The Buffalo Gnat, *Eusimulium pecuarum* Riley, in Mississippi 1933

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Background

The first report of the presence of adult *Eusimulium pecuarum* during 1933 was made by Mr. D.W. Grimes at Durant, Mississippi, about February 1, when this pest was said to be fairly abundant near that place. They were noticed at other places in the delta region of Mississippi during February, but no knowledge of their being present anywhere in numbers sufficient to be annoying was obtained. After the first of March they increased rapidly, probably reaching the peak of abundance for the season between the middle and latter part of this month. Although the gnats were present in large numbers this year, there were only isolated reports of their killing stock, and it is my impression that these pests were much less abundant this year than in 1932. After the first on April the numbers declined and by the middle of the month they were so few as to make greasing of stock unnecessary except in isolated localities.

In the vicinity of Webb, Mississippi, after having been practically absent for three weeks, adults of *Eusimulium pecuarum* reappeared on the seventh of May in numbers sufficient to warrant spraying. This outbreak lasted only about a week. During the past two years inquiry has been made as to whether there occurred two peaks of gnat abundance to ascertain whether there might be two generations of this pest. Farmers and fishermen have agreed that this does not occur. This late outbreak in 1933 was local in extent and it is not believed that it represents a small second generation, but rather the emergence of a goodly number of gnats whose development had in some way been retarded.

Table No. 1 gives a record of the comparative data on temperatures for the past three winters in Mississippi. No attempt has been made to closely correlate these temperatures with the beginning of the gnat season but it can be seen that they are more or less definitely related. During 1931 the gnats were not reported as troublesome until the first few days of April when large numbers of mules were killed by their attacks. It may be that the subnormal temperatures existing during the winter of 1930-31 delayed pupation and that when favorable temperatures did arrive pupation and emergence occurred rapidly, causing the exceptionally great swarms which were reported to have been present during the outbreak of that year. In 1931 the gnats were present in increasing numbers from around the first of January until the latter part of March after which they rapidly declined. It will be noted that during the winter of 1931-32 the temperatures were much above normal, probably accounting for the gradual emergence which spread the

brood over a large period as there was no sudden appearance of the hordes of gnats as occurred in 1931, and only an isolated report of any stock being killed.

The 1933 season had subnormal temperatures up until January when a warm period occurred followed by approximately normal temperatures during March and April. The gnats appeared during February but were most troublesome during the latter half of March and early in April. No cold period occurred in the spring as did in March, 1931, to delay emergence, but as in 1932 the emergence proceeded gradually over a considerable period. No sudden outbreaks occurred and practically no stock was lost due to gnat attacks. Dr. V.F. Bess reported 1 mule and 1 horse were killed by gnats during latter half of March along the Big Black River near Vicksburg, Mississippi.

(Note: It is intended as time permits to make a detailed study of the relation of temperatures to the time of occurrence and disappearance of gnats and on the severity of the outbreaks.)

No survey of gnat conditions in other states was made during the season. On March 18 a newspaper item was seen which reported gnats as being abundant near Helena, Arkansas, but no damage to stock was reported.

Area Affected

In Mississippi, *Eusimulium pecuarum* are found chiefly in the delta section, roughly between Highway 51 on the east and the Sunflower River on the west, and from just south of Vicksburg almost to the state line on the north. They are normally most abundant along the rivers which breed these gnats, via., Coldwater, Yalobusha, Tallahatchie, Yazoo, and Big Black, but on occasion, as in 1931, they migrate to areas which usually see very few of these pests. No migratory flights were reported in 1933.

Notes on Occurrence

General

It was stated in the 1932 report on *Eusimulium pecuarum* that this gnat was found breeding in those rivers which rise in the hills but only in such portions of these rivers as lie in the delta. These rivers are those just enumerated. The Sunflower and Quiver Rivers and Cassidy Bayou, which are wholly delta streams were not found breeding *E. pecuarum* in the areas examined in 1932.

This year, however, a few pupae of *E. pecuarum* were found in the Quiver River near Schlater, Mississippi, from which one adult emerged and this proved to be *E. pecuarum.* Buffalo gnats are often

reported as serious pests along this river in the vicinity of Schlater and it may be that further search will reveal the larvae in numbers.

