens were secured from rocks in the rapids of Cumberland River at the point above Pineville where specimens were secured in August and September. Numerous other insects were found among the submerged rocks in Straight Creek, Cumberland River and Clear Creek. Some account of them is included in what follows, not because of any definitely determined relation to the main object of my search, but because some of them may later prove to have relations with this and certainly have with other subjects of interest to the people of the State. For it is to be remembered that it is not certain that gnats of the genus Simulium have to do with pellagra. It is possible that some other insect or animal is concerned in its spread.

Looking at the matter from the point of view of the entomologist and naturalist it seemed to me very evident when I had examined only a few cases of pellagra that some agent in the air had to do with its spread, and it may be of interest to recall the facts that most appealed to me. In the

first place the eruption on the hands began apparently about the bases of the fingers and extended thence upward to the elbows, where it stopped abruptly. On the legs it seemed to begin at the feet, affecting the upper surface and extending to the knees, where it terminated in a well marked line. On the head and neck it affected in all cases examined only the skin constantly exposed, and terminated at the hair and at the collar. Yet in some instances recorded there is an extension of the affected skin down upon the chest, coinciding somewhat closely with the opening in the shirt front. One such case, which I did not have a chance to see, was reported to me as residing at Old Straight Creek, above Pineville. All of these conditions seemed consistent with Dr. Sambon's theory that an insect carries the virus of the disease from ill to well, attacking the exposed skin and injecting into it something, bacteria or protozoa, which gives rise to the disease.

Furthermore the disease is contracted and afterward becomes active in early spring at just the time when our gnats of the genus Simulium come from the water in greatest numbers as adults.

Again it often affects children, who constantly go barefooted and bare-legged in this region and are disposed to play and wade in the streams. Women, too, were affected more than men, about the arms and neck generally, but also in some cases on the feet and calves. Men go less frequently perhaps with the limbs bare, and are much less often attacked. The skin trouble appears upon the trunk rather rarely, though cases are on record of parts generally kept covered by clothing becoming affected.

With these facts in mind, it was with very great interest that I examined a case at Moss's Camp above Pineville which seemed to oppose the idea of insect agency in the disease. The case was that of a middle aged woman whose arms showed in a marked manner the symmetrical development of the skin lesions, so often mentioned by writers on the ailment. It was interesting further because it was then (Sept. 1) in an active condition, whereas all the

other cases examined showed the usual summer cessation of the disease and an improvement in general health. The affected regions on the two arms were surrounded by a deep red border, as if something had got access to the blood in the center of the area and was spreading outward into the healthy skin, much as one sees in plants a fungus pushing outward from a point of inoculation by a growth of its mycelium. The area on the two arms and forearms seemed to be of about equal extent. This affected region was such as might at some time have been exposed to the air when the patient was busy about her domestic affairs. A more interesting and puzzling feature of this case was the presence of two isolated round spots of diseased skin, one on the point of each shoulder. If there had been one only, I should have thought a hole in a gown might at some time have exposed the part to infection, but the chances seem against the presence of two such holes exactly alike, one on each shoulder. I am giving this fact as an illustration of what some physicians claim to be an invariable feature of the ailment, no matter where the skin trouble appears, namely, a symmetry in the skin affection, which they regard as evidence that the seat of the disease is within and the skin lesions only incidental and dependent. The case appears to support this view, yet it may prove when we know more of the conditions attending the contraction of the disease that such cases are still explainable on the theory of insect agency.

THE STREAMS.

In general character the streams examined are much alike. A gap in the Pine Mountain range lets the Cumberland through from the south. It makes a bend after clearing the gap, and partially encircling Pineville, located at the base of the mountain, flows off to the westward. In its course it receives numerous small creeks and rills from springs, and farther west and north is joined by Laurel River. Its water was rather warm at the time of my first visit, and did not seem to me particularly well suited to the

requirements of Simulium larvæ, judging by what I had seen of them at other times and in other places. The numerous springs, however, send into it a good deal of cool and rather pure water at all times, and no doubt in the spring of the year its quality is much better because of the larger quantities present and the consequent dilution and rapid carrying away of sewage. The bed of the stream was cut in places through a conglomerate and red sandstone, and large fragments of this rock cumbered the channel and produced rapids. In the creeks the same conditions prevailed on a smaller scale. My photographs will convey a fuller idea of their character. (See Figures 59 to 63, inclusive.) The banks of the streams support a growth more or less thick, of willow and other deciduous trees. On the slopes, trees, though small, become more numerous and occur in greater variety. Where the valleys widen out are tracts of bottom land, generally planted in corn, which is the most important agricultural crop of the valleys.

The region is one of great natural beauty and attractiveness. The wooded slopes of mountains rise abruptly from the valleys and river beds, presenting constantly changing effects in light from both sun and moon, effects often enhanced by floating wisps of cloud about the peaks and slopes. The landscape of other parts of Kentucky may be in its own fashion as beautiful as this, but as a type of beauty the Cumberland mountain region stands unique in the State.

It is unfortunate that a section calculated naturally to be so healthful and attractive, should be permitted to become a center for the spread of so dangerous a disease as pellagra. The State Board of Health has shown commendable forethought and enterprise in taking hold of the matter at once, and making an effort to arrest its further spread.

Yet it should be known by the people of Kentucky that pellagra is no longer restricted to the mountain counties. Through the kindness of Dr. F. H. Clarke of Lexington and the authorities of the Eastern Kentucky Asylum for the Insane, I have been able to learn the distribution of the

cases that have been sent to the Asylum. To my surprise they have been found to come from widely scattered counties of Eastern Kentucky, extending from the mountains to the Ohio River. Judged by the distribution of these cases there is no county in the Eastern third of the State that can be regarded as exempt. And considering other cases occurring in other parts of Kentucky, together with those recorded from Tennessee, Illinois, Michigan and other states, it appears that pellagra may occur anywhere within our borders.

Yet it must be remembered that the history of these cases at asylums is not fully known. People attacked by a lingering malady sometimes become restive and dissatisfied because of their ill health, and move away from the locality where the disease was contracted. The cases scattered about Kentucky may thus in some instances have come originally from the mountains. I sometimes found on questioning patients about Corbin and Pineville that they had somewhat recently changed their residences.

Once introduced into a locality, however, the disease appears to spread, as if some agent of infection were everywhere at hand. In some asylums, numbers of cases are said to have developed after the admission of a single one. And it may be remarked in passing that the fact, if fact it is, that cases may originate within the walls of an asylum is opposed to the theory that Simulium is the agent of transmission, for these insects are pre-eminently creatures of the wild wood.

THE INSECTS FOUND IN THE STREAMS.

Most of the aquatic species collected in situations examined for Simulium were such as are constructed for living in swift currents. They are in some cases quick strong swimmers, but more often are of the lurking sorts that depend upon clinging tightly to rocks and other objects in the water. Species belonging to eight different orders were collected by me, representing over forty species.

SIMULIDÆ (SAND FLIES).

The members of this family are rather small stout-bodied, two-winged flies, as young, living in the water of rapid streams. Twenty-seven species of the genus Simulium are listed from North America, of which three are known to me to occur in Kentucky. To the accounts of these species have been added below description of the turkey gnat, which will probably be found here, and of the European *S. reptans.*

Simulium venustum (The Black Fly).

This is the species of which I collected larvæ and pupæ at Cary, Coleman, and elsewhere in the left Fork of Straight Creek. It is known as a pest in northern woods, especially in the Adirondacks, but has a wide distribution in this country, extending from Canada and Minnesota southward to Texas, Mississippi and Florida. The original description of the species written by Say, a pioneer entomologist, of New Harmony, Indiana, was based upon specimens collected at Shippingsport on the Ohio River in 1823. He describes the adult fly as black, with two pearly spots on the front of the thorax and a larger one behind, the poisers black; the wings whitish with yellow and iridescent reflections; and says of it: "This pretty species perched in considerable numbers on our boat at Shippingsport, Falls of the Ohio. It ran with considerable rapidity, constantly advancing its long anterior feet. Its bite is pungent."

Harris, writing of the same insect in 1852, says "Travelers and new settlers in some parts of New England are very much molested by a small gnat, called the black fly, swarms of which fill the air during the month of June. Every bite that they make draws blood and is followed by an inflammation and swelling which lasts several days. These little tormentors are of a black color; their wings are transparent; their legs are stout, and have a broad whitish ring around them. The length of their body rarely extends one-tenth of an inch. They begin to appear in May, and continue about six weeks, after which they are no more seen."

The insect has doubtless become less common than it was formerly, yet my brief stay in the mountains was sufficient to show that it is still there and probably more abundant than is commonly supposed. My own material is all immature, yet the characters of the pupæ and larvæ are such as to leave little doubt as to the correctness of their identification. The following detailed descriptions are based upon the material collected at Cary and Pineville, and together with the illustrations made by Mr. Matthews of the Division will serve for the recognition of the insects, should any one wish to search for them in the streams.

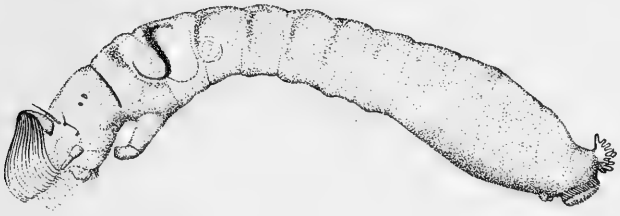

FIG. 1—Larva of Simulium venustum from the Left Fork of Straight Creek, Ky., 1911.

Larva.—Rather thick bodied, more slender at the middle, becoming greatly thickened at the posterior extremity, and enlarging somewhat behind the head. Head relatively large, brownish, bearing two large brushes of long curved bristles. A false leg, bearing rust-brown chitinous hooks at the tip, arises from the first body division and projects forward beneath the head. Posterior extremity with a ring of dusky microscopic hooks by which the insect secures itself to rocks and other objects. Translucent white, with blackish markings, in the larger examples sometimes assuming the form of cross bands. Length of largest example secured, 4 millimeters or about 0.16 inch; diameter of swollen posterior region about 0.6 mm. Collected, first, September 1, 1911, in a rapid of the Left Fork of Straight Creek, a few hundred feet from a dwelling in which were four cases of pellagra. Later, collected in Cumberland River, near Pineville, and at different points in Straight Creek.

Head large, its depth three-fourths its length. The fans

of curved bristles conspicuous, consisting of a stout basal stalk at each side of the head, bearing about 36 bristles, these flattened, strong, curved, expanded at their bases, the inner edges with short, rigid, straight, obliquely-placed, or erect setæ, excepting a small portion of the tip of each. Very minute soft hairs fringe the margin also, between the rigid setæ, and these soft hairs are present at the tips as well as elsewhere. Antennæ very slender and inconspicuous, erect, consisting of a long basal piece, then a short, very slender one, ending with a very slender short distal segment. Lower lip (labium) black along the anterior border; side margin a trifle excavated anteriorly, then suddenly arching outward, with four appressed marginal teeth at the beginning of the arched portion. Anterior median edge a little excavated, with, at each side, an outer rather prominent acute tooth, a median tooth of about the same size and character, and between the median and each outer tooth three small teeth, making nine in all. Nearly parallel with the lateral margin of each side are three hairs with divided tips, the most anterior being opposite the appressed teeth of the margin. Mandible of the usual structure in the genus, consisting of a central elongate piece, arched without, and bearing at the tip three rather strong acute black teeth, the median of which is smallest; proximal to these teeth is a series of three acute straight teeth successively shorter from the outermost; then succeeds a series of six close-placed, long, spine-like teeth, with two stouter ones completing the series within. Two stout teeth, looking as if cut out of the margin complete the armament, and are placed proximal to all the others. The usual brushes of hairs arise from the inner edge of the basal half of the mandible. The maxilla consists of a stout broad basal piece from which arises a cylindrical segment tapering a little to the tip but blunt and bearing at the extremity several short teeth. An inner lobe about as broad as long bears on its side a tuft of hairs extending beyond the tip; a triangular basal piece bears several setæ along its anterior edge and at its apex is one conspicuous pectinate spine. On each side of the head are

two black specks, the posterior the larger and reniform, the anterior elongate and nearly straight.

From the first body segment following the head, on its ventral side, arises a jointed leg extending forward and turning upward beneath the head. Its extremity is armed with rust-brown chitinous hooks by which it is enabled to cling, the structure being an organ of locomotion. At the posterior extremity of the body is a circle of microscopic hooks for clinging, this larva like others attaching itself to a web which it spins on the surface of rocks, and then standing erect swaying about in the current. The external respiratory organs consist of three tufts of soft white finger-like processes thrust out above the posterior extremity of the body, each lateral tuft consisting of four processes and the median of about the same number. These structures are retractile and are not visible on most of the specimens collected.

The colors of the larvæ secured vary somewhat with age and size, the very young being largely white, older ones showing evident bands of black on the middle body segments. An example before me shows a black dot posterior to the base of each fan-like brush of the head, while several close-placed brown points are visible from above near the posterior lateral margin, and a group of about six median ones appears between them. Sutures of the head and posterior margin black. Foot white, excepting the roughened tip, which is rust-brown. Swollen posterior part of body white beneath; ring of hooks brown.

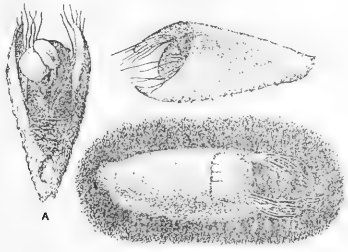

FIG. 2.—Pupae of S. venustum. A, adult emerging From Straight Creek, 1911.

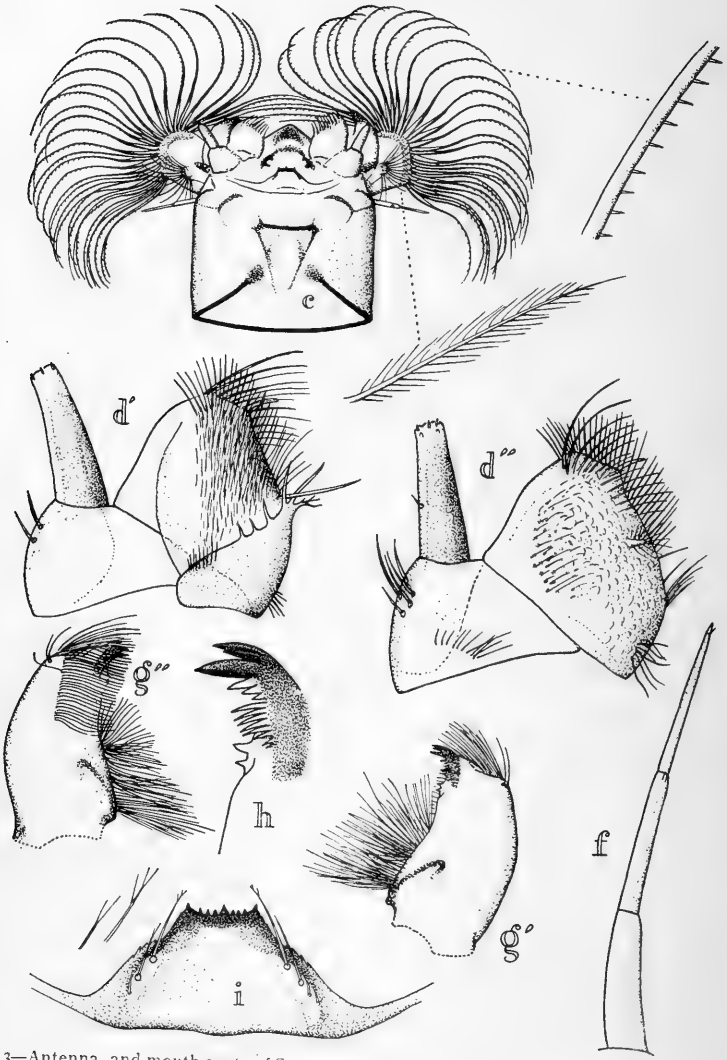

FIG. 3—Antenna and mouth-parts of S. venustum. *c*, ventral view of head; *d'*, maxilla; *d''*, opposite side of maxilla; *f*, antenna; *g' g''*, mandible; *h*, enlarged tip of mandible; *i*, labium.

Pupa.—Pupa cases were taken from the same rapids as the larvæ above described. They were of the "wall-pocket" type and were attached to a bit of submerged bark in one case, to rocks in others. They are elongate, leathery, pale brown, rounded from side to side, becoming gradually wider to the open end, from which projects the head of the brown pupa bearing two tufts of respiratory filaments, each tuft made up of six simple filaments. Length of case 4 mm. (0.056 inch). The case is closed beneath along the attached side for about one-half its length.

Only the rounded anterior extremity of the pupa shows in the case. The brown tapering filaments project some distance beyond the opening, and together with the case serve to distinguish members of the genus from any other aquatic Diptera. The six simple respiratory filaments are characteristic of but two species likely to occur here, namely, *S. venustum*, the black fly, and *S. meridionale*, the turkey gnat. The black fly larva differs, however, in having an independent pair of setæ near the tip of the mandible, on the convex side, and the three large teeth of its labium are about equal in size, characters in which the Kentucky specimens agree. No adult insects were collected, though I examined the creek carefully on several different days, between Pineville and Cary. One of the pupæ was in process of giving up the adult, as shown in Figure 2, A, a fact proving the emergence of a fall brood, as do a number of empty cases secured.

Simulium pecuarum (The Buffalo Gnat*).

In the southern states this gnat is the best known member of the genus. It has been at times a great pest to stock on the bottoms of the Mississippi and other streams in the South. In former years it was well known in Western Kentucky along both the Mississippi and the Ohio rivers. It is

*The impression has been conveyed that the writer of this bulletin regards the Buffalo Gnat as the species concerned in conveying the virus of pellagra. I have never regarded it as an agent of infection. All my inquiries of people residing in the region in which pellagra is most prevalent failed to produce any evidence that this particular species occurs there. Residents knew nothing about it, yet every man, woman and child seemed to know about the "new disease". On the bottoms of the Mississippi River near Columbus, on the other hand, residents are familiar with the Buffalo Gnat, but know nothing of pellagra.

still known to the dwellers on these streams. Apparently it is less common than it was in early pioneer days, when, according to information furnished me, it sometimes appeared in early spring in immense swarms, actually killing mules and other stock left unprotected in the bottoms. Yet I cannot find that such an insect is recognized by people living in the mountains where pellagra is prevalent, and although the insect is known to attack man, it seems unlikely that it is the insect agent for conveying the disease. If it were, we ought to find it in Illinois, and throughout Eastern Kentucky where pellagra occurs. Other species of Simulium occur, however, throughout all the territory in which pellagra is known at present, and even if we exclude this species from the problem these others must for the present be considered as possible agents of infection.

FIG. 4.—Adult of Buffalo gnat. (*S. pecuarum*) drawn from alcoholic specimen received from Texas. x 10.

The adult buffalo gnat is a good deal like the black fly in general form, being stout-bodied, the thorax especially prominent and rounded, the legs moderately long, the beak very short but stout. Its two wings are ample, transparent,

and few-veined, the stronger veins being close-placed near the anterior margin.

Alcoholic specimens of the fly received from Dr. M. Francis of College Station, Texas, many years ago, and thus probably altered in color, measure 3.3 mm. (0.13 inch) in length, the relatively large and broad wings measuring a little more, 3.6 mm. (0.14 inch). The head is somewhat produced in advance of the eyes, the palpi rather long and slender, curving downward and posteriorly. Puncturing mouth-parts rather short but sharp and strong, not in evidence, except by dissection and microscopic examination. Antennæ about as long as head, rather thick, of numerous divisions, these crowded, and mostly placed a little obliquely. Thorax very thick, and strongly convex dorsally to accommodate the powerful muscles of flight. Legs of moderate length, the posterior largest. Abdomen broadly attached to the thorax, oval and tapering to a point behind.