Coldwater River

This river rises in the hills in the north-central part of Mississippi and enters the delta a few miles north of Prichard. It then flows through the delta and empties in to the Tallahatchie River a few miles southeast of Marks, Mississippi. Examinations for larvae were made in this river in the hill county near Arkabutla, Mississippi on March 15 and April 27. On neither of these days were any larvae or pupae of *pecuarum* found, although on March 15 adults of this species were abundant in the river bottom and very few were seen on the latter date. Larvae of a species of *Simulium* were obtained on March 15 and a single simulium pupa was found on April 27.

At Prichard, Mississippi, larvae of *E. pecuarum* were abundant in the river on March 1, and fishermen told me that the larvae had first been noted on their nets about ten days previous. Adult gnats were present but had not appeared in sufficient abundance to cause any annoyance to stock. By March 16 the adults were abundant and troublesome in this vicinity and continued to be so until about April 25. None could be found on May 4. Larvae and pupae had practically disappeared from the river by April 22 and none were found on the 25th. At this time the vegetation and debris to which larvae had attached were becoming covered with filamentous algae.

Birdie, Mississippi – On March 1 very few adults were present at this place; no examination of the river was made. On March 15 larvae and pupae were found to be abundant, but adults were still not numerous.. On April 25 all larvae had disappeared from the river; adults were scarce. The twigs and debris to which larvae had been attached were algae and silt coated.

Tallahatchie River

This river rises in the hills of northeastern Mississippi, enters the delta north of Crowder, Mississippi and joins with the Yalobusha River near Greenwood to form the Yazoo River, Examinations made on February 21 at Phillip showed that larvae of *pecuarum* were very abundant, few had pupated, and although the day was bright and warm only a few adults were present. This same condition prevailed at Nikoma, Mississippi on March 4, and at Money on March 8. No further examinations were made at the first two of these places during the season on account of flood waters covering the road. On May 3 at

Swan Lake no adults of *E. pecuarum* could be seen; a few small gnats of S. *occidentalis* were flying. Fishermen reported seeing no buffalo gnats since the middle of April. On June 12 a few larvae, pupae, and adults of a small species of simulium were taken. On May 4 at Money, no larvae, pupae, or adults of *pecuarum* could be found but a very few adults and larvae of another species, probably S. *occidentalis*, were present. It was reported that buffalo gnats had not been troublesome since the middle of April.

Yalobusha River

This river rises in the hills north of Houston, Mississippi and joins the Yazoo River near Greenwood. It enters the delta just west of Holcomb, Mississippi. On March 4 larvae of *E. pecuarum* were found very abundantly at Whaley and it was reported by fishermen that their nets had been getting covered with larvae for the past two weeks. Few adults were present. This same condition prevailed on March 15 after which this place could not be reached until April 25 on account of high water. On April 25 a very few larvae of *E. pecuarum* were in the river but none could be found on April 29; the places where *pecuarum* larvae had been found were covered by the larvae of a small species of simulium, probably S. *occidentalis*. Adults of this species were annoying chickens and dogs in the vicinity. Adults of *E. pecuarum* were fairly abundant on April 29 but rapidly became fewer and were very scarce by May 10.

This river was also examined near McComb, which is in the hills, on March 15. Only a few *Simulium* larvae were found and these were not *pecuarum.*

Yazoo River

This river is formed by the Yalobusha and Tallahatchie coming together near Greenwood, and flows south joining the Mississippi at Vicksburg, Mississippi. *E. pecuarum* larvae were fairly abundant in the river in the vicinity of Greenwood on February 21 and April 8, and adults, both males and females, were common on the show windows in the city as early as February 26. Just below Greenwood at Rising Sun, the river was examined on February 23 and March 8, and no signs of *pecuarum* larvae could be found. A fisherman in the vicinity who claimed to have been located there for 30 years reported that he had never seen gnat larvae on his nets. On May 8 a few larvae of S. *occidentalis* were found in the river at this point.

Adult *E. pecuarum* were abundant and troublesome along the Yazoo River from Greenwood south, during the spring. In the river examinations made at Belzoni, Belle Prairie, Yazoo City, and Satartia

during April and May, no larvae of this species were found, although larvae of other *Simuliidae* were abundant.

Big Black River

This river rises in the hills of eastern Mississippi near Maben, and enters the Mississippi River south of Vicksburg. It is more of a hill stream than is the Yazoo system, and does not flow through any extensive delta section, although there are large areas of bottom land along its western course. Examination this year at Durant, Pickens, and Edwards did not show the presence of *E. pecuarum* in this river, although it is known that the Big Black does produce this species. It was found breeding in abundance near Flora, Mississippi in March, 1932.

Adult *pecuarum* were reported as present at Durant in February and a very few were taken at Durant, Pickens, and Edwards on March 31 and April 1. No examinations were made below Edwards where it was later learned that gnats, probably *E. pecuarum,* had appeared in numbers in the latter part of March and were reported as causing the death of 1 mule and 1 horse. None were present in these places on May 23 and 23.

Larvae of other species of simulium were taken from the river at the above mentioned localities which are not yet identified.

Sunflower River

This river rises in the delta north of Clarksdale and flows through the delta joining the Yazoo south of Holly Bluff, Mississippi. Examinations for larvae of *E. pecuarum* were made at Ruleville on March 28 and May 17, at Murphy on April 3 and May 27, and at Holly Bluff on April 4 and May 26. No larvae of this species were found. Adult gnats were not reported as causing any concern except at Murphy, where it was stated that buffalo gnats were abundant during the latter part of March. A very few larvae of other species of simulium were found in the river examination.

Quiver River

This river rises in the delta near Sumner, Mississippi, and flows south, joining the Sunflower near Indianola. Examinations were made for larvae of *E. pecuarum* near Ruleville on March 28 and May 17, and none were found. Near Schlater, examinations were made on April 12 and May 16. On April 12 a

very few pupae were found, from one of which an adult *E. pecuarum* emerged; this being the only record of *pecuarum* from this river. On May 27 a very few larvae of another species were obtained at this point.

Environmental Factors

In the observations on gnat environments in 1932, there appeared to be no essential difference in the conditions in those areas which were concerned with the production of *E. pecuarum* in Mississippi and those which were not breeding these pests. These observations were superficial and included only an estimation of whether the current was slow or swift, and whether or not there was ample debris and vegetation for attachment. A number of observations were made in 1933 on other conditions in the breeding and non-breeding areas in an attempt to ascertain factors which may be associated with this condition. These observations have included current rate, dissolved oxygen content, temperature, hydrogen-ion concentration and turbidity.

The current rate was measured with a standard U.S.G.S. current meter, and readings were made at depths of 2 inches and 3 feet below the water surface.

Dissolved oxygen was determined at depths of 2 inches and 3 feet by use of the Rideal Stewart Modification to the Winkler Method as given in “Standard Methods of Water Analysis’ published by the American Public Health Association, 1923.

The temperature was measured about 3 inches below the water surface at the time the water samples were taken.

The turbidity was measured by the platinum wire method using a rod with graduations similar to those of the U.S. Geological Survey rod of 1902. The directions for using this rod state that “waters having turbidity greater than 500 shall be diluted with clear water before the observations are made and the degree of dilution reported.” This note was overlooked, and therefore the readings here are not standard for reading of 500 and less.

Hydrogen-ion concentration was determined by the use of a LaMotte Colorimetric Set. The following tables, No. 2, 3, and 4, gives the results of the observations made on these conditions in Mississippi Rivers. Considering turbidity, it is not believed that this factor can be discussed satisfactorily with the data given. These are not only too few, but were made at such irregular intervals that they give no accurate picture of conditions. For instance, after a period of heavy rain the turbidity would be great due to silt

being washed into the river, while if the observation was made just before a rain it would be much lower due to the silt having settled out. The load of silt carried by a river thus varies greatly and in order to estimate this load with any degree of accuracy, frequent and regular readings are necessary. The data on turbidity in Tables No. 2, 3, and 4 shows that larvae of *E. pecuarum* were not taken when the turbidity was over 800; however, it is also shown that the rivers in which *pecuarum* occur have at times a much greater turbidity.

The pH of the river water in the areas when *E. pecuarum* were taken varied from 6.4 to 7.1. This same range was found to exist in non-breeding places.

The records on temperature, oxygen content, and current given in Tables No 2, 3, and 4 have been summarized in Table No. 5. It is shown in this table that no larvae of *pecuarum* were found in the rivers after the waters had reached 67*F.

During the buffalo gnat season, that is, when the water temperatures were below 67*F, the average current rate in the areas where gnat larvae were found was slightly less than that in the areas where they were absent, the ranges of this rate in the two classes of areas also showed slightly lower rates in the breeding areas. These differences are probably too small for consideration. The oxygen content of the two classes of areas is shown to average slightly higher in the breeding areas, but the range of these observations shows some lower readings in the breeding areas than were found in the non-breeding areas.