In his original account of the species the late C. V. Riley describes the sexes somewhat as follows :

Male.—Eyes meeting and with two sets of facets. Mouth-parts soft. Head black. Antennæ black, with some red. Maxillary palpi black. Thorax black above. Abdomen black, with grayish white posterior margins to segments.

Female.—Eyes not meeting. Head gray slate, with short yellow hairs. Eyes black, with coppery or brassy reflections. Antennæ black with whitish pubescence. Thorax grayish slate and generally distinctly marked with two medio-dorsal and two subdorsal longitudinal black bands. Under side of thorax, grayish slate. Abdomen with a broad gray longitudinal band from near the base of the second segment, where it is broadest.

This fly is distributed throughout much of North America, although often denominated the Southern Buffalo Gnat because of the immense numbers occurring in the southern states. It has been recorded from Alaska, New Hampshire, Indiana, Kentucky, Mississippi and Kansas, and unless several species have been confounded, it is to be found in many of the other states.

The gnat makes its appearance during the early spring at a time when bottoms are flooded. The larvæ require rather good water with a current, and are never at home in stagnant, badly polluted pools. They attach themselves to submerged sticks, leaves, logs and rails, clinging by means of the circle of hooks at the hind end of the body, their hold being made secure by a silken web spun over the surface.

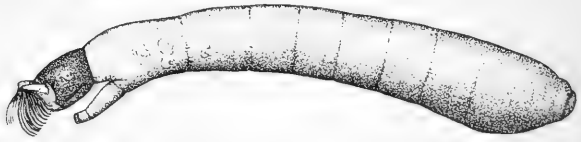

Fig. 5—Larva of Buffalo Gnat, from an alcoholic specimen from Texas. x 10.

When dislodged they drop down stream suspended by a silken thread let out from the mouth, and are by its use enabled to return again to the surface whence dislodged. The eggs were found placed on rocks on the banks a few inches above the surface of the water. They are placed in a close layer, are soft, ovoid in shape, except as influenced by pressure of other objects, and measure 0.40 mm in length by 0.18 in diameter. The young are believed to feed upon small crustaceans and other similar animal food brought to their mouths by the peculiar brushes of bristles on each side of the head. The pupæ are formed in leathery brown cases placed well down in the water on wood where they are not likely to be left dry during seasons of drought. The respiratory filaments arising from each side of the thoracic region are many-branched and project beyond the opening of the case.

In Kentucky in recent years the buffalo gnat has become almost unknown in sections where it was formerly troublesome. It is still to be found along both the Ohio and Mississippi rivers from Daviess County westward and southward, though some correspondents in this region say they have seen none for twenty or thirty years. It is evident, however, that the gnats do occur in noticeable numbers every season locally, and that in small numbers they are probably constantly present throughout the bottom land along the Ohio and Mississippi rivers in Western Kentucky.

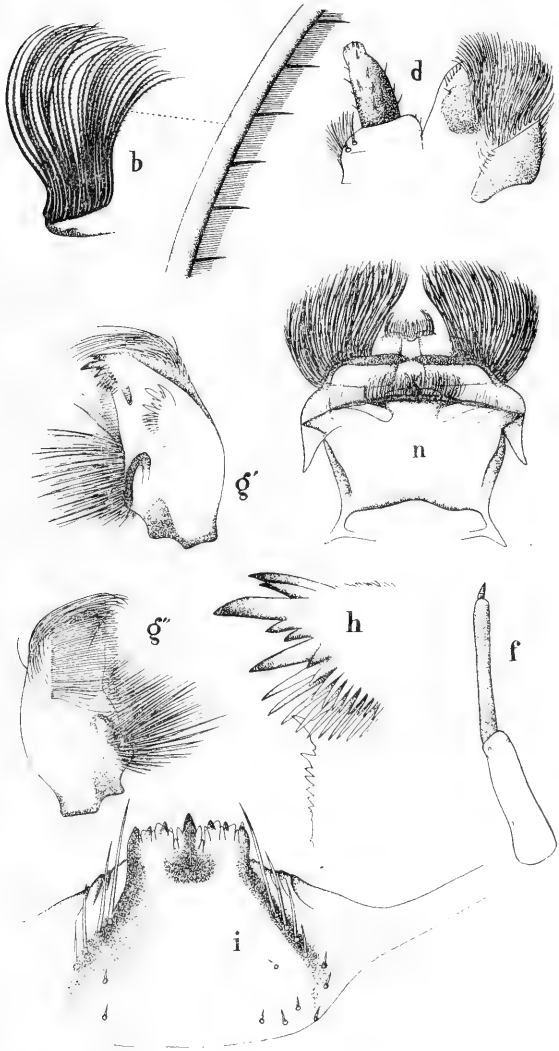

Fig. 6.—Antenna and mouth-parts of Buffalo Gnat larva. *b*, vibratile bristles from side of mouth; *d*, maxilla; *f*, antenna; *g' g''*, mandible; *h*, tip of mandible highly magnified; *i*, labium; *n*, hypopharynx.

The appearance of the adult is often very sudden in a neighborhood, sometimes accompanying a change in the wind. With strong wings it flies rapidly, and thus probably often migrates considerable distances from the waters in which it develops. The gnats attack stock by creeping into the ears and nostrils, and collect over the prominent veins along the under side of the body, when very abundant alighting upon and attacking any part. Riley, who studied the insects many years ago in Mississippi, says that they are most active during dark cloudy weather when a storm is brewing, but that in bright days from eleven o'clock in the morning to four in the afternoon they are inclined to be inactive.

When first attacked animals suffer greatly, and often become quite frantic. They grow more accustomed to the injury after a time and submit to it without fretting. It is said that the stock in gnat-infested regions become to an extent immune, or at any rate animals learn to take better care of themselves and do not so often succumb as does stock recently brought to the region.

The puncture seems to be intensely irritating, and brings blood at once. Oddly, the poison causes in animals an ailment resembling colic, a fact which will recall the accompanying digestive derangements in pellagra. A poison of some sort appears to be injected into the blood, and the result on badly stung animals is said to be somewhat like that following the bite of the rattlesnake.

Smudges of smoke, and sponging with coal-tar water, fish oil and some other preparations, are used to repel the insects. Many of those tried are ineffective.

Simulium pictipes (The Innoxious Sand Fly).

Fig. 7.—Larva of *S. pictipes*. x 10.

The larva of a third species of the genus has long been known to me as occurring in great numbers in small streams

flowing into Kentucky River in the region about Clay's Ferry about 15 miles southeast of Lexington. It was first observed July 14, 1893. By simply closing the blades of my forceps over the rocks in shallow water, then holding them together and removing them, numbers of the larvæ could be picked up by the silken threads they emit as they let go their hold and float down stream. They are true silk-spinners like the other members of the genus.

This is a very large species. Dr. Howard, writing of it in Insect Life (Vol. 1, p. 99) says of examples collected by him at Ithaca, New York, that some of them measured three-fourths inch in length. I have none from our streams as long as this, but the larvæ are much larger than the others collected in this State.

Adult male.—Dr. Johannsen in an article published in Bulletin No. 68, N. Y. State Museum describes the male as gray, the antennæ and palpi black; the metanotum with golden pubescence, black, with lateral margins gray, and a gray spot extending inward from each humerus; a pair of silvery spots within the gray ones. Beneath gray. Abdomen deep velvety black. Legs black or dark brown. Knobs of balancers, orange-yellow. Length 3.5 to 4 mm.

Adult female.—The same author describes the head and thorax of the female as opaque gray, the metanotum with three deep brown or black stripes; abdomen velvety black, beneath gray. Legs grayish or pallid; tips of tibiæ and tarsi generally black. Knobs of balancers yellowish white. Length 3 to 5 mm.

Larvæ in numbers were collected and preserved in alcohol in 1893. The largest measure about eleven millimeters in length, and are blackish, excepting the head, which is reddish brown, and the ventral side of the swollen posterior region of the body, which is white. Head of a decided reddish brown, the large brushes of strongly ciliate setæ of the same color. The usual pair of black specks on the side of the head, in a pallid area. Antennæ of three segments, the basal long and a little curved, with some appearance of being subdivided; second segment straight and

Fig. 8.—Mouth-parts and other structures of the larva of *S. pictipes*. *a*, dorsal view of head; *b*, stalk of vibratile bristles; *c*, ventral view of head; *e*, palpus of maxilla greatly magnified; *f*, antanna; *g*, mandible; *h*, tip of mandible greatly magnified; *i*, labium; *j*, tip of foot; *k*, ring of spinules at hind end of body; *m*, side view, extremity of abdomen showing protrusible respiratory appendages.

more slender, about half the length of the first; third segment very small and short, acute, one-tenth the length of the second. Mandibles with an anteapical pair of hairs; apical teeth strong, acute, black. Labium with a strong central tooth, outside which on each are three small teeth, the outer being largest; at each angle is a strong acute tooth somewhat like the median one but not so large. External margins slightly convex in outline or nearly straight, a half dozen small appressed teeth are present just external to the toothed angle.

The pupa has not been collected by me. Dr. Jonannsen says its case is boot-shaped. Nine filaments are borne on each side of the thorax.

The species is not of the same interest at present as the others, because it is reputed not to sting, and can thus have nothing to do with the eruption accompanying pellagra.

Simulium meridionale (The Turkey Gnat).

Quite recently I have collected larvæ of a Simulium from rapids in Benson Creek at Frankfort, that possess the characters of this insect, but this material is so scanty that I do not care to pronounce on it finally. The turkey gnat is, however, distributed in the United States somewhat like the buffalo gnat, and so probably occurs here. It is a well known stinging species. In Insect Life for July, 1888 (Vol. 1, p. 14) is an interesting note from a correspondent writing from Virginia to Professor Riley, in which it is stated that these gnats destroy "thousands of chickens and turkeys yearly" and that it is called the cholera gnat because its attacks cause symptoms resembling those of chicken cholera. Gobblers and roosters are killed first because the wattles and combs afford an exposed region peculiarly open to attack.

The male, according to Riley, is from 1.5 to 2 mm. in length, the eyes meeting above, where the facets are coarser and of a brilliant coppery luster, those on the ventral side smaller and black. Thorax dense black with bluish luster, ventral side grayish. Legs reddish with black tarsi. Abdo-

men above black, posterior margin of segments edged with gray. Ventral sides of segments two and three light reddish gray, the rest blackish with gray posterior margins.

The female is described by the same writer as from 2.5 to 3 mm. long; the head slate-blue, with silvery pubescence; the thorax, slate-blue, with three longitudinal lines, the median narrow and widening at the apex, the outer curving in at the base and out at the apex; beneath slate-blue; abdomen with last five segments dark blue above; segments 2, 3 and 4 each, with a black cross bar; segments 5, 6 and 7, with two submedian stripes, disappearing on 7; bluish white everywhere beneath; legs brownish black.

Simulium reptans.

As already stated, this common European species has been recorded from Greenland, and may yet be found on this continent. It is described as black, the female with a white spot on each side of the thorax, the sides of the thorax silvery.

The name *S. reptans* has many synonyms, due apparently to the insect being somewhat variable. It would seem to be a near ally of our Kentucky insect, *S. venustum. Simulium columbaczensis,* on the other hand, notorious because of its injuries to cattle in Hungary and other countries of the same general region, is apparently the European analog of our buffalo gnat.

CHIRONOMIDÆ (GNATS).

With the Simulium pupæ I took from submerged wood and other objects in Straight Creek and Cumberland River a number of singular cases which may perhaps be mistaken for the pupa cases of Simulium. They are produced by a slender larva, which is sometimes secured with its head out of the case, as shown in Figure 9. It is the young of one of the gnats belonging to the family Chironomidæ, a group represented in ponds and lakes by blood-red larvæ living free or within transient tubes of loose granular material secured to the surfaees of stones. The group is

interesting in this relation, because while some of the genera of the family do not sting and cannot be regarded as noxious, some are pests, and may become the source of a good deal of annoyance to people living along streams. The punkie or no-see-em (*Ceratopogon nocivum*) of northern woods is an example. We have this, or a similar species, in Kentucky, sometimes encountered even about the City Reservoir at Lexington during the first warm spring days, and occasionly within the city limits. Harris says of them (Insects of Massachusetts, 1852): "So small are they that they would hardly be perceived were it not for their wings which are of a whitish color mottled with black. Toward evening these winged atoms come forth and creep under the clothes of the inhabitants, and by their bites produce an intolerable irritation." * * * * In my own experience these minute stinging gnats simply sting the moist back of of the hand and show little or no disposition to creep under the clothing.

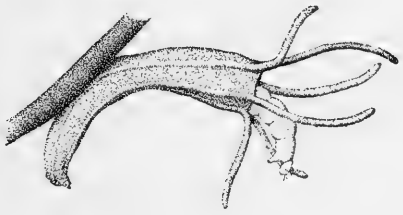

Fig. 9.—Larva and case of Tanytarsus from Left Fork of Straight Creek, 1911. X 8⅓.

The case-making species collected at Cary, Sept. 1, belongs to the genus Tanytarsus, and may prove to be *T. exiguus*, of Johannsen, though there are some differences to be accounted for before this can be considered established.

No. 1. Tanytarsus sp.—Length, 3.5 mm. Translucent, white, the head pale yellow. Cylindrical, the somites somewhat thicker anteriorly, segmentation very evident, the body consisting of twelve somites, of which the anterior bears a pair of clawed prolegs and the posterior is truncate and bears two tufts of long black setæ on its dorsum, a pair of retractile clawed prolegs on its ventral side and posteriorly four lanceolate respiratory appendages. The head

is small, firm-walled, with a few setæ arising from its dorsal surface; on each side with two black specks a short distance behind the base of the antenna, the dorsal of which is larger. Head 0.286 mm. long, being a little more than

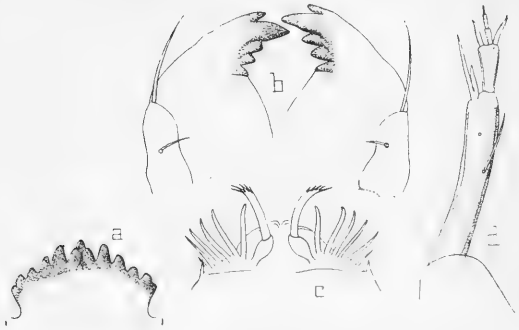

Fig. 10.—Mouth-parts of larva of Tanytarsus sp. *a*, labium; *b*, mandibles; *c*, labrum with characteristic spines; *d*, left antenna.

twice as long as the antennæ. Prominences on which antennæ arise, evident. Antenna, .01358 mm. long; 1st segment slightly curved, a little more than three times as long as the second, bearing at its tip a slender appendage somewhat longer than the second; second segment straight, slightly enlarging from base to tip, bearing at its extremity two acute appendages about two-thirds the length of the remaining joints; third, fourth, and fifth segments minute and tapering. Labrum with two strong pectinate claws curving toward the ventral side; on each side of these claws

Fig. 11.—Larva of Tanytarsus removed from case. x 23.

are about five smaller simple claws of the same general character, all being evidently of service as grappling hooks. Mandibles strong, curved, with black teeth, as follows: an apical rather short tooth, a very long strong tooth just within it, then three shorter teeth of about equal size; within the latter the mandible expands, as in other related genera. Labium with black teeth, the median largest and

longest, with a slight lobe on each side, outside it on each side are five additional teeth gradually diminishing in size.

Case brown, elongate, straight, or slightly curved, gradually expanding to its open end, from the edges of which arise six more or less bent cylindrical processes continued as ridges along the surface of the case. Processes about half the length of the case, which measures 3.5 mm. long, the expanded open end measuring 1 mm. in diameter. Small cases are continued at the closed end into a slender stalk, but as far as observed were attached by the side, to stones, wood, and other objects, in the water. The case has an appearance of being composed of mud or refuse glued together, and is very fragile. The longitudinal ridges of the surface appear to be produced by building out the open end of the case by adding material between the projecting processes.

Dr. Johannsen's species was obtained from small streams at Ithaca, New York. The case is, he says, composed of silk, but those from Straight Creek are, as stated, composed very largely of refuse. Differences between the larva described by him and those collected by me are apparently as follows: (1) The shorter antennæ of the Kentucky species (about half the length of the head); (2) the acute appendages of the second antennal segment; (3) the strongly pectinate median claws of the labrum.

No. 2.—This is a second, cylindrical, elongate larva, taken with others on the under surfaces of rocks in rapids of the Left Fork of Straight Creek. It resembles the one inhabiting the brown cases so much that it would by most people be considered identical. The head is pale yellowish brown, the two black specks of the sides of the head well forward and contiguous, though a line separates them. Antennæ short, less than half the length of the head; first division long, bearing a seta at its distal extremity, nearly as long as all the rest of the antenna; second segment without appendages; three small distal segments tapering. Claws of the prolegs of the first body division numerous, simple. Posterior clawed legs long and diverging. Two

distal tufts of long diverging setæ arise from prominences near the posterior margin of the posterior body segment. Behind the tufts at the posterior margin of the segment are two additional setæ. Respiratory appendages three-jointed, tapering. Length of body 5.5 mm.

No. 3. Orthocladius sp.—This larva resembles the two preceding in a general way and was taken in some numbers about rocks in Straight Creek near a dwelling occupied by people affected with pellagra. Cylindrical, elongate, plainly segmented. Head yellowish brown, posterior margin at sides definitely black. Jaws black at tips, curved, acute, three sharp denticles within apex, then a strong process from which springs a very finely denticulate plate expanding toward the base of the jaw. Mentum black at lateral margin, brown medially; four lateral teeth large, acute, black, tooth next within smaller, brownish; the next obliquely truncate and brown; median broad, plate-like, brown. Antennæ on small prominences, less than one-fourth the length of the head; first segment longest, bearing at its distal extremity two acute appendages, one nearly as long as all the remaining segments, the second not quite two-thirds as long; second segment a little more than one third the length of the first. Black specks on side of head not quite contiguous, the anterior much smaller and lunate. Claws of the false legs of the first body division strongly curved, many of them toothed. Tufts of hairs at posterior extremity on small prominences. Respiratory appendages not jointed, the dorsal pair longer and club-shaped. Length 4.5 mm. The broad truncate median tooth of the mentum is suggestive of the genus Thalassomya, as described by authors.

No. 4 Ablabesmyia sp..—A single dipterous larva found at Cary in the Left Fork of Straight Creek is very different from all the above in a number of features. The body is rather short and stout, about 4.5 mm. long; the head relatively large, elongate and flat, with one black speck on each side, with an anterior fissure. Antennæ with the long first segment largely concealed by an extension of the crust. Hooks of anterior prolegs retractile. Each body division

with several long soft hairs. Segmentation distinct. Posterior prolegs long, projecting far beyond the posterior somite. Dorsal tufts of setæ of posterior somite arising from long pedicels. Two long setæ at posterior edge of the somite behind the tufts. Respiratory appendages dusky, tapering, about half the length of the prolegs. See Fig. 26.

Still other larvæ belonging to related genera were observed, among them one with swollen anterior body segments and evidently belonging to the genus Tanypus. They are largely fragile, harmless gnats when adult, and the relation they bear to Simulium as competitors or enemies may be the only one they sustain to the immediate subject of this paper. Such larvæ often constitute an important element of the food of other aquatic animals.

No. 5.—A number of singular dipterous larvæ were collected near the Roark cottage on Straight Creek, while searching for Simulium larvæ and have not been definitely determined. The figures 27 and 28, of larva and pupa, give a good idea of their character. The specimens were all taken together from a piece of submerged wood in rapid water.

It is a sluggish rather stout, tough-skinned grub, with a small head which widens rapidly from the anterior extremity to the base, giving it a somewhat triangular outline. The sides of most of the body divisions are produced and pointed, each process bearing a long, curved bristle near its tip. Posterior extremity of body expanded into a clawed disc. Ventral sides of first body division (prothorax) with two clusters of obliquely-placed, curved, black hooks. Head dusky brown; antennæ short, erect. A black speck at the base of each. First body division dusky at sides, widest posteriorly; second, widest of the three thoracic segments; third, a little narrower, with a very short lateral point and bristle; first to seventh somites constituting the abdomen, each with a strong lateral extension and bristle; eighth division narrower, a little angular at middle, but with no process; ninth expanded and provided with strong curved hooks beneath, a pair of long hairs projecting pos-

teriorly and a median pair of teeth. A pair of bristles arises on the dorsum of each of the body divisions two to eleven inclusive, each bristle originating in a black dot. Posterior somite black centrally. Skin everywhere roughened with small granulations.

Apparently gregarious. Pupæ were taken with the larvæ, and still retained the cast larval skin about the posterior part of the body.

CULICIDÆ (MOSQUITOES).

Members of this family are present in the mountains, but appear to attract less attention than they do in more level countries in which are more ponds and sluggish streams. Some larvæ commonly known as wrigglers are to be found there in barrels of water and in ditches and pools of various sorts. They were about gone from their usual haunts, however, and I saw less of them at Pineville than I probably should earlier in the season. The streams themselves because of their rapid current are not well suited to the requirements of mosquitoes. People with whom I conversed reported some mosquitoes as giving trouble during the hot summer months. I found confirmation of their statements in an engorged adult of *Anopheles punctipennis* in my room in Pineville. My attention was of necessity concentrated on the genus Simulium, and I learned less of the mosquitoes as a consequence than I otherwise should. More attention will be given to them later.

Fig. 12.—Larva of *Anopheles maculipennis*, from Horse Creek, Corbin, Ky., August, 1911. x 13.

Anopheles sp.—A few minutes use of a dip net in a sluggish pool of Horse Creek near Corbin, August 29, 1911,

resulted in the capture of a larva (figure 12) belonging to the genus Anopheles. It does not quite agree in structure or coloration with the species known to me from Kentucky, but larval characters are rather uncertain quantities, and with a single example it is not worth while to attempt a determination at present. Even the "combs" of teeth sometimes made use of in separating species, appear to be variable in the same batch of larvæ.

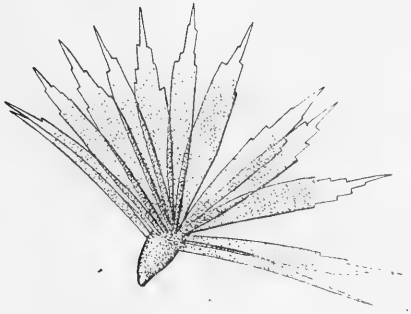

Fig. 13.—Characteristic stalked tuft of spines from body of larva of Anopheles from Horse Creek. x 376.

The markings of the head are well represented in the figure. The singular dusky tufts (figure 13) on the abdominal somites 3 to 7 inclusive, consist of blade-like spines denticulate on the margins and mounted on a short stout pedicel. Six plumose hairs ranged across the head between the eyes are attached within a dusky area. Body in general dull gray, with a black dorsal plate on the last abdominal segment. Length 5.5 mm.

Anopheles punctipennis.—As stated, a single engorged adult of this strikingly marked species was taken on the wall of my room at Pineville. It is to be recognized among our species of mosquitoes by its wings, which are conspicuously marked with dusky and yellow, and by a sharply defined ash-gray area along the dorsal side of the thorax. These characters, together with its disposition to elevate the abdomen when at rest should enable any one to recognize it, and at the same time distinguish it from the ob-

scurely marked *Anopheles maculipennis*, also frequently found in dwellings in this State.

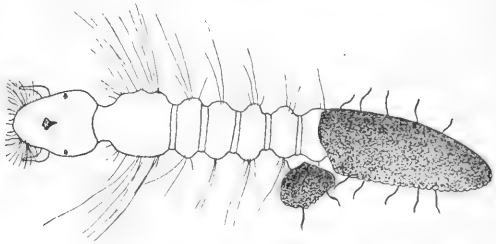

Fig. 14.—Larva of yellow fever mosquito (*Stegomyia fasciata*) when hatching.

Stegomyia fasciata (The Yellow Fever Mosquito).—From a barrel of water near Cary on Straight Creek I took, October 21, 1911, a larva that appears to belong here. It was late in the season to look for adults, though they occur until after frost at Lexington. The adult, as stated in a bulletin published in 1901 (Ky. Experiment Station, No. 96) is a common household insect in Kentucky, breeding close about dwellings in buckets, barrels, troughs, etc. If we should ever be visited by yellow fever refugees this little pest stands ready to do its part in spreading the disease. Its disposition to sting the wrists, backs of hands and ankles is well known, and may suggest a possible relation between it and the spread of pellagra.

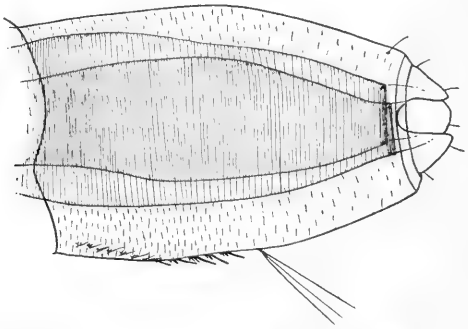

Fig. 15.—Respiratory tube of yellow fever mosquito larva greatly magnified, showing the two large tracheal trunks.

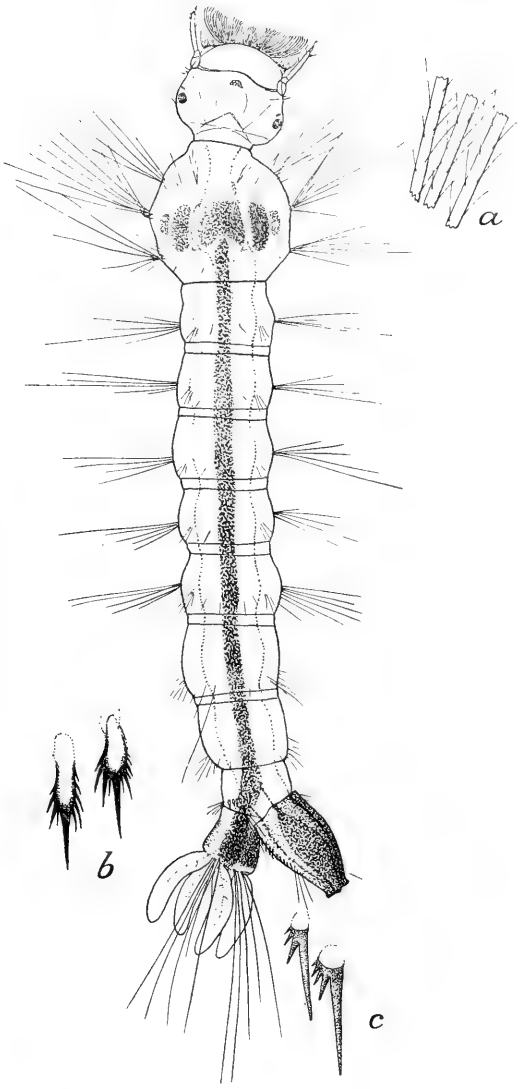

Fig. 16.—Well grown larva of yellow fever mosquito. *a*, plumose hairs of body tufts *b*, spines from "comb" of posterior body segment; *c*, spines from series on side of respiratory tube. x 14½.

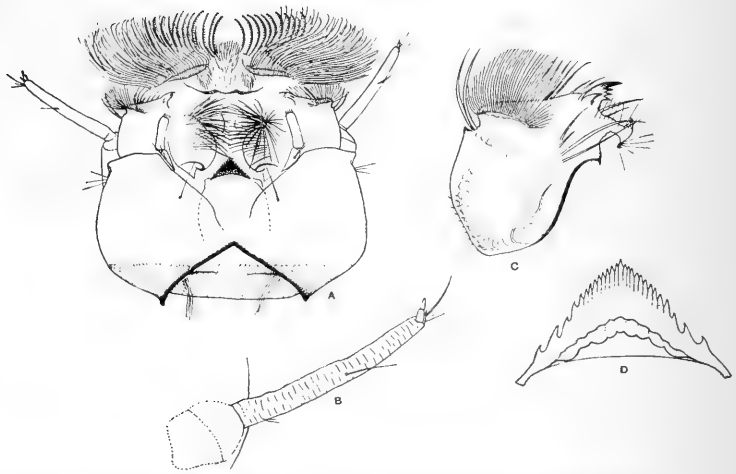

Fig. 17.—Ventral view of head and mouth-parts of yellow fever mosquito larva. *a*, head; *b*, antenna; *c*, mandibles; *d*, labium.

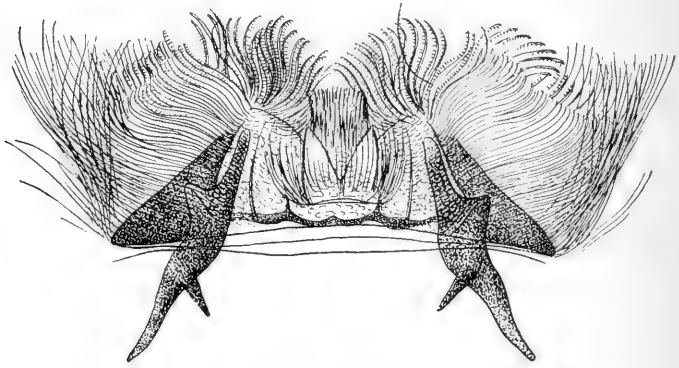

Fig. 18.—Vibratile hairs from mouth of yellow fever mosquito larva.

TIPULIDÆ (CRANE FLIES).

In the spring-fed rivulets flowing down the banks of the Left Fork of Straight Creek, I took October 21, 1911, a number of the leathery larvæ belonging to this group. None of the adults are known to sting, and excepting as they are sometimes attracted to lights are not often seen about dwellings. Larvæ of terrestrial species are often found in large numbers about decaying vegetable matter on lawns,

and in fields, where they constitute an important element of the food of robins.

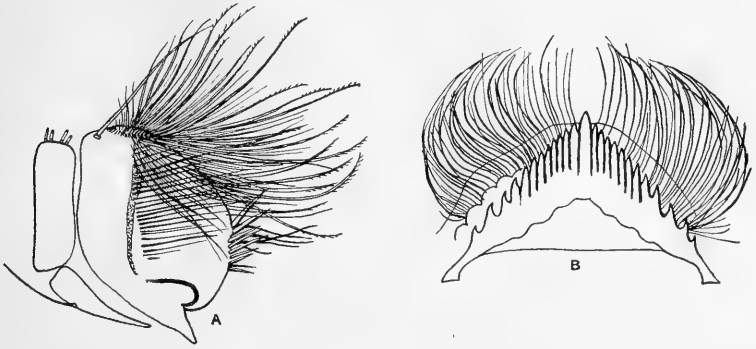

Fig. 19.—*a*, maxilla; *b*, labium. Yellow fever mosquito larva.

The aquatic species are generally found among dead leaves and other vegetable refuse washed into streams, and probably obtain their food from such sources.

The larvæ collected near Cary are like other members of this family of flies, soft-bodied, leathery-skinned, cylin-

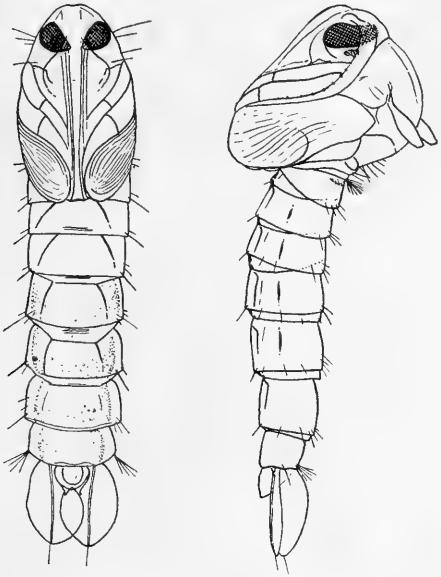

Fig. 20.—Pupa of yellow fever mosquito, ventral and side views. x 14½.

drical, dull-gray grubs, with a rather small head more or less completely withdrawn and concealed in the first body segment. The body is deeply and simply wrinkled, each division with a few short erect black hairs, in pairs. Obscure tubercular prominences become more pronounced on the ventral sides of the somites, the last one of which bears three pairs of fleshy, unjointed, dusky appendages, as follows: A pair of short ones on the dorsal side; a pair of longer ones, one on each side of the dorsal pair, with a tuft of black hairs at the tip of each and a couple of small tubercular offshoots; a third still longer pair projecting downward and backward, each bearing a tuft of radiating black hairs at the tip and with two small tubercles. A pair of eye-like structures is conspicuous at the back of the short dorsal pair of appendages. The under side of the posterior somite bears six soft contorted appendages. Length of largest example 20 mm.

TABANIDÆ (GADFLIES).

Tabanus sp.—A larva of one of these stinging flies was taken in the Left Fork of Straight Creek near a dwelling occupied by people suffering with pellagra. The strong-flying adults produced from such grubs are known as gad flies, and are common pests of stock, attacking especially horses and cattle, but not neglecting even hogs, and now and then venturing upon man himself. The young have sharp puncturing mouth-parts with which they destroy snails and other aquatic animals upon which they feed. They are found in mud and among vegetable refuse at the bottom, commonly, and being without limbs move by a wriggling motion, but when dislodged swim to some purpose though rather awkwardly.

It is not likely that they will prove to have anything to do with pellagra, though the strong beaks of the flies are efficient instruments for puncturing the tough and thick skins of cattle, and might easily serve to convey the virus of diseases. Fortunately they are not commonly disposed to attack us.

A single pure white larva twenty millimeters long was taken among rocks in the Left Fork of Straight Creek, September 1, 1911. Its body is composed of eleven somites and an additional small terminal segment is cylindrical and tapers toward its extremity. A faint brown band follows the anterior margins of the segments behind the first. At the anterior edge and ventral sides of segments four and five are six tubercles. Succeeding segments, except the two posterior, bear a ring of tubercles, two on the dorsum, the rest at the sides and beneath.

HEMIPTERA (TRUE BUGS).

This order contains members that are generally to be found in either standing or running waters, in which they reside at all periods of their lives, some swimming beneath the surface where they remain much of their lives concealed from us. When their surroundings become from any cause unsuited to them, they may, as in the case of the large electric light bugs (*Benacus griseus and Belostoma americanum*) and of the water boatman belonging to the genus Corisa, leave the water, and fly about in search of a better stream or pond. They are as a consequence often captured about electric lights and even in dwellings on hot summer evenings. The species observed in the Cumberland River and the tributaries are well known to every boy as water striders or water skaters, because of their manner of progression on the surface of water. When pursued they dive and conceal themselves, but soon reappear at the surface where they float and row themselves about in a leisurely fashion generally in small schools of from three or four to a dozen. All these insects are provided with beaks, with which they capture and kill other animals upon which they feed. Occasionally the collector receives a severe stab from such species as *Naucoris poeyi*, when handling water plants, but so far as I know, the aquatic species do not at any stage of their lives deliberately attack man. They are interesting in this connection because of their association with Simulium and other stinging gnats in our waters.

Two small, blackish species were rather common in Straight Creek and in the Cumberland River at Pineville. The commonest one is represented by figure 35. It is without wings, and rows itself about with such rapidity that it is not easily captured. On each of its middle feet is a fan composed of feathered hairs which are caught and held expanded by a claw of the split tarsus. This fan appears to dip beneath the surface when in use and gives its possessor a purchase on the water much like that obtained by a boatman with an oar.

Rhagovelia obesa, Uhler.—At the edges of the creeks and of Cumberland River small schools of these water striders, so-called, were often observed. They were especially common near Cary in Straight Creek and in the gap of Pine Mountain along the rapids of the river. They generally stayed in the sheltered places about submerged rocks in the larger stream, but are surprisingly quick in escaping the collector's net, and are quite able to care for themselves under any circumstances likely to arise in the swift current. These little insects are provided with a jointed beak and prey upon other insects which fall upon the water.

Length 3.2—3.3 mm. Division of body following the head widest. Front of head nearly even with the rounded eyes. Legs long, slender, the middle pair longest and bearing a fan-shaped tuft of plumose hairs (lacking in the young), kept expanded by claws of the tarsus. Last tarsal segment long, split. Abdomen of the male with straight carinæ along the margins of the abdominal somites terminating abruptly at the sides near the tip without meeting. In the female ridges originate at the sides of the thorax, thence curve backward and inward extending along the dorsum of the abdomen and meeting behind. Posterior femora of male noticeably thickened, and bearing behind a spine followed outwardly by a series of small denticles. In the female the large spine alone is present and the femora are not thickened. Both sexes are wingless in all examples collected. Color black. Antennæ and legs whitish at bases. A pair of transverse yellow spots on the dorsal

side of the thorax just behind the head. Carinæ of abdomen brown.

Metrobates hesperius.—A second species resembling the preceding in a general way, but with the four long slender tapering hind legs attached well back and close together, was found on one occasion, August 31, 1911, in the water at the edge of Cumberland River. It is a very alert species, and somewhat difficult of capture. Two females and one male were secured.

It is broad oval in shape, the female 3.8 mm. long, the male about the same in length, but much more slender and with a protruding cylindrical terminal abdominal segment. Wingless. Color black, a dull yellowish red spot on the occiput, excised in front. Eyes reddish brown. A relatively large bright yellow spot in the middle of the prothorax above, touching the posterior margin, but not reaching the anterior edge. Antennæ black, yellow at base. Legs black, bases of front pair and the prosternum dull yellow. A yellow mark in front of the bases of the middle legs. Under a lens a blue-gray longitudinal band is seen to extend along the middle of the thorax above. Another similar well-defined area extends along the sides. At the edges of the abdominal somites also the same color appears, and much of the ventral surface is so colored.

This insect resembles another water strider, *Trepobates pictus*, collected by me in 1889 and subsequently in rocky streams at Lexington, but the latter is elaborately marked with yellow and is more slender. Other larger species of the group *Hygrotrechus remigis* and *Limnotrechus marginatus*, are common in most streams in Blue-grass Kentucky. They are predatory insects, feeding upon flies and other insects that become stranded on the surface of water. As far as known they have no objectionable traits.

COLEOPTERA (BEETLES).

In most quiet fresh waters are to be found numbers of flattish beetles which swim well by means of their legs, which are in many cases expanded and fringed for the pur-

pose. In the swift streams of mountain regions these beetles of the family Hydrophilidæ and Dytiscidæ are not commonly seen. They appear not to endure buffeting well enough to hold their own in such waters. But their places are taken by others which are perfectly able to take care of themselves in the swiftest currents. One of the whirligig beetles was observed repeatedly in both creeks and rivers, often lurking in sheltered nooks among partly submerged rocks, but striking out in the swift current if pursued and when pressed diving to the bottom. These beetles are exclusively aquatic, their form and flattened middle and hind

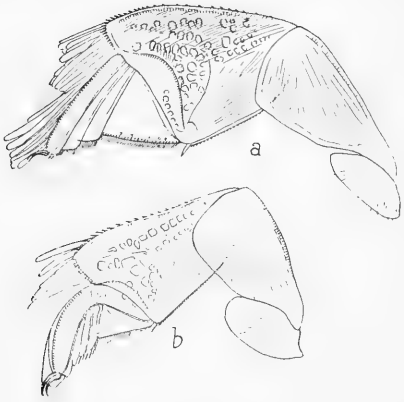

Fig. 21.—Expanded legs of the whirligig beetle, *Dineutes discolor*. *a*, right hind leg; *b*, right middle leg. Greatly magnified.

legs rendering them strong swimmers and unsuiting them for locomotion on the land. They have four compound eyes, or at any rate four independent divisions, two looking downward in the water and two looking upward.