The data on these factors obtained after the larvae had disappeared from the rivers show a slightly increased current rate and decreased oxygen content for the areas which had been producing *pecuarum* . In the non-producing areas both the current rate and oxygen content showed a decrease.

Considering these data it appears that during the breeding season the conditions as regards pH, current rate, and oxygen content are essentially the same in those areas in which larvae of *E. pecuarum* are found and in those where they are absent. Conditions later in the season show a lessening in the current rate in those areas in which larvae were not found, and a slight increase in this rate in those areas where the larvae were previously found. The oxygen content in both classes of areas showed a considerable decrease. It may be that further observations on these factors later in the season may show

increasing changes in these two classes of river areas to explain the presence or absence of *pecuarum* larvae during the spring.

Repellants

Tests made in 1932 with repellants for protecting animals from gnat attacks indicated that the commonly used repellant which consists of 1 pint of pine tar in 1 gallon of crankcase or cottonseed oil was as efficient as any of the other substances tried. These substances included mineral oil with the following odors: wintergreen, citronella, pennyroyal, coriander, and fennel; and also kerosene extract of pyrethrum alone and mixed with heavier oils. It was also noted that mopping the greases on the animals protected them for longer periods than spraying. The objection to mopping is that grease is injurious to the animals, causing blistering and overheating and thus keeping the work animals in poor condition at a season when heavy farm work is necessary. This year it was decided to try some of the non-oily repellants. The substances used were: (See Kansas State Agricultural College Press Bulletin No. 65)

Solution No. 1

Compound	Parts
Pulverized resin	2
Soap shavings	1
Water	1/2
Kerosene	1
Oil of tar	1
Fish oil	1
Water	3
Total	9 1/2

The resin and soap are boiled in the half part of water until the resin is dissolved. The oil of tar, kerosene and fish oil are then added with the rest of the water and the mixture is then stirred while it boils for 15 minutes.

Solution No. 2

Compound	Ounces	Quarts
Crude Fish Oil	64	2
Crude carbolic acid	16	0.5
Pennyroyal	1	0.03
Kerosene	48	1.5
Oil of tar	8	0.25
Total	137	4.3

Solution No. 3

5 percent emulsion of pine tar creosote

Solution No. 4

5 percent emulsion of pine oil

Solutions 3 and 4 were made by boiling ½ pound of soap in 1 gallon of water and then adding 6 ounces of the repellant while stirring vigorously.

Table No. 6 summarizes the tests made with these repellants.

Only one test was made with Solution No. 2, as I was a little afraid of the effect of this spray on the mules on account of the high carbolic acid content and as the preliminary test did not show any marked repellant effect it was not used further.

The table shows the tests as made by days on account of the fact that tests made with repellants on one day are not comparable to those made on another because of the daily variations in the abundance and persistence of the gnats. It will be noted that Solution No. 1 was a very effective repellant and that it was as good or better than the tar and grease in keeping the gnats from the mules. This solution (see formula) is a heavy sticky substance and when applied to mules is comparable to coating them with tanglefoot. It mats their hair and makes it impossible to clean the mules from day to day. When released in the barnyard the mules treated with the substance usually wallow in the dust and become coated with mud which dries and cakes over the body and altogether makes a nasty animal to work with. It is very doubtful that this material, although beneficial as a gnat repellant, would never displace tar and grease. It is also rather expensive and the ingredients are not always readily obtainable.

Solution No. 3 at first glance does not appear to be a very effective repellant and considering only the length of time it is effective it cannot compare with solution No. 1 or with tar and grease. However, it is believed that this emulsion will prove of considerable value in caring for animals in the gnat infested country for those who consider the welfare of their animals. This emulsion is easily and cheaply made, the cost need not exceed 6 or 7 cents per gallon. It has none of the disadvantages of Solution No. 1 or of tar and grease. It can be applied by either brush or spray and does not mess up the animal or cause overheating. The data in Table No. 6 show that under conditions when gnats are not persistent all day

(March 22, 23, and 24) one application of about 1 pint may protect the animal all day or for the greater part of the day. On March 24 when the gnats were not particularly troublesome, this material was as efficient as either tar and grease or Solution No. 2. On the other days, when gnats were really troublesome, it was necessary to spray or mop the animals with Solution No. 3 from 2 to 5 times during the day to give them efficient protection, as much as a quart or slightly more of the emulsion per day per animal being used. It is, therefore, not a remedy which can be relied on to give lasting protection from gnats, but appears to be one which may well be used by those who would protect their animals with a minimum of damage to them, and at low cost.