The only species collected was *Dineutes discolor*. It is shining black with an olivaceous cast, in some lights with purple and bronzy reflections, especially about the head and the anterior edges of the wing covers. Eyes in preserved examples, reddish brown. Body rapidly contracted forward from the middle of the wing covers and meeting evenly behind with angles little evident and margin not serrulate. Labrum protruding, rounded, with a dense silken white

fringe of hairs. A tuft of similar hairs about the bases of the antennæ. Body beneath yellow to reddish, darker at the sutures. Legs reddish yellow. Male, length 11.1; diameter 5.5 mm. Female, length 13.4; diameter 6 mm.

These insects are predatory, both in the larva and adult stages. The young were not seen. Larvæ of the genus may be recognized by their elongate slender bodies bearing on each abdominal segment a pair of long lateral plumose respiratory appendages, the posterior somite with four such appendages directed posteriorly.

Parnidæ.

Perhaps the most characteristic beetles of the waters are members of this family. The adults appear by structure completely unadapted to life in the water, being provided with legs of the type seen in most terrestrial members of the order Coleoptera. They do not swim, but by means of long and strong tarsal claws cling tightly to the under sides of stones and wood, and are there shielded to some extent from the force of the current. Several species were rather common in the streams, and examples are figured.

The larvæ are among the most singular of the immature stages of aquatic insects. The crust of the dorsal side of the body is in them greatly developed, expanded, and the segments closely fitted to each other, producing a convex shield, the edges of which are held close against the underside of objects in the water. The limbs and head of the insect itself are to be seen only when the larva is detached and turned over. Like the adult it does not swim, but trusts to its capacity to cling tightly, and thus lives and thrives where the water races and tumbles among the rocks. The species are so generally present where Simulium was found that I have thought it worth while to note below the different species collected in the streams, having in mind a possible relation between the two, either as competitors or enemies.

Dryops lithophilus, Germ.—An elongate moderately convex black beetle, of a faint bronzy green color, found

clinging to the undersides of rocks in swift water. Head withdrawn in thorax up to the eyes. Thorax with sides rounded, anterior lateral angles acute, projecting forward as a spine alongside each eye. Wing covers contracted and sloping rapidly behind the middle, meeting behind in an acute angle. Surface evenly clothed with fine appressed silky pubescence. Antennæ, palpi and tarsi reddish. Legs in the main black. Length 4.3—4.4 mm.; diameter 2 mm. The most common and generally distributed species in Straight Creek and Cumberland River.

Dryops fastigiatus, Say.—This species resembles the preceding in a general way and is of about the same size. Black, rather coarsely and unevenly pubescent, the hairs being largely wanting from the region adjacent to the suture of the wing cover, and on the sloping posterior region of the thorax. Head immersed. Prothorax broadly rounded and a trifle angulate behind the middle. Anterior lateral angles slightly apiculate. Pubescence yellow. Legs black; tarsi reddish. Palpi reddish. Antennæ short. Length 5 mm; diameter 2.3 mm.

This insect was found associated with the preceding in Straight Creek, August 29, 1911, and in Cumberland River, August 31, but is relatively rare.

Stenelmis crenatus, Say.—A small rather slender gray beetle collected August 31, 1911, in the Cumberland River, at Pineville, September 1, in rapids of the Left Fork of Straight Creek, and on September 4, in Benson Creek at Frankfort. Head projecting. Antennæ slender, reddish. Prothorax with a rather deep median longitudinal channel bounded by two carinæ. Several obscure prominences on each side. Front angles acute, sides rounded behind, converging and nearly straight in front. Wing cover dull gray, with a ridge beginning on each side of the scutellum and gradually fading out a little beyond the middle of the elytron. A second decided ridge begins at each humerus and extends posteriorly and a little inwardly, terminating rather abruptly where the posterior slope descends to the tips. Legs gray, tarsi reddish, an obscure red spot between

the ridges of the wing cover and a second at the extremity of the lateral ridge. Length 3.2; diameter 1.4 mm.

The examples of the species collected in the Left Fork of Straight Creek, September 1, and in Benson Creek at Frankfort, September 24, differ in having the red of the elytra continued to form an obscure stripe.

Macronychus glabratus, Say.—Black, elongate, shining, punctured. Antennæ short, reddish; palpi reddish; distal segment of maxillary palpi black. Thorax elongate, widest behind, sides straight and rapidly converging from an angle behind the middle. Anterior margin pallid, wing covers with an obscure ridge near the suture, fading out beyond the middle. A conspicuous ridge terminates abruptly at the slope behind. Outside the latter ridge, and extending inward beyond it, is a silken whitish stripe. Legs long, sprangling, black, tarsi reddish; tibiæ with silken pubescence within. Pubescence of thorax scattered, golden, a trifle longer and more conspicuous on each side of the median line. A similar line of conspicuous golden pubescence on each side of the elytral suture. Length 2.7; diameter 1 mm.

Next to *Dryops lithophilus,* the most common species. It occurs in similar situations, but is less generally distributed. Cumberland River, Pineville, August 31; Left Fork Straight Creek, Sept. 1.

Ancyronyx variegatus, Germ.—This oddly marked beetle was not rare in the waters collected from. Specimens were collected in Clear Creek, August 31, and in the Left Fork of Straight Creek, Sept. 1.

Head black, exserted, antennæ slender, pale yellow, apex black. Thorax wide behind, strongly narrowed in front, and projecting over the head. A broad yellow transverse band along the anterior margin. Posterior margin more narrowly and obscurely yellow. Wing covers with a conspicuous bent yellow band beginning at the humerus and extending inward to the suture where it is narrowed, then widening and extending outward nearly to the margin. An elongate yellow spot on each side near the suture on the

sloping part of the wing cover. Legs black; femora yellow at base; tibiæ largely yellow; tarsi black, with yellow claws. Length 2.7; diameter 1.7 mm.

Larva No. 1 (Parnidæ).—Yellow, marked with dark brown. A series of round dots follows the margin, each placed just before a suture between segments. Anterior and lateral regions just within the dots reticulate with brown. Central region more completely brown, with a series of round dots along the median line and a second series on each side of it on the abdominal segments, the latter dots transversely lengthened. Margin fringed with close-placed rigid golden yellow hairs.

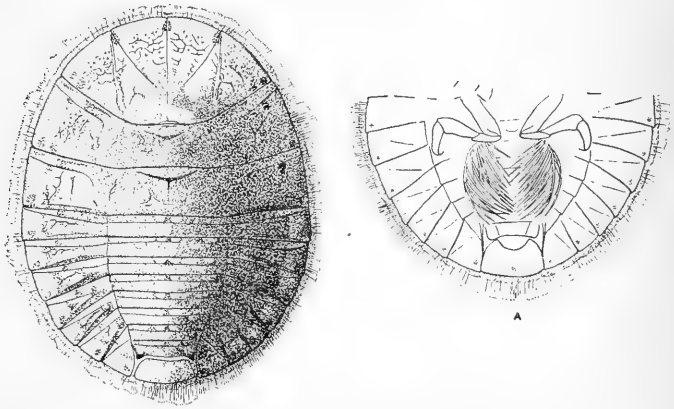

Fig. 22.—Buckler-shaped larva of beetle of the family Parnidæ. *a*, ventral view of posterior part of body, showing the two tufts of gill filaments. Larva No. 1 of Text. x 6.

Largely yellow ventrally, the marginal dots the only conspicuous markings.

Convex above, beneath concave, the body proper elevated, and the head free, with a pair of slender yellow antennæ and dark eyes. Legs strong, not reaching beyond the expanded terga, and thus giving the insect an appearance of being legless when viewed from above. Just posterior to the third pair of legs on each side are several tufts of long white respiratory filaments. Ten somites appear to be outlined in the terga, with median anterior and posterior plates added. Length 7—9; diameter 4.7—7.6 mm.

Collected adhering to the under sides of stones in Laurel River, Corbin; Clear Creek, August 31; Cumberland River, Pineville, August 31.

Larva No. 2 (Parnidæ).—A smaller and more slender species of the family was taken from Laurel River at Corbin in August. The preserved specimen is reddish brown, dusted with black, the sutures at the sides sharply black. Beneath yellow, with the black sutures at the sides conspicuous. Four white respiratory filaments behind the legs. Length 9 mm.; diameter 6 mm.

Larva No. 3.—An elongate brown larva was taken from Cumberland River, October 12, 1911, that appears to belong to the order Coleoptera, but cannot be exactly placed with the literature at hand.

Elongate, brown, tapering to the posterior extremity, with two dusky longitudinal lines along the middle of the back and outside this a series of dots. Head well developed. Three pairs of jointed legs. A brush of retractile hairs at the posterior end of the body. These are thrust out when the insect is detached from its hold on submerged plants or roots and seem to be kept concealed when the insect is at rest. It was found clinging to exposed roots in Cumberland River in October, and lies lengthwise of the root to which it clings, thus escaping observation. When detached it is evidently uncomfortable, and returns as soon as possible to any root or stick within reach, at once placing itself lengthwise of the object, and clinging tightly even when removed from the water. Length 3 mm.

TRICHOPTERA (CASE-FLIES).

In working among the rapids of the rivers and creeks I frequently came across pebbles secured together and attached loosely to the under sides of rocks. They were recognized as the shelters made by certain larvæ belonging to this group of insects. The insects construct a delicate net between the pebbles, often of considerable size, so as to catch floating objects suitable for food. The shelters and nets are often broken up and destroyed when the rocks are moved, and the larvæ are thus likely to be encountered

creeping about as if free. Several species were collected in the waters examined, together with others which construct and drag about with them very characteristic cases. Some of these cases obtained are composed of bits of sand glued together in a spiral form so as to resemble a small snail shell, the larva living within, keeping its head and rather long legs in the opening. Other cases collected are cylindrical and composed of bits of wood or other vegetable matter. Types of the different larvæ and of the cases are described and figured so as to give a definite idea of their appearance. These singular and interesting larvæ are in part predatory and carnivorous, such members of the group frequenting the situations preferred by Simulium larvæ, and probably at times act as enemies or competitors of the latter; in fact Miall definitely states it to be a fact that European species feed upon Simulium.

When ready to become pupæ case-fly larvæ secure their cases to rocks or other heavy objects in the water, close up the apertures, leaving, however, openings for the circulation of the water, and become quiescent. A single pupa, probably one of the net-making species, was taken from Straight Creek near Pineville, enclosed in a short case made of coarse bits of sand, the whole attached to a rock. Adult case-flies are delicate little four-winged insects often seen at lights in dwellings, and in very large numbers about the arc electric lights of towns and cities in the State. They look somewhat like a clothes moth, and are not commonly discriminated from these insects, all being called candle flies. A species (*Hydropsyche speciosa*) with blotched wings is especially common at times in midsummer about the electric lights at Lexington. They are all harmless to us.

Case-fly No. 1.—A cylindrical case, with small bits of woody material fastened over the surface. Straight, or a little curved, the smaller extremity fitted with a round disc within the aperture, provided with a single slit-like opening. About this end, some bits of sand are attached as if to anchor it. Length 13 mm.; diameter 2.5 mm.; at smaller end, 1.8 mm. Another example measures 14x2.9x2.6 mm.

Case-fly No. 2.—A second case collected is cylindrical and covered with elongate bits of woody material, some of it obliquely placed. Rougher than No. 1, and thicker. Both apertures closed, and thus probably contains a pupa. Large aperture with a grating, and with sand grains attached about it. The opposite end has a small aperture with three rounded extensions. Length of case 16.5 mm.; diameter at smaller end 3.4 mm.; at larger end 3.9 mm.

Case-fly Larva No. 3.—Case spiral, covered with grains of sand firmly glued together and making a hard tough structure. Diameter 4, depth 2 mm. Convex above, with a small, deep, round central cavity below. Whorls three, separated by a slight groove. Aperture wide, the head kept just within, the legs more or less projecting. Taken from rocks in very rapid water in Clear Creek, Pineville August 31. Larvæ were removed from these cases with some difficulty. The body is curved to fit the case, and clings by hooks at the posterior end. The case itself, as already noted, is extremely tough and hard, so that one is likely to damage the insect before it can be removed.

Larva pure white in general, the head brownish black, with a pallid area about the eye speck on each side. With erect black hairs. Jaws acute, black; other mouth-parts largely pallid and protruding. Throat white, with several brown dots on each side. Thoracic divisions with erect hairs; first division of thorax with black shield; second and third with some black above, on sides, and about the bases of legs, Legs of moderate length, those of the third pair longest, projecting forward before the head. Tarsal claw strongly curved. First abdominal division with an elongate prominence above. All the abdominal divisions smooth, with delicate respiratory appendages on some of the anterior somites. A pair of brown claws on the ventral side of the last division of the body. See Fig. 41.

This interesting species is widely distributed in Eastern Kentucky and can probably be found in most of our small streams. It was collected by me in a rocky stream in a meadow at Lexington, August 5, 1889, when the cases were

closed by a thin flexible brown concentrically striate silken disc, each with an excentric curved slit. Pupæ were already formed in some of them, lying with the head just behind the disc. Other specimens were collected in Elkhorn Creek, near Lexington, July 4, 1890, and at Elk Lick Falls, July 14, 1893. The late A. S. Packard named the species producing a spiral shell in New England, *Helicopsyche glabra*, but in the American Naturalist for 1869, p. 160, quotes Hagen as pronouncing it *H. borealis*. Hagen in the same connection states that he thinks a species described by Lea, the concologist, as *Valvata arenifera*, from the Cumberland River, near Nashville, is different. Ulmer in "Genera Insectorum" lists Lea's name as a valid one. It was used by Lea in the Transactions of the American Philosophical Society, Vol. 4, p. 104, 1834. There is some reason for thinking that the Kentucky material represents the supposed snail described by Lea. Judging by Packard's description and figures the case of the Kentucky insect differs from that of *H. borealis* in being composed of much coarser material, and the silken disc spun in the aperture before pupation appears to lack the slender teeth which he says project from each side over the slit and form an imperfect grating.

The pupa is enclosed in a thin pellicle, probably cast when the adult emerges. A sharp tooth projects forward from the mouth. Eyes conspicuous. The long antennæ and legs lie free along the sides of the body. On the back of the abdominal segments are short spines, some projecting backward and the others forward, probably of service in getting out of the shell finally. The long body is curved to fit the shell and bears a bar and tuft of hairs at the end. Length about 6 mm.

Case-fly Larva No. 4.—A third larva resembles the preceding in general structure, but is provided with branched appendages of respiration on the ventral side of the body. While the surface everywhere is rather densely pubescent, the last segment bearing a pair of long, clawed, false legs, each with a brush of long plumose hairs, generally loaded with dirt and often bearing living stalked Protozoans, which

thus obtain free transportation. It was collected in the broken up shelters made of pebbles and found under rocks. It is probably the owner of these shelters and a member of the genus Hydropsyche.

Body pubescent. Head small, and with three thoracic somites, brownish black dorsally. Eye in a pallid area. Jointed legs yellow, pubescent. Second and third thoracic and six abdominal somites with whitish ventral branched appendages.

Possibly several species are represented among material collected with the above. One example noted has a green abdomen. Others show several protrusible finger-like appendages dorsal to the posterior false legs. The head has a peculiar unfinished appearance, and is shorter and smaller every way than the heads of other free-living larvæ collected. The pubescent body and long brush of hairs on the false legs were generally loaded with sediment in the streams of Bell County. Examples of what appears to be the same insect from Benson Creek in Franklin County bore very little such material. This same insect was collected at Elk Lick Falls, July 14, 1893.

Case-fly Larva No. 5.—A single example of this species was taken from the Left Fork of Straight Creek, October 21, 1911. It resembles No. 4 in a general way, having a fine pubescence over head and body, and being provided with similar branched ventral appendages on the thorax and abdomen. The brush of the false legs at the posterior extremity is not so dense. The head is larger, more elongate, thickened dorso-ventrally in the occipital region. Dusky above on head and thorax. A pallid region about the eye extends posteriorly on the side of the head and then dorsally along the occiput. It is probably a Hydropsyche.

Case-fly Larva No. 6.—Length of large examples 10 mm. Pure white. No ventral branched appendages. Head large relatively and elongate, yellow, the eye well forward just posterior to bases of mandibles. A large white membranous T-shaped expansion of the upper lip overlying the mandibles. Dorsal plate of prothorax and legs pale yellow. Posterior

edge of head at sides, and sutures on side of thorax at bases of the legs, black. Body with scattered erect hairs. No branched respiratory appendages. False legs at posterior end of body somewhat tapering, with a claw and a couple of long hairs. Fleshy terminal protrusible appendages are apparent in some examples, dorsal to the false legs on the last somite. One example, Cumberland River, September 1, another October 22; a half dozen examples, Left Fork of Straight Creek, October 21, 1911. The unprotected, soft condition of the body indicates a larva inhabiting a close shelter, or case of some sort. The head, with its strong sharp jaws denotes carnivorous habits. It is probably a member of the genus Polycentropus.

Case-fly Larva No. 7.—One small larva differing from all of the above case-fly young was taken from the Cumberland River, August 31. It is yellowish, a trifle dusky on the terga of the abdominal segments, with scattered erect hairs on head and thorax, becoming more numerous but of the same character on the abdomen. Head large relatively, elongate and oddly flattened from the mouth backward, the area produced sloping gradually upward to the occiput and with a definite margin at each side, passing just over the small eye. Head and thoracic plates yellow. Jointed legs pallid. Branched ventral appendages white. Two divergent posterior false legs with strong curved claws, and about six long straight hairs. This species resembles No. 5, but its flattened head and lack of pubescence distinguishes it. Probably a Hydropsyche.

Case-fly No. 8.—A rather large cylindrical case was collected by me in Clear Creek near Pineville, June 16, 1892, and appears to be different from Nos. 1 and 2. It is pretty even in diameter from end to end, measuring 6 mm. in diameter and 24 mm. in length. It is occupied by a larva with a short reddish-brown head. The hooks at the hind end of its body still retain it in its case so securely that to examine it would involve breaking the case or injuring the insect. The whole case is covered with bits of gravel, and one end is closed with a rather large white frag-

ment. This case has the dimensions and general character of one described as Halesus sp., by Professor Cornelius Betten, New York Mus. Bul. 47, p. 569. The Kentucky case has no wood about it, and the head of the larva is not marked with black.

Case-fly No. 9.—A rather slender cylindrical case with thin walls covered with fine grains of sand was collected by me June 15, 1892, in the Cumberland River, at Pineville. Length 15 mm., diameter 3 mm. Very slightly tapering from the head end. Both ends closed with a thin disc of silk set a little distance within the aperture, the one in the larger opening with a straight eccentric slit for respiration. Edges of the apertures with bits of woody material attached.

NEUROPTERA (HELLGRAMMITES).

One of the most characteristic insects of the creeks and rivers is the singular and formidable looking dobson or hellgrammite (*Corydalis cornuta*). It is more common under rocks in these streams than I have ever observed it elsewhere in the United States. Boys who were attracted by curiosity to my operations called the larvæ grampuses, and expressed fear of them. They nip with their strong mandibles with a good deal of spirit, and no doubt prove very destructive to the small fry living in the rapids with them. Adults gather in large numbers about the electric lights of Pineville, in July, and some years ago I secured at an arc light at the edge of the town more than I have collected elsewhere in many years. They are calculated to have a decided influence on the organisms of these waters, but are at no stage of their lives to be greatly feared by man. The adult males have a ferocious appearance from the great length of their jaws, and will use them freely if given an opportunity, yet they are ordinarily used only in self-defense. The young make good bait, it is said.

The Grampus (*Corydalis cornuta*).—Large, reaching a length of over two inches. Black, pubescent, rough, forbidding in appearance. Body flattened. Head large, flattish, jaws strong. Legs short and stout, provided

with two claws, these sometimes double and often reinforced by curved spines. Prothoracic shield longer than wide, large. Middle and posterior thoracic somites with small transverse shields. Abdominal somites with a hairy, tapering, lateral filament on each side; beneath and within the filaments of each side are tufts of slender branchial filaments on the abdominal somites one to seven, inclusive. A pair of terminal false feet present, each with two long curved claws and a filament, like those along the sides, but more slender.

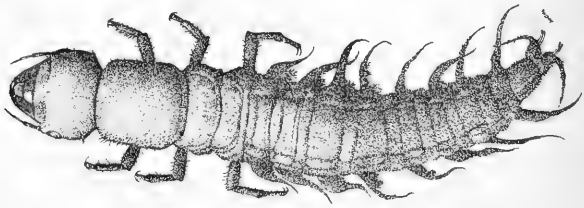

Fig. 23.—Larva of grampus or hellgrammite (*Corydalis cornuta*). x ½.

It was constantly met prowling about under rocks, often with its body coated with mud and refuse, as if for concealment. Its eyes are in a cluster on each side of the head, but are not conspicuous in the large larvæ because of the dark hue of the whole animal. Younger larvæ presumed to be this have the head and first body division reddish brown, marked with black, and the black eye-specks are conspicuous, forming a cluster on each side of the head, one of them occupying the center, the rest ranged in a curved series about it, the ventral median one smaller than the rest.

The smallest larva of the family collected is white, and the branched respiratory structures of the abdominal somites consist of a basal piece and several simple branches, as in some of the case-fly larvæ described. Possibly it is a different species. It was taken in the Left Fork of Straight Creek, September 1, 1911.

EPHEMERIDA (MAY FLIES).

Perhaps the commonest insects inhabiting the swift waters collected from about Pineville and indeed everywhere

in the State, are the larvæ of fragile, gauzy-winged insects known as May flies. Though holding their own against the current as well as tougher-skinned and more strongly built insects, they do this more by virtue of their expertness in sticking close to the under sides of rocks than by their capacity to swim. They resemble somewhat the stone flies in general appearance, being, like them, provided with slender, tapering antennæ and long, jointed, caudal stylets, three in number, however, in well-grown examples, whereas the stone fly young have at all stages only two. They can always be distinguished by the presence of gills, plate-like in all the species collected, along the sides of the abdomen, and by the presence of but one tarsal claw. Adults of small species belonging to this group of insects were emerging October 23, 1911, at Pineville, and were found in some numbers early in the morning in the mud and sand at the edge of the water, though the temperature at the time was close to freezing. These were doubtless from some of the small larvæ, noted farther along under No. 4 of this part of my account. They are slender, pallid, fragile insects, with large membranous front wings and small or minute hind ones. At the end of the body are two long slender setæ. The creatures are rather feeble fliers and after mating drop their eggs in the water and soon die. The members of the group are sometimes called day flies, the adults being popularly supposed to live but a day. They do indeed last but a short time, once adult, but live for a year or more in the water.

Ephemeride Larva No. 1.—A common and widely distributed larva of the group was taken in all the mountain streams examined. Its body is flat, the head broad, the outline everywhere rounded. The simple eyes are accompanied by three pale dots. The series of gills along the sides of the abdomen are terminated by a simple fringed filament behind. The abdominal segments are provided with a strong sharp tooth at each side. The caudal appendages are noticeably setose. The color above is a mixed pattern of black and pale yellow; the legs are banded with

dusky. The caudal setæ are of a decided yellow. Beneath, pale yellow, the posterior edges of the abdominal somites dusky, the posterior ones more completely so. Length 10 mm. Cumberland River, Straight Creek, Benson Creek, and brooks about Lexington.

Ephemeride Larva No. 2.—This larva is figured in this bulletin (Fig. 46). It is less common than No. 1, but bears a close general resemblance.

The abdominal segments are not toothed. The caudal setæ are only very slightly setose and are distinctly banded with white and black. Length 9.5 mm. Cumberland River and Straight Creek.

Ephemeride Larva No. 3. (Chirotenetes sp.)—One of the most striking insect larvæ collected is of a deep umber-brown color, with a pale stripe along the back, the legs sharply banded with black and white. Head small and not flat. Thorax strongly convex and not expanded. Tibiæ of anterior legs with strong spines and a double fringe of long hairs. Wing-pads black. Gill-plates alongside of abdomen turned outward, each with a large purple central area. Abdomen marked with black at the edges of segments, two at the posterior extremity with the lateral angles produced into a sharp spine. Central caudal seta shorter than the others, heavily fringed along the sides, the extreme base black, then more than half the length a deep yellow, then a band of black, the distal portion white. Lateral setæ heavily fringed within, marked like the median seta, but with a slender black terminal unfringed region beyond the white. Length 12.3 mm. Cumberland River, Left Fork of Straight Creek, Benson Creek.

An adult of this insect was collected October 21, 1911, at the edge of Cumberland River at Pineville. Its body resembles somewhat closely in form, general structure, and even color, that of the young. The second and third pairs of legs are pure white. The wings are smoky, the veins black. Two slender caudal setæ are pallid. I take this to be *Chirotenetes albomanicatus*, described by Professor Needham, who says of the larva, that it feeds upon the larvæ of

Simulium, but appears to take a mixed food, consisting of algæ as well as insects.

Ephemeride Larva No. 4.—Several very small larvæ, having the same general form as No. 3 were everywhere common in the rapids of the streams. They are generally pale whitish with obscure dusky markings, most of them with a dusky band across the heavily fringed caudal setæ.

Adults from some of these larvæ were emerging from the water October 23, 1911, at Pineville, and were found stranded on mud and sand at the edge of the river. The males have singular large cap-shaped eyes meeting on the top of the head and in addition a smaller second eye is present on the side of the head beneath the other. The abdomen is provided with but two seteæ. Dried specimens brought home with me measure from two to four millimeters in length, and probably represent several species.

ODONATA (DRAGON FLIES).

This group of striking insects is represented by individuals about all fresh waters of this country. The species are not very closely discriminated by the angler and hunter, but every one knows them by the name dragon flies, snake doctors, and mosquito hawks. They are powerful fliers, with enormous eyes and often gaudy colors, which flit back and forth over the water, some species appearing very early in spring, but most of them during the hot weather of July and August. The adults are provided with strong jaws, but never attack large animals of any sort, their prey being small insects which they capture on the wing. No doubt their influence is felt by the small fry of this sort, especially in the immediate neighborhood of streams and pools. They do not so often appear about dwellings, and it may be questioned if they have any special effect on the members of our house-infesting mosquitoes, since these generally breed close about dwellings.

The young of these showy insects are rather obscure water-frequenting animals, lurking about the bottom, partly buried in mud or rubbish, sometimes clinging to water

plants, and to be found in some numbers under stones and boards. In contrast with the habit of the adult these larvæ are still-hunters, lying in wait, often concealed, until suitable prey comes within their reach, when suddenly they thrust out a peculiar lower lip with strong jaws at its extremity and fasten upon it. They destroy in this way hosts of small insects, Simulium probably among the rest, and attack and sometimes do a good deal of mischief to very young fish fry.

The larvæ of this order collected in Laurel River, Cumberland River, Straight Creek, and Clear Creek, represent two main groups, one of which comprises rather slender species (Represented by Fig. 45) with three long flat plates for respiration at the hind end of the body. These are the young of the damsel flies, very slender and rather small gauzy-winged insects known to everybody from their disposition to alight on one's float or cork when fishing. The second group lacks these plates, and is composed of larger broader species (See Fig. 44) which respire by means of gills placed on the walls of the hind portion of the digestive tube.

Species of Progomphus, Gomphus, Macromia, Calopteryx, etc., were collected among the rocks on which Simulium larvæ occurred.

PLECTOPTERA (STONE FLIES).

In every locality collected from, I found a few representatives of this group of aquatic insects. The larvæ were associated with many examples of the group Ephemerida, but not more than one of the stone fly larvæ to a hundred of the others was seen. They are flat insects with wide heads, the thorax in three broad divisions, the antennæ many jointed and long, the abdomen terminating in two long, tapering jointed stylets, much like the antennæ in structure. They are active predatory insects, feeding with special relish upon gnat larvæ, according to Miall. They are found with Simulium in rapids, on the under sides of rocks, which surfaces they quickly regain if permitted when

rocks are overturned. Three different forms of these larvæ were collected. By far the commonest is represented by Figure 47.

Larva No. 1.—Elongate, flattish, the head wide, produced into a pronounced angle behind each eye. Next three divisions (thoracic) of body with expanded dorsal plates, the two hindmost a little produced backward at sides. Six tufts of fine gill-filaments are placed about the legs of each side, and another within the base of each long posterior abdominal sylet, making fourteen in all. The back is brightly marked with black and yellow. The longest example, taken June 15, 1892, from the Cumberland River, at Pineville, is about three-quarters of an inch long. Other examples collected from Straight Creek, Clear Creek and Cumberland River, in August and October, 1911, range from 5 to 20 mm. in length.

Larva No. 2.—Small, slender, the head and thorax but little wider than the abdomen, the sides of the head behind the eyes rounded and not produced. Abdomen rather long, its sides parallel. No gills. Color plain olive. One example 5.5 mm. long, but with the wing pads well developed and thus ready to produce the adult, was taken from Horse Creek at Corbin, August 29, 1911.

Larva No. 3.—A singular, flat larva was taken from a spring-fed rill near Cary along Straight Creek, October 21, 1911. It is represented in my Figure 48. In general shape it resembles a small roach, the head and thorax being excessively expanded, the antennæ tapering, and the stout legs with two tarsal claws. The length of this example is 6 mm., its greatest width 2.5 mm. On looking over some old material collected by me at Pineville in June, 1892, I find a second example of the same insect, measuring 2.5 mm. in length. Head wide, bent downward; eyes at outer angles; antennæ long, regularly tapering, many jointed (broken at tips). Dorsal plates of the three thoracic divisions broadly expanded, overlapping, the posterior lateral angles rounded, the posterior margin broadly and evenly, though slightly concave. Abdominal somites abruptly narrower, contracting

gradually in width to the posterior end of the body; posterior margins straight, except that of the last which is angled; edged with a fringe of short bristles. Legs short and stout, gradually increasing in size from first to third; femora very stout and flattish. Sterna of thoracic divisions large, plate-like; the sides and posterior angles of first rounded, the posterior margin broadly incised; sides of second rounded, posterior margin broadly and deeply excised; third narrower, angled, the posterior margin still more deeply concave. Body everywhere clothed with a fine felt-like pubescence. Edges of segments above and at sides with series of short rigid spines. At the posterior end of the body is the usual pair of tapering jointed appendages, characteristic of the family. Respiratory organs in the form of simple tapering white filaments arising at the bases of the legs, both above and beneath.

Color brown, eyes black; obscure dusky markings on first segment of the thorax; second, with three elongate dusky dots; third with three similar dots, the median longest, all concealed by the overlapping second tergum.

ARACHNIDA (MITES, ETC.).

Members of this group of animals could be found about the edges of the streams at any time, but there were none that attracted special attention because of any apparent relation to the object of my investigations, except jiggers, chigoes, or harvest mites. These microscopic mites were common about the streams in the vicinity of Pineville in August, and are the cause of a good deal of annoyance during the summer to those who go much among blackberry bushes and other shrubbery along the banks of the streams. Berry pickers are especially liable to attack. But the mites attack by preference the covered parts of the skin, and generally those regions upon which the clothing presses most closely, as about the waist and under socks and stockings. In the case of men I know from experience that jiggers sometimes manage to get under the tongues of shoes and cause red mounds on the upper surface of the feet.

The mites are the young of red species belonging to the genus Trombidium. They enter the skin to complete their development, but appear to be unable to do this on human beings. Their habit of making the attempt seems to be one of nature's mistakes, for all of those entering the human skin die there. Women and children often suffer greatly from the attacks, probably because of their more tender skin. Men constantly living in the infested regions become more or less completely immune, either because their skins become tough and thick, or because they do not from long exposure to the attacks become inflamed by the presence of the imbedded mites. The fact of importance, however, from the point of view here taken is that the mites do not attack a person subsequent to an attack upon another, and hence cannot well be concerned in carrying skin diseases from ill to well.

Clearing away close-growing vegetation by mowing, or by fire, is a good way to get rid of them about premises.

PROTOZOA.

The microscopic unicellular organisms of this sort, were, of course, common in all the waters. Water taken from the river and brought to Lexington in jars was found to contain large numbers of several species. A large ciliate species in a general way resembling Paramœcium, was extremely

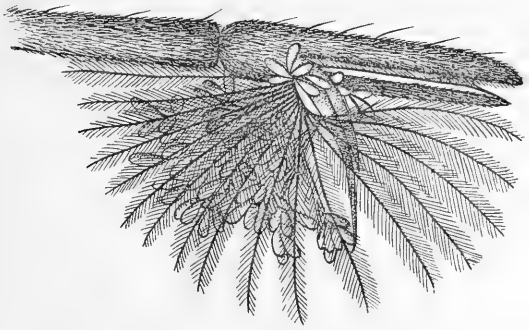

FIG. 24.—Hind tarsus of the water strider, *Rhagavelia obesa*, with expanded oar, and a cluster of stalked Protozoans attached. Greatly magnified, as seen under the microscope.

common, and so large that it could be seen with the naked eye by holding a jar up to the light. A stalked species was observed attached to the foot of one of the bugs known as water striders and is represented in one of my figures (Fig. 24).

CRUSTACEA (CRAWFISHES, ETC.).

The best known crustacean of the fresh waters of this country are known everywhere as crawfishes, sometimes simply as craws, and among college men, as crayfishes, this British word having been imported with laboratory manuals. All of the species of the Eastern United States belong to the genus Cambarus, of which there are about sixty known, eleven of them, possibly a few more, occurring in Kentucky. They are all much alike in general structure, being provided with a pair of strong forceps, on the forward pair of walking legs, and at the hind end of the body with a fin composed partly of the flattened last segment and partly of the hindmost expanded and branched appendages. With this caudal fin they swim swiftly backward, as everybody knows, a method of progression with the advantage of keeping the strong claws and eyes directed toward pursuing enemies, but with some disadvantages also, as when one of them swims thus into the mouth of a black bass. They are in fact excellent fish bait. They are common in the streams about Pineville, and though my attention was concentrated on the search for Simulium, two species of crawfish, *Cambarus bartoni* and *C. putnami* were collected in the Cumberland River, and a third, apparently *C. girardianus*, was collected in the rapids near the Roark cottage at Cary.

The crawfishes are of special interest as inhabitants of these waters because of their value for fish food. But their great abundance in situations frequented by Simulium may give them an important relation to the welfare of the latter. As a rule, I believe they are more vegetarian than predatory, but while feeding upon plants at all times, some of them undoubtedly seize and devour animals coming within their reach, when prowling about under rocks, and they are

known when in confinement to eat one another if other food is not available.

In addition to the crawfishes, several species of small flat crustaceans belonging to the group Isopoda were now and then encountered in the streams. One of the most interesting was the blind crustacean (*Cecidotea stygia*) taken in October from a spring-fed stream flowing into Straight Creek near Cary. It is a common species throughout Eastern Kentucky. In addition to this Isopod a few specimens of an eyed species of Asellus were obtained under rocks at the edge of Cumberland River. So far as known to me our species of this group are vegetable feeders.

BRYOZOA OR POLYZOA (MOSS ANIMALS).

Water mains in cities sometimes become infested with a singular small animal growing associated in groups and forming branching colonies attached to the inner surfaces of the pipes. At times these growths become so numerous as to offer a serious hindrance to the flow of water, and their decay at certain seasons pollutes water supplies so as to be a source of danger to health. One of these branching growths was common in the swiftest water of Cumberland River and Straight Creek. When rocks lying in the water were turned over, extensive and often rather pretty patches were revealed closely attached to the under surfaces, so closely in fact that they were liable to be broken into small fragments by attempts to remove them. At the extremity of each branch is an opening through which an individual may protrude its beautifully tentacled forward extremity. The same species has been repeatedly collected by me in rocky streams at Lexington. The food consists of microscopic plants and animals.

The winter is passed in the egg stage and at this season the singular winter eggs (statoblasts) may be collected from water mains and streams. Animals of this group are much more common in fresh waters of all sorts than is generally supposed. The reason they are not recognized for what they are is because of their plant-like appearance. They

are true animals of an ancient type, being better represented as fossils than as recent species.

The presence of Bryozoa in water pipes may be determined by securing a fine sieve, or piece of muslin, over a tap and allowing the water to flow through it for an hour or two. In the winter brown tubular fragments of the enclosing test or shell of the organisms may be thus collected in quantities and with them the winter eggs. The latter are very singular and characteristic, being oval, flattish, the surface granular under the microscope, the color of the outlying regions pale brown, and a round central region, the egg proper, of a deep umber-brown. The length of these eggs or buds is about .35 mm; the diameter 0.24 mm.

VERMES (TRUE WORMS).

No worms of special interest were collected, but on the roots of plants growing on the edge of Cumberland River in the gap of the Pine Mountain, were noted small knots or nodules somewhat like the bacterial nodules of clovers and other leguminous plants. These knots were recognized as the work of a small thread worm, and on subsequent examination with the microscope the eggs and young of the worm were found in the plant tissue. It is possible that this is the root-knot worm, *Heterodera radicicola*, which is so destructive to cultivated plants of different sorts in the South Atlantic states. If so, it would appear to be making its way northward with pellagra along the Cumberland River. This worm is parastic only on plants. The plant on which the knots occurred could not be identified positively because of its having been browsed by stock, leaving only the stubble and roots in the river's edge.

MOLLUSCA (SNAILS AND CLAMS).

These animals are scavengers and vegetarians. One small snail (*Goniobasis brevispira*) with an elongate spiral shell was constantly present about and on the rocks in all of the streams, and in Cumberland River could often be followed for some distance by a trail left behind it, the surface

Fig. 25.—Larva of Orthocladius sp. (No. 3) from Left Fork of Straight Creek, Cary, Ky. x 22.

Fig. 26.—Larva of Ablabesmya (No. 4) Left Fork of Straight Creek, Cary, Ky. x 21.

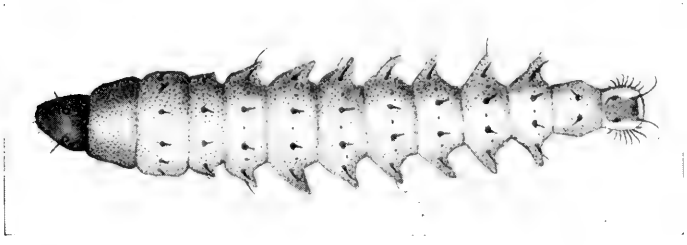

Fig. 27.—Fly Larva (undetermined) from Left Fork of Straight Creek, with Simulium larvæ. x 20.

Fig. 28.—Pupa of preceding species (Fig 27). x 20.

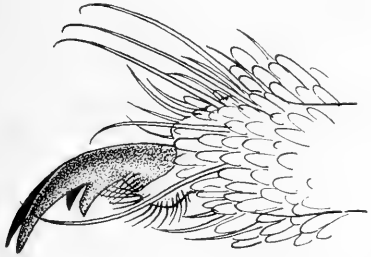

Fig. 29.—Tarsal claw of fore-leg adult female yellow fever mosquito.

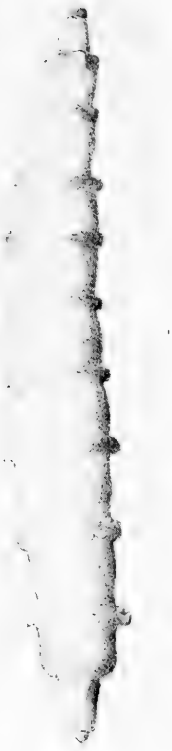

Fig. 31.—Larva of gad fly from Left Fork of Straight Creek, near Roark Cottage. x 4½.

Fig. 30.—Egg of yellow fever mosquito greatly magnified. x 100.

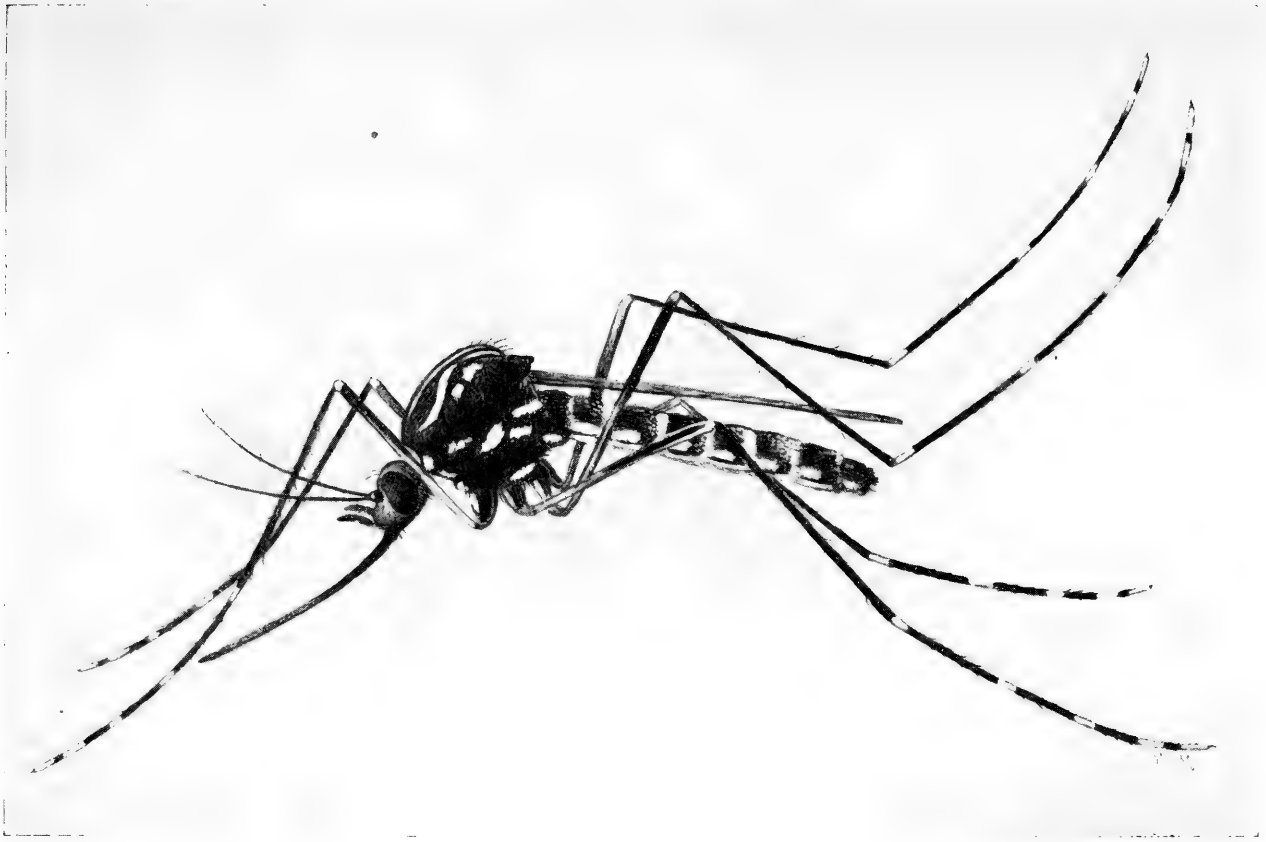

Fig. 32.—Side view of female yellow fever mosquito. x 13.

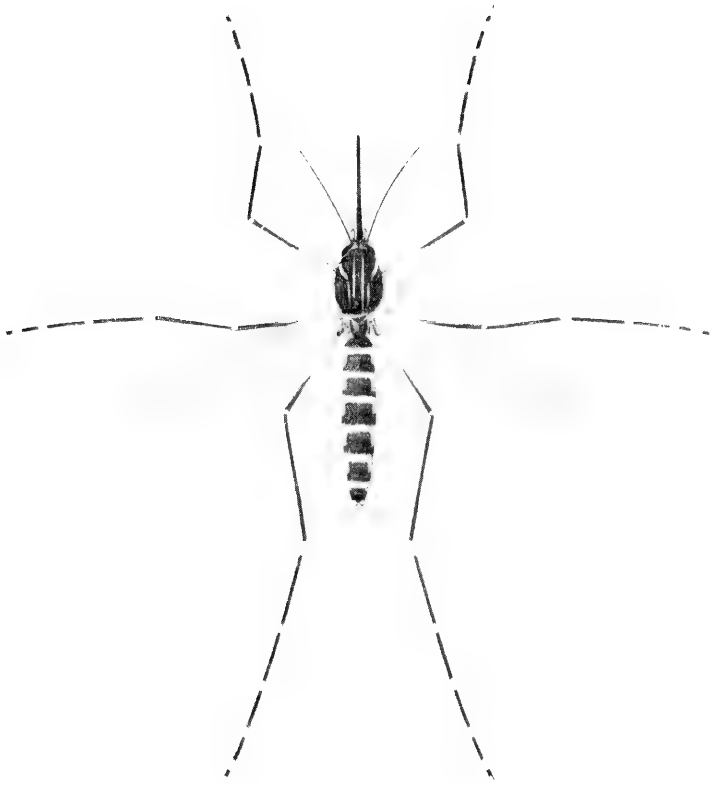

Fig. 33.—Dorsal view of female yellow fever mosquito. x 7.

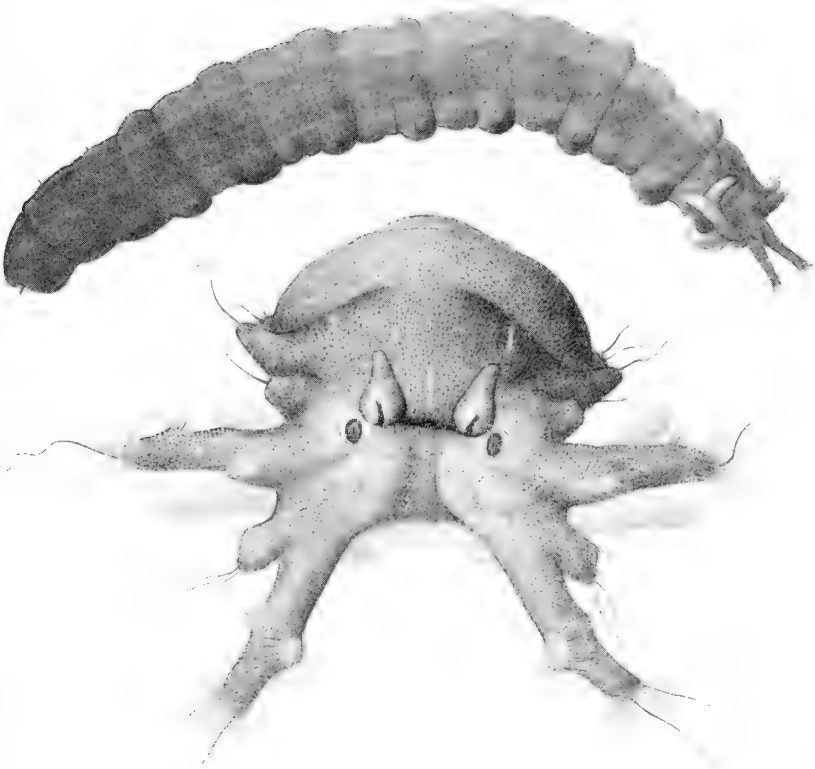

Fig. 34.—Crane fly larva x 5½ (family Tipulidæ) from Left Fork of Straight Creek. Lower figure shows hind end of body magnified to show appendages.

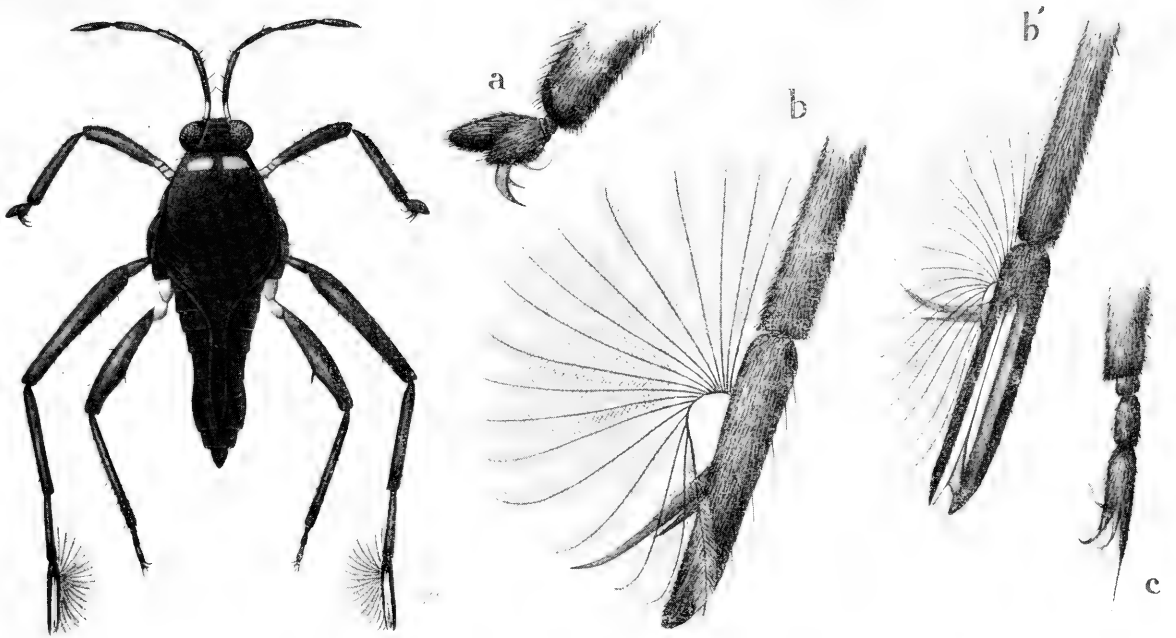

Fig. 35.—Water strider *Rhagovedia obesa*, x 14, from Straight Creek and Cumberland River. *a*, anterior tarsus; *b*, tarsus of middle leg; *b'*, same turned to show the split segment; *c*, hind tarsus.

Fig 36.—Whirligig beetle (*Dineutes discolor*) from the creeks and rivers. x 4½.

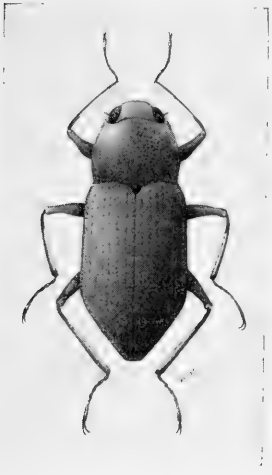

Fig. 37.--Spider beetle, *Dryops lithophilus*. x 8.

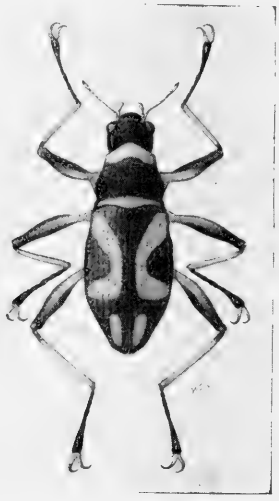

Fig. 38.—Spider beetle, *Ancyronyx variegatus*. x 11.

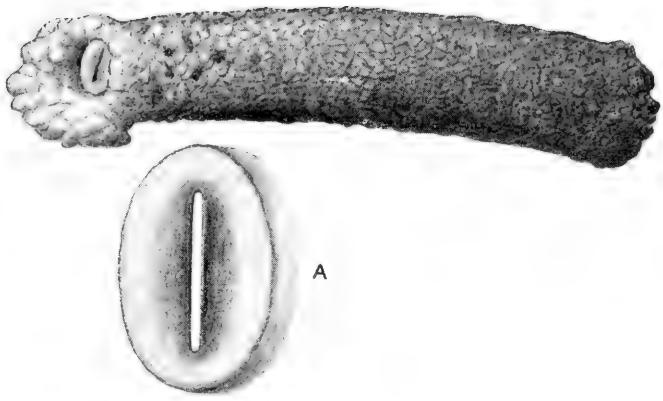

Fig. 39.—Case fly No. 1. x 6½. Disc closing case shown more enlarged at *A*.

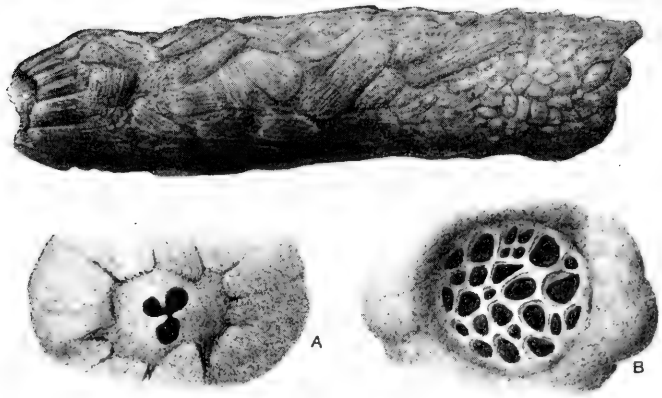

Fig. 40.—Case fly No. 2. x 5. Discs closing case when pupa is formed shown at *A* and *B*, more highly magnified.

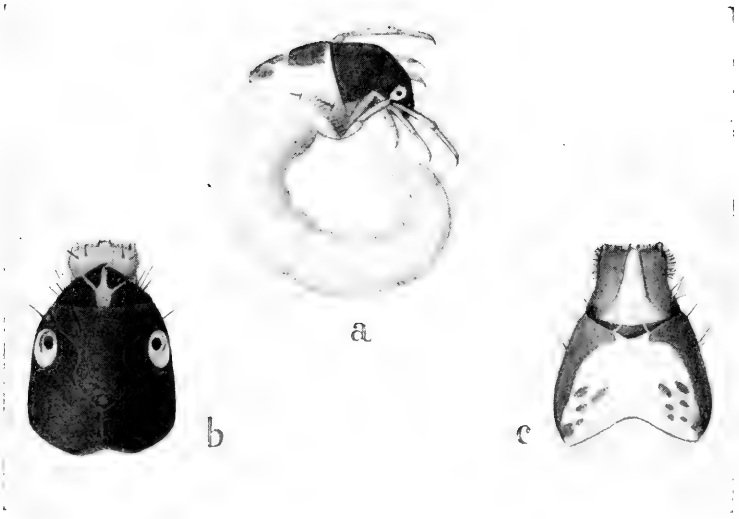

Fig. 41.—Helicopsyche sp. (No. 3.) *a*, larva removed from case x 11½ (delicate respiratory filaments not shown); *b*, dorsal view of head; *c*, ventral view of head.

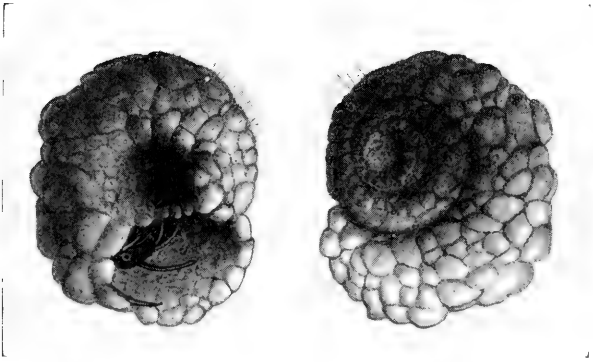

Fig. 42.--Spiral case of larva shown under figure 41. x 7½.

Fig. 43.—Larva of Hydropsyche sp. a common species in all the streams, living among gravel under rocks. x 17.

Fig. 44.—Dragon fly larva, Left Fork Straight Creek. x 4½.

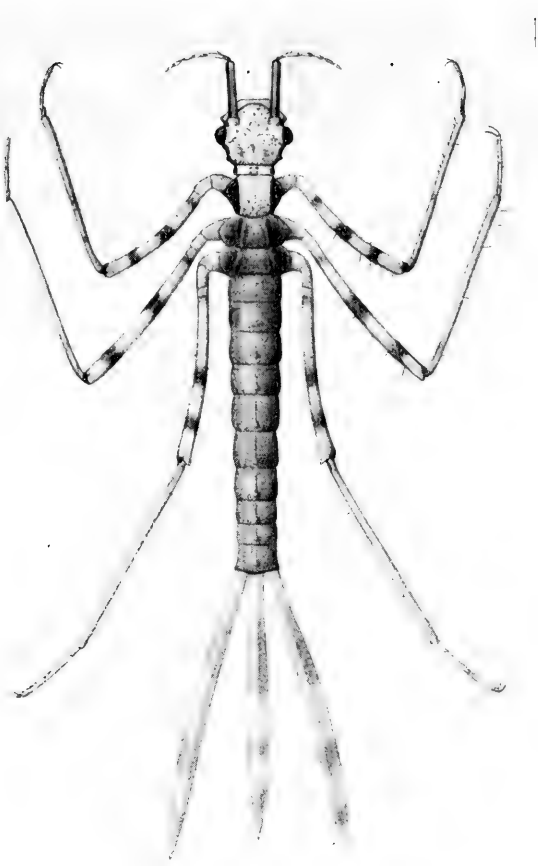

Fig. 45.—Damsel fly larva (*Calopteryx maculata*) Clear Creek, Pineville. x 9.

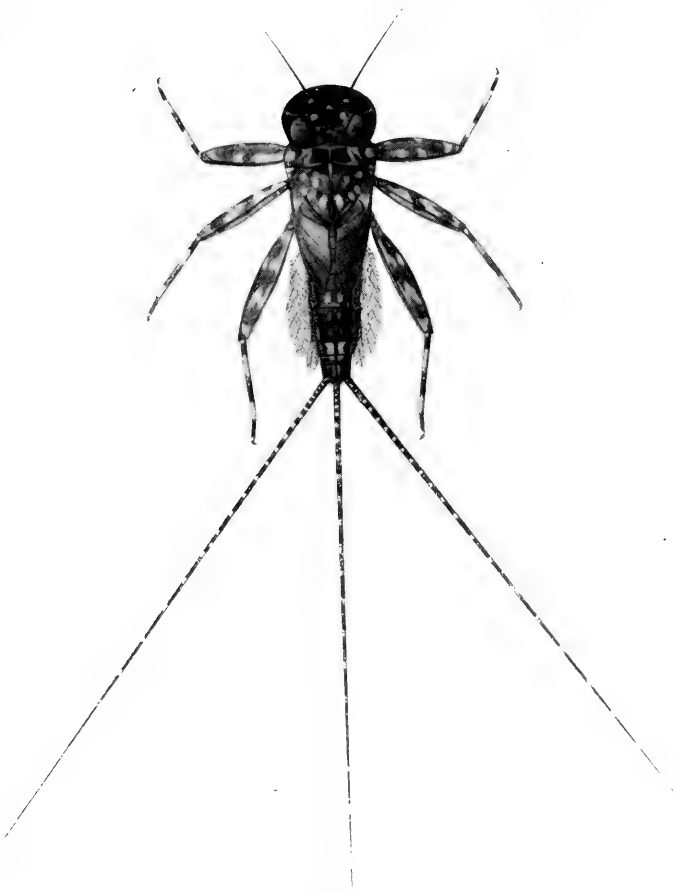

Fig. 46.—May fly larva (No. 2) common under stones in all the streams. × 4.

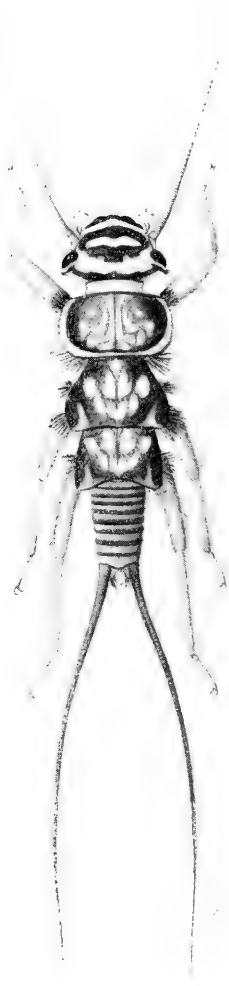

Fig. 47.—A common stone-fly larva (No. 1) in the creeks and rivers. × 4.

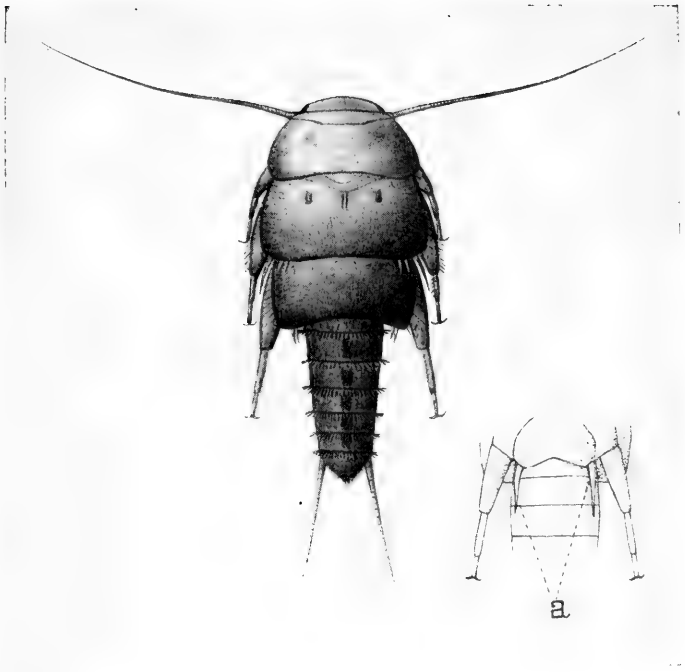

Fig. 48.—An undetermined stone-fly larva (No. 3) from spring-fed rill flowing into Straight Greek, near Cary, Ky. x 8.

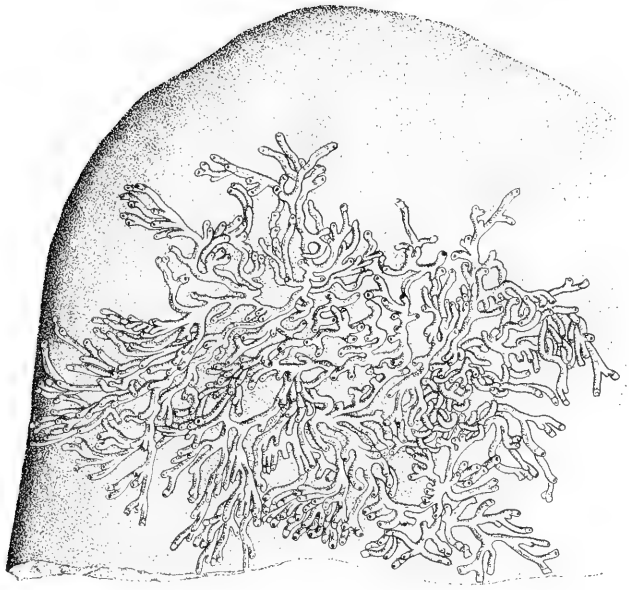

Fig. 49.—Colony of a Polyzoan, Plumatella sp. as it grows on the under sides of rocks in Cumberland River and other Kentucky streams. x 2.

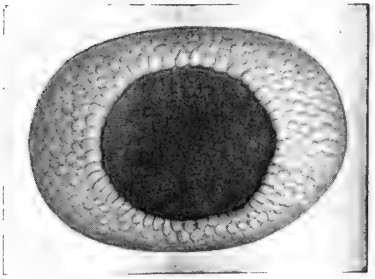

Fig. 50.—Statoblast or winter bud of the fresh water polyzoan Plumatella. x 120. From Benson Creek, Frankfort, Ky., Sep. 14.

Fig. 51.—A few individuals with tentacles expanded of a species of polyzoan from a pond at Lexington. Greatly magnified.

Fig. 52.—*Goniobasis brevispira*, the commonest snail of Cumberland River and Straight Creek. x 4.

Fig. 53.—*Physa sayi*, from Straight Creek. x 4.

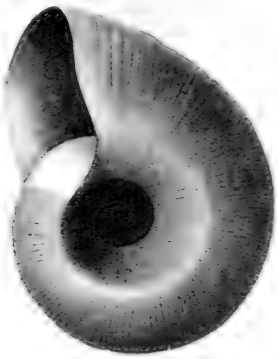

Fig. 54.—*Planorbis bicarinatus*, from Straight Creek. x 4.

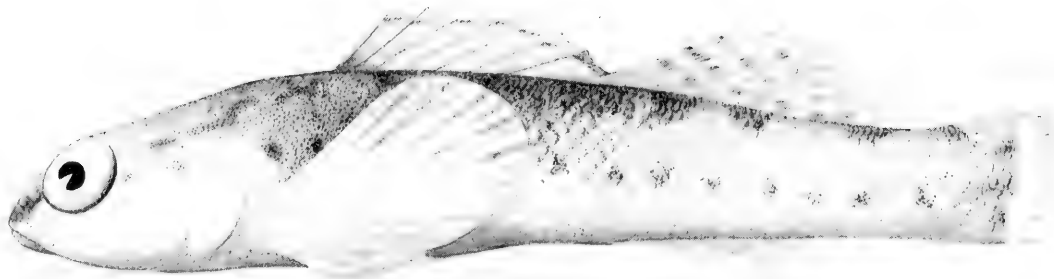

Fig. 55.– *Etheostoma olcyense*, from the rapids of Straight Creek in which Simulium larvæ were found. x 4.

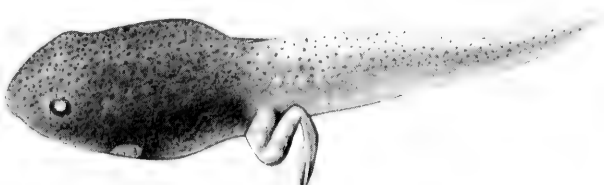

Fig. 56.– Tadpole of the spring frog, *Rana clamitans*, abundant in August in Straight Creek. x ⅓.

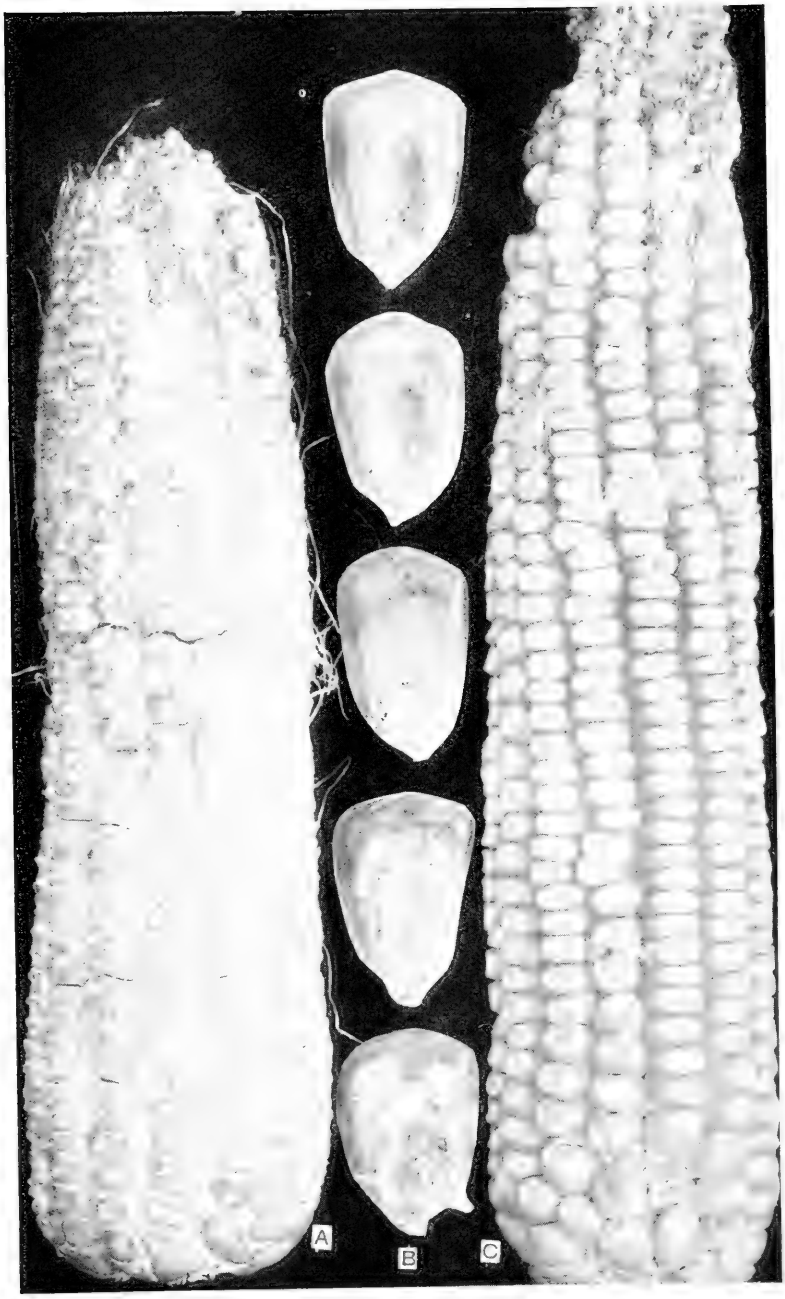

Fig. 57.—*A*, an ear of corn destroyed by the fungus, *Diplodia zeæ*, received from J. B. Walker, of Christian County. *B*, kernels twice enlarged, bearing black fruiting bodies (pycnidia) of *D. zeæ* about the germs, from Lexington. *C*, an ear with scattering kernels affected with the pink fungus (*Trichothecium roseum*). A and C reduced in size; B, x 2.

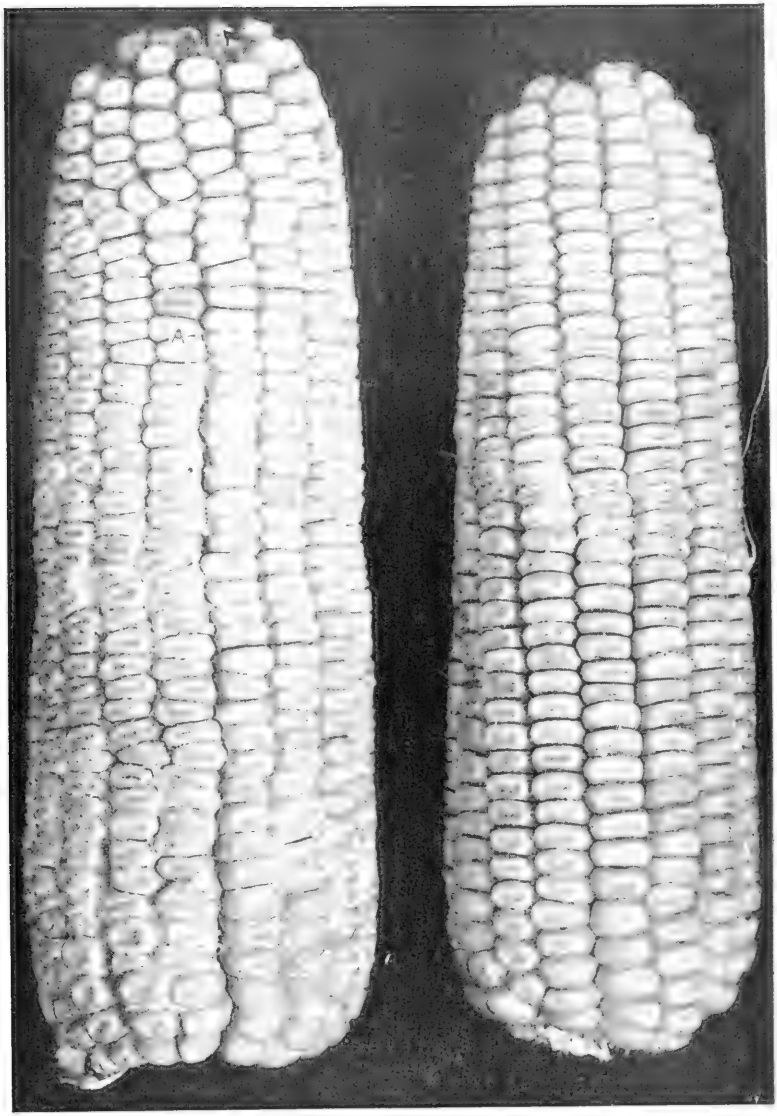

Fig. 58.—Ears of corn from Lexington, damaged by the fungus *Diplodia zeæ*, the basal parts and scattered kernels (as at A) killed and embrowned by the attack, the rest of the kernels appearing sound. A more dangerous condition than when the ears are completely invaded and destroyed, as at A, Fig. 57. Natural size.

Fig. 59. Cottage on bank of the Left Fork of Straight Creek, near Cary, in which reside several cases of pellagra. The spring and washing kettles are located near A.

Fig. 60. Looking to the left and down stream from point from which Fig. 59 was photographed. Simulium larvæ and pupæ were collected September 1 at A.

Fig. 61.- Rapids of Cumberland River near Pineville. Simulium larvæ were collected among the rocks in August and September, 1911.

Fig. 62. Laurel River near Corbin. A dwelling containing pellagrins is located near A, but is concealed by the trees.

Fig. 63. Clear Creek, Pineville. An occupant of the cottage at A is affected with the disease.

Fig. 64.—A family in which are three pellagrins—the second, third and fifth, counting from the left.

Fig. 65.—Two of the cases represented in Fig. 64, not so much reduced. The skin lesions are best shown on the leg of the left figure.

having been cleared along the line of travel of its coating of algæ and slime. This coating of the rocks was everywhere present, and seems to furnish food to a host of microscopic animals, and some larger ones, including some of the insects. A large percentage of it consists of algæ and protozoa, and grazing animals, such as the snails, find it nutritious forage easily obtained. Several other species of snails (*Physa sayi* and *Planorbis bicarinatus* among them) were collected, and a small elongate clam. The collection, however, gives a wholly inadequate idea of the molluscan fauna of the streams. The material collected was merely picked up incidentally and because it chanced to catch my attention when searching for other things.

The shells mentioned were identified by Drs. Pilsbry and Sterki.

FISHES.

The community of insects and other animals, of which Simulium larvæ form a part, inhabiting the rapids of our mountain streams, is relatively free from the attacks of the larger fishes. Such fishes cannot follow them here. Frogs and water birds, also, have little chance to get them, hidden as they are in narrow spaces among the rocks and generally clinging to the under surfaces. Even the larger carnivorous beetles and bugs, such as Dytiscus and Belostoma, cannot maintain themselves in the rapids, and the small species suited to the peculiar situation are thus here as nowhere else in our waters free from their attacks. A single family of fishes, however, contains members that have been driven like the insects in the struggle for existence to these same waters, and has become adapted to the peculiar conditions here prevailing. The sand darters (Etheostomatidæ) are very small often brightly colored fishes, the largest reaching a length of six inches or thereabouts, that habitually lurk in shallow running waters, many of them under rocks in the swiftest streams. They are relatively slender, often with pointed snouts, and naked napes, the scales being gone as if rubbed away by probing under stones for shelter and food.

Though small, they are quick, strong swimmers, the pectoral fins especially being relatively large. When uncovered they dart at once under another rock, and are thus not very easy to observe and capture. Indeed they are not often seen excepting by collectors of fishes, and are all but unknown to anglers. When by accident brought to the notice of the latter they are generally regarded as the young of wall-eyed pike and other large game fishes which they somewhat resemble.

These diminutive fishes can pursue the insects living in rapids wherever they may go, and being exclusively carnivorous must have a decided regulative effect on the numbers of insects inhabiting the rapids. The species collected at Cary in Straight Creek in October is *Etheostoma obeyense*, originally described from small tributaries of the Cumberland River in Whitley and Clinton counties. The stomach of an example captured with a small dip net in a rapid in which Simulium occurred contained an almost perfect Mayfly larva.

Etheostoma obeyense.—Length 1.36 inches; depth 5.2 in length. Eye a trifle longer than snout. Cheeks, opercles, and nape, naked. Lateral line with 46 scales, 25 to 26 of the anterior ones with tubes. Spinous dorsal moderately low, with 8 spines; soft dorsal with 11 rays. Ventral, with two spines and seven rays. Color pale olivaceous with a series of dusky blotches along the back and another of small dots along the lateral line. Head with a dusky bar from the eye to the tip of the snout, and a faint vertical bar ventral to the eye. Head dusky above, pallid below, minutely specked with black. Spinous dorsal dusky edged. Soft dorsal barred with dusky. Caudal with six bars of dusky, the anterior partly on the extremity of the caudal peduncle.

I do not know any other fish of our waters very likely to be mistaken for this, though no less than eighteen members of its family occur in the Cumberland River and its small tributaries in this part of Kentucky. The above species is highly characteristic of the locality.

The game fishes and the small competitors of the sand darters adapted to the quieter and deeper parts of streams appear to be the barrier which keeps the sand darters pretty closely confined to the more rapid and shallow parts of the Cumberland. Fifty-four species of fishes in addition to the darters are known to inhabit the headwaters of the Cumberland, giving a total of seventy-two. The number will be increased, I have no doubt, with careful collecting.

AMPHIBIANS.

The common spring frog, a large, olive, obscurely marked species, is very common in the small creeks emptying into the Cumberland in the vicinity of Pineville. The adults were not seen, but the large slippery tadpoles, some of them with the legs of considerable size, occurred in numbers in the shallows at the edges of the creeks, and attracted attention by the disturbance they made in retreating to deeper water. They were easily captured because of their lack of alertness. An example is just about three inches long (76 mm.), the color olive brown, minutely dotted on the head and upper part of the sides with black. The mouth is small, inferior, with several lines of black filaments backed by papillæ at the sides and behind. The tail is broad and lanceolate, constituting a very effective means of propulsion.

These larvæ pass the winter in the water, they were very common during my first visit to the streams in August and September. In October they were not seen, having retreated from the shallows for hibernation. The abundance of this animal renders it an important feature of the life of the waters, and no doubt its presence is felt by other organisms in many ways. The capacious body cavity of the tadpoles is filled with the slender, closely coiled intestine; it is coiled in several horizontal layers, one above the other, looking very much like a small red rubber hose. A larva before me, taken August 31, 1911, from Straight Creek, measured two and five-eights inch (2.5 inch) in length, while its uncoiled digestive tube measures a little over

twenty-one inches. The food as seen under the microscope consists of the slimy ooze which collects in summer on the bottom and over objects in the water. It contains vast numbers of microscopic plants known as diatoms, of desmids, and of the rod-shaped Oscillaria, of numerous protozoans, and of granular matter, vegetable and animal, in process of decomposition.

The adult frog is one of our largest American species, next in size to the bull frog and a good deal like it. The bull frog, however, prefers swamps, and is common in bottom lands along the Mississippi River in the West. The spring frog frequents springs and spring-fed streams. It may always be distinguished by the incurved edges of the webs of the hind feet and the presence of a glandular fold along the sides of its body. An example of the adult caught some years ago in Edmonson County near Mammoth Cave had fed on water beetles.

VEGETATION IN AND ABOUT THE STREAMS.

A rust-brown material, coating objects in the streams, looked at first like iron and I thought might result from the washings of mines and heaps of slaty material thrown out of them. It proved when examined with the microscope to be a filamentous alga, and was composed of fiber-like strands becoming smaller and smaller as they divided. I judge they are denuded strands of Batrachospermum. They were not in good condition for examination when I reached home.

Algæ were of course common in the waters, on rocks and wood. With diatoms and desmids, both of which were numerous, they constitute the most important feature of the aquatic vegetable life of these waters.

But one strictly aquatic plant of the higher groups was observed: A slender species of Nitella was collected in August from the Cumberland.

The banks of all the streams are fringed more or less closely with shrubs and trees. Without giving them any-

thing like close attention, I noted the following while working along the banks at different times.

Scrub Pine (*Pinus virginiana*). Common on slopes.

Yellow Pine (*Pinus echinata*). Well up on slopes along the Cumberland at Wasioto.

Willow (Salix sp.)

Butternut (*Juglans cinerea*).

Black Walnut (*Juglans nigra*).

Shell-bark Hickory (*Carya ovata*).

Iron Wood (*Carpinus caroliniana*).

Sweet Birch (*Betula lenta*).

River Birch (*Betula nigra*). Common.

Alder (*Alnus sp.*)

Beech (*Fagus grandifolia*).

Chestnut (*Castanea dentata*). Common.

Postoak (*Quercus stellata*).

Black Oak (*Q. velutina*).

Spanish Oak (*Q. falcata*).

Rock Elm (*Ulmus racemosa*).

Slippery Elm (*Ulmus fulva*).

Winged Elm (*Ulmus alata*).

Hackberry (*Celtis occidentalis*).

Mulberry (*Morus rubra*).

Cucumber Tree (*Magnolia acuminata*).

Umbrella Tree, Eklwood (*Magnolia tripetala*). Common.

Great-leaved Magnolia (*Magnolia macrophylla*).

Tulip Poplar (*Liriodendron tulipifera*). Common.

Papaw (*Asimina triloba*). Common.

Sweet Gum (*Liquidambar styraciflua*). Occasional.

Sycamore (*Platanus occidentalis*).

Red Haw (Cratægus sp.)

Blackberry (*Rubus sp.*) Common.

Red Bud (*Cercis canadensis*).

Black Locust (*Robinia pseudacacia*).

Tree of Heaven (*Ailanthus glandulosus*).

Dwarf Sumach (*Rhus copallina*).

Holly (*Ilex opaca*).

Dahoon Holly (*Ilex cassine*).

Strawberry Bush (*Euonymus americanus*).
Sugar Maple (*Acer saccharum*).
Red Maple (*Acer rubrum*).
Box Elder (*Acer negundo*).
Sweet Buckeye (*Aesculus octandra*).
Muscadine Grape (*Vitis rotundifolia*). Corbin, Horse Creek.
Frost Grape (Vitis sp.)
Stewartia pentagyna. Clear Creek.
Dogwood (*Cornus florida*)).
Kinnikinnik (*Cornus amomum*).
Great Laurel (*Rhododendron maximum*).
Mountain Laurel (*Kalmia latifolia*).
Sorrel Tree (*Oxydendrum arboreum*).
Checkerberry (*Gaultheria procumbens*).
Buttonbush (*Cephalanthus occidentalis*).

The woody growth of all sorts is being cleared away rapidly, and merchantable timber will not last many years longer. It is important on many accounts that the State bestir itself soon to the end that its young forest growth may not also be destroyed.

BACTERIA.

I did not take a compound microscope with me, and so could do little with the microscopic organisms. No doubt the waters would furnish a rich field of study in this line. The suggestion sometimes made that something of this sort in drinking water is responsible for pellagra led me to look at springs used by pellagrins with some interest. At the Roark cottage at Cary the surface of the ground sloped toward the creek, and at the bottom of this slope a hundred feet from the house and perhaps twenty-five from the edge of Straight Creek is the spring. It is badly located with reference to the house, and the flow from it is sluggish. From its situation and character one would expect people using it to suffer from bowel troubles as the very least of its ill effects. A sample of this water was taken October 23, in a sterile bottle, and brought to Lexington with me. The

results of tests made from it in the laboratory are given below, and confirm the impression received from an examination of the spring itself. Such water may not have anything to do with pellagra, yet pellagrins more than others should avoid any possible evil that may lurk in bad drinking water.

Sample No. 1161.—At twenty-four hours it gave 30,600 colonies of bacteria per cubic centimeter; at forty-eight hours it gave 41,000 colonies per cubic centimeter. The dextrose fermentation test gave 35 per cent. gas at the end of the first day; 67 per cent. at the end of the second. The litmus-lactose, acid-lactose, neutral red and acid agar tests each gave positive results. The lactose-bile test gave 25 per cent. gas.

The water of the streams is of course badly polluted with sewage in and below towns. In the mining camps practically all sewage is received sooner or later by the small creeks. In summer especially when the flow is not great the water must be exceedingly dangerous for drinking. Certainly it ought always to be boiled before using it for this purpose.

THE CONDITION OF THE CORN CROP ALONG THE STREAMS.

Corn grows well on the bottom lands along the mountain streams of Bell and adjoining counties. It appeared to me quite as good as that grown elsewhere in the State. Like corn grown in other parts of Kentucky, it was in some fields badly infested with the corn worm (*Chloridea obsoleta*). The injury done by the insect, even when slight, is generally followed by an invasion of molds, and thus often more harm results from the opening it makes in the husks than from the amount of grain it destroys. Corn brought home with me showed on some of the kernels at the tip of an ear a pink mold, and on the husks dusky blotches, appearing on the inner surface as brown spots with the tissues somewhat elevated and disturbed. The pink fungus appears to be the same as one observed on corn at Lexington and elsewhere in Kentucky. It gets to the kernels only by way of burrows

made by the corn worm, and would thus probably be controlled by preventing the injuries of the insect.

The only other fungus observed on this corn is a dull green mold which with age becomes brownish-black. Cultures were made from this corn October 19, 19I1, on Soy bean agar. A Fusarium was obtained in a dense cottony white growth, completely covering the slanted surface and bearing numerous conidia. The pink fungus of this corn did not grow, but has been isolated from corn received since from the same locality. The green fungus grew readily in gelatine and is a species of Aspergillus; I think it only attacks kernels that have been injured by other agencies. It is generally present on the gnawed kernels left by the corn worm at the upper end of the ear.

Corn sent me from London, Ky., December 13, 1911, by Mr. B. F. Johnson, is in about the same condition as that observed earlier at Corbin and brought home with me. The injury by the corn worm, though slight, is evident at the tips of every one of the six ears in the lot, and accompanying it is the pink growth on some of the kernels. The cobs of these ears are mostly sound, though one is affected with some fungus and shows a purple discoloration about the margins of the pithy center. Some kernels on three of these ears have germinated, and indicate that the corn was too damp at some time, probably after being shocked.

Another lot of six ears sent me December 14, 1911, by O. W. Stamper, of Corbin, shows the same prevalence of slight injury by the corn worm, every one of the six being affected. Three of them have sound cobs, but show scattered pink kernels, sometimes broken and crumbling.

A large ear of this lot with thin, sharp-edged seeds shows scattered brown discolored kernels, and when broken a purple discoloration extending to the center of the cob. I take this to be the work of a Fusarium, which in cultures on sterile rice produces a cottony growth and a purple discoloration like that seen in the cobs. It appears to be associated with the pink fungus and also with Diplodia in some samples.

The fifth and sixth ears received with the above and still in their husks are utterly destroyed by the fungus *Diplodia zeæ*, the kernels being brown and dead, the cobs spongy and brown from base to tip, in one with a whitish mycelium between the husks and a sooty discoloration on their outer surfaces near the tip. Both are injured by the corn worm, but the Diplodia evidently came up from the shank.

These sample give a good idea of the condition of moldy corn everywhere in Kentucky. Since pellagra has been under discussion the writer has examined such corn from a good many counties representing all parts of the State. From the mountain section samples have been examined from Letcher, Knott, Laurel, Bell, Wayne and Whitley. Other samples represent the central and western sections, coming, some of them from Fayette, Kenton, Jefferson, Warren, Taylor, McCracken and Fulton. They have not been fully studied, but examinations and cultures indicate the general distribution in Kentucky, from Letcher County to Fulton, of the fungus *Diplodia zeæ*, of the pink fungus and of a Fusarium producing a white cottony growth, and of the green Aspergillus. The distribution of the corn ear worm coincides with that of the latter fungus and with that of the pink mold, these fungi being most common where the worm does its greatest mischief. Accordingly, Jefferson County, because of the large quantities of early table corn grown there, is badly infested with both worms and molds. The *Diplodia zeæ* is not dependent on the openings made by the worm, generally invading ears by way of the shank. Its distribution is a little more general and its presence more constant on corn of all sorts, as a result.

For a number of years the writer has made a point of inspecting the exhibits of corn at local and state fairs, both with reference to the adaptability of varieties and with regard to their susceptibility to disease. Corn infested with the pink mold, and sometimes with Diplodia, has at times been seen in these exhibits, and in some instances judges have assigned the blue ribbon, and even the purple ribbon,

to entries on which the fungi were apparent. The time is coming, I believe, wnen such corn will be barred from exhibits, and no good corn breeder will think of showing diseased corn, any more than a breeder of Jersey cattle would think of competing for premiums with animals affected with tuberculosis. Seed corn is worth thinking about by farmers and seed corn men as one of the agencies by which molds may be scattered about the State.

Seed infested with molds, even slightly, should not be planted. As a precaution against introducing the molds it may be well to treat suspected corn with formalin or blue stone in the manner customary for wheat.

Judging from statements coming to me from farmers I should think the percentage of loss this year to the crop alone would not fall below ten per cent., which means a loss to the State of about 10,000,000 bushels. Some farmers would, I have no doubt, place the percentage of loss much higher. One of my correspondents asserts that fifty per cent. of the crop is moldy in his county this year.

THE EFFECT OF MOLDY CORN ON STOCK.

That some of these fungi are capable of injuring stock is evident from complaints reaching the Station every year, and coming from farmers who have suffered loss of horses, cattle, hogs, or poultry. Correspondents writing this Fall have asserted that numerous cases of blind staggers have resulted from feeding such corn. Corn being fed to these animals have in some cases reached my hands, and bore the pink fungus and the Aspergillus. An ear of this sort has recently been handed me by Dr. Graham of the Station and was received by him from Shelby county, where stock has been dying. Diplodia fed to mice has been found to cause paralysis and ultimate death. Corn smut fed to animals in large quantities has been shown, on the contrary, to have no ill effect. Some recent claims have been put forward with reference to the effect of corn fungi on poultry, and it has been asserted that a disease presenting some of the symptoms of pellagra has been induced ex-

perimentally in fowls by feeding certain organisms cultivated on ground maize. Dr. C. C. Bass, for example, claims in the Southern Medical Journal for August, 1911, that a disease of chickens regarded by the Italians as pellagra is produced by feeding them moldy corn. The symptoms appear in summer, and especially in the young, which shed their feathers, and practically all die with blistered backs if turned out in the sun. Again, in the American Medical Journal for November 18, 1911, the same writer claims to have himself produced in poultry a disease resembling pellagra, by feeding spoiled maize inoculated with a "specific Bacterium."

But while Dr. Bass may prove to be on the right track, it is well to note that physicians who have studied the subject, hold widely divergent opinions as to the relation of corn to pellagra*, and some very emphatic statements have been published with reference to several different agencies, not all of which can have to do with the disease.

Treatment for Corn Mold.—This bulletin is in the nature of a preliminary survey, and the corn ear fungi must be dealt with briefly, the publication of some details and results of cultures being reserved for a later date. But it may be said that the molding of corn is greatly encouraged by conditions over which the farmer has some control.

In the first place the fungus Diplodia remains in the fields and continues developing there in the grain and stalks long after the crop is cut. Old stalks lying about fields may continue to produce the spores of the fungus for several seasons, and thus infect growing crops. Where mold is prevalent, and especially after a season favorable to mold, it is important to get the crop, stalks and all, off the land and disposed of as soon as practicable. The corn should be husked at once when mature and put in a dry cool crib. The fodder should be either fed or burned.

* In an article entitled "Pellagra, Its Etiology, Pathology, Diagnosis and Treatment", written by Dr. C. W. G. Rohrer, Medical Assistant to the State Board of Health, of Maryland, and published in the Transactions of the National Conference on pellagra, in 1910, it is positively stated that the disease is due to the fungus *Aspergillus fumigatus*, and that the author has observed this fungus growing on corn, peas, beans and buckwheat, when "beaten to the ground by heavy rains.

When kernels of corn are completely invaded by mold the germ is killed, and common sense will teach that such corn is not to be planted. But it sometimes happens that ears bear only a little of the fungi and these are the ones most likely to be fed, or used for planting. As suggested under another head moldy corn should be avoided as far as practicable for such purposes, and when suspected of bearing the fungi, seed corn may well be treated with formalin, or bluestone, as a precaution against conveying mold fungi to the corn field.

Judges of corn exhibits can help to rid the State of these molds by discouraging the exhibition of diseased corn.

Unfortunately it is not possible to say at present whether or not the spores remain alive in manure. The spores of the smut fungus of corn are, it will be remembered, capable of living in manure, and are believed to be distributed thus to corn fields. But in the absence of definite experimental data with reference to the ear molds, it would be well to use manure from moldy corn fodder only on land planted in some other crop than corn.

And because of the disposition of the fungus to remain alive in the fields and on the corn stalks, it is always best to practice rotation of corn with other crops not subject to injury.

The fungus Diplodia is believed to be restricted to maize. It is widely scattered in the United States, and occurs in Italy where pellagra is prevalent. Of the distribution of the species of Fusarium it is impossible to speak positively at present, though they are known to be common on corn over a large part, and perhaps all, of our territory.

DR. SAMBON'S THEORY AS PRESENTED IN HIS PUBLISHED PAPERS.

Since writing the above I have had an opportunity to see the articles published by Dr. Louis W. Sambon, in the Journal of Tropical Medicine and Hygiene, in the library of the Surgeon General of the United States Army at Wash-

ington. I find that Dr. Sambon has weighed the evidence for and against his idea with a good deal of care. He went over the territory in Italy where pellagra is most prevalent, studying the disease, and found Simulium larvæ or pupæ, in the streams wherever he found pellagra. He states his views in concise form as follows: (Vol. XIII. Sep. 15, 1910, p. 271.)

"So far I have been able to establish:

(1) That pellagra is not due to the eating of maize, either sound or deteriorated, as hitherto almost universally believed.

(2) That it has a striking, peculiar and well defined topographical distribution.

(3) That its endemic foci or 'stations' have remained exactly the same in many places for at least a century.

(4) That its stations are closely associated with streams of running water.

(5) That a minute blood-sucking fly of the genus Simulium is, in all probability, the agent by which pellagra is conveyed."

Dr. Sambon admits that he has made no experiments testing his theory, but thinks the facts he has brought together are sufficiently powerful as evidence to render it almost a certainty.

After enumerating fully the various theories held in Italy as to the origin of pellagra, Dr. Sambon declares that there is no foundation for the belief that pellagra broke out on the introduction of maize into Europe, and that the topographical distribution of pellagra does not coincide either with the distribution of maize, its cultivation, or its consumption; and, further, that all preventive means based on the maize theory have failed.

Maize appears to have been used in Italy as early as 1554, by the records, and was certainly used in this country much earlier, in fact the early explorers make frequent mention of maize used as food by Indians, and often so badly prepared as to be inedible to the white man. Samuel de Champlain in his narrative of exploration written in 1613,

says, after describing different methods by which the Indians prepare maize:

"They have another way of eating Indian corn. To prepare it they take ears of it and put them in the water under the mud, leaving them two or three months in this state until they think it decayed. Then they take it out and boil it with meat or fish; then eat it. They also roast it and it is better so than boiled. There is nothing that smells so bad as this corn when it comes out of the water all muddy." * * *

In addition to the evidence collected by Dr. Sambon, showing the presence of species of Simulium wherever pellagra occurs, he gives several other reasons for believing the disease to be insect borne. In the first place, the alternate periods of latency and activity in pellagra correspond in a way with malaria produced by the protozoan parasite, *Plasmodium vivax*, a parasite known to be conveyed by mosquitoes of the genus Anopheles. Its symptoms, course, duration and characteristic lesions are, he says, like those of parasitic diseases. "It is insect borne because not directly contagious; because neither food nor water account for its peculiar epidemiology." It is limited to rural districts only, he asserts, towns and villages almost invariably escaping.

In Kentucky, it must be said, the disease is rural in general, but puzzling instances are known to me of well-to-do people becoming affected while living in the heart of a city. Cases believed to have originated in asylums also appear to contradict the sand fly theory. Yet it should in fairness be added that the circumstances under which these cases have appeared are not fully known, and more complete knowledge of the disease at its inception in each case might bring all of the apparent exceptions into agreement with the idea so well presented and supported by Dr. Sambon.

ACKNOWLEDGMENTS.

In concluding, it is appropriate that acknowledgment be made of courtesies extended to me by physicians at Corbin, Pineville and Cary. To Doctor M. H. Steele and

Doctor Parker of Corbin; to Doctor J. G. Foley of Pineville, and to Doctor J. H. Hendren, of Cary, I am indebted for information as to cases of pellagra in their charge. Drs. Steele and Hendren were so good as to accompany me to points of special interest, at the cost to them, I felt sure, of valuable time. Mr. Robert Asher, of Pineville, provided me with photographs relative to one of the cases in charge of Doctor Foley. To Doctor J. N. McCormack, Secretary of the State Board of Health, I am indebted for addresses of physicians having charge of cases, information which proved of much value by saving time in locating places at which observations and collections could most profitably be made. Doctor F. H. Clark, of Lexington, has shown at all times a keen interest in the matter, and has secured for me a list of cases in the Eastern Kentucky Asylum. Each of of these gentlemen has my sincere thanks for his kindness.

All drawings illustrating the bulletin are original, and were made under my direction by Mr. Matthews of this Division. Excepting those of the buffalo gnat and a few others, they were made from material collected about Corbin and Pineville. The photographs reproduced are also new, and were made inpart by Mr. Vaughn of the Division, and in part by myself.

CORRIGENDA.

Page 17, first paragraph, for (*0.056 inch*) read (*0.16 inch*) and add: *greatest width, 1.6 mm.* (*0.064 inch*); *greatest depth, 1. 4 mm.* (*0.056 inch*).

Page 26, fourth paragraph, for *columbateczensis* read *columbæzensis.*