In these tests a cheap brush-broom was used for mopping, and for spraying a cheap spray gun costing 25 cents retail was used. The animals which were coated with tar and grease (T&G) were not treated with any given amount of this material but were well mopped in the manner usual in gnat country.

(Note: In reporting these tests it may be stated that in the opinion of the writer the general abundance of gnats this year was much less than during the 1932 season.)

Toxicity of Gnat Bites to Animals

During gnat outbreaks there is always much discussion as to what causes animals to die. The most common theories are:

1. That the flies enter the nasal passages and lungs and cause suffocation.
2. That the flies are so abundant as to bleed the animals to death.
3. That a poison is injected with the bite which kills the animals.

The first is usually discounted by veterinarians, some of whom have performed post-mortem examinations and have found no basis for this assertion. No definite observations are at hand bearing on the second. It has been stated by Steidle (1927) in reporting on experiments, that aqueous extracts of *Simuliidae* which had been dried or preserved in alcohol caused, when injected into rabbits, symptoms similar to those reported for domestic animals during gnat outbreaks. He states that the toxic substance in question, which by its pharmacological properties shares the toxic effect of many other animal poisons is boil proof; the poison is insoluble in alcohol, ether or chloroform.

In order to obtain some information on the toxicity of *E. pecuarum* to animals, several lots of gnats were collected and sent to Dr. F.C. Bishopp in Washington during March, 1933, for his use in making toxicity tests. Some of these lots were preserved in alcohol, some in glycerin and some merely killed by heat and allowed to dry. Dr. Bishopp has given me the following information on his experiments: "From the first lot of 429 gnats, weighing 283 mg., we made an extract, using 20 cc. of normal saline solution. One cc. of this was injected subcutaneously in the back of a rabbit, and 1½ cc. subcutaneously in the ear of another. A slight temperature rise was recorded, and there was evidence of mild irritation, as shown by the rabbits scratching the points of injection. From the third sending (2674 mg. of gnats) we made an extract, using 15 cc. of distilled sterile water. One and one-fourth cc. of this was injected subcutaneously in one rabbit, 1 cc intravenously in another, 0.8 cc. subcutaneously in a guinea pig, 1 drop inserted in the eye of a rabbit, and several saturated packs applied for considerable periods to the arms of men. Soon after injection the rabbits showed a decided tendency to scratch the points of injection, but this irritation soon subsided. No other manifestations were observed in this series of tests."

The gnats used by Dr. Bishopp in these experiments were collected, of course, at a time when, although gnats were abundant, no killing of stock was reported.

It is thought by many persons in the delta that the gnats are more poisonous in some years than others. I have been told that these pests are sometimes as abundant in years when no deaths occur as they are when losses do occur. Whether this is so or not, as has been mentioned previously in this report, there is considerable variation in the manner of appearance of adult *E. pecuarum* each year, and that when they appear suddenly in large numbers stock losses result; when they appear in increasingly large numbers during the spring few, if any, losses occur. This may mean, of course that an immunity to gnat poison may be acquired by animals during seasons when these gnats appear first in small numbers and gradually increase in abundance.

Egg Laying

Webster (1887; 1888) has reported observing females of *E. pecuarum* in the act of egg laying. He states that the eggs are deposited just above the water's edge on anything, vertical objects preferred, in the midst of the current, and also that "the eggs hatch within a few hours and the young larvae at once find

their way into the stream." As was the case last year this process of egg laying has not been observed, no have the eggs been found to hatch within a few hours.

The observations made both last year and this year are that the female gnats after having fed and become gravid, return to the river to oviposit, and that they may be taken there in large numbers as they engage in an upstream flight just before dusk. It was noted that during this flight the gnats are often seen striking the water in such numbers as to make the surface of the water appear as if rain were falling. This striking of the water while in flight is, however, not peculiar to gravid females, as both males and females with no ovary development do likewise when disturbed at any time from their resting places on branches overhanging the river. As it was impossible to observe egg laying as described by Mr. Webster at the places visited, it occurred to the writer that possibly eggs were being laid as the females hit the water, as is the case with certain dragonflies. Following up this theory, plankton catches were made in the rivers and gnat eggs were found.

Females taken by net from the upstream flight at dusk and confined in jars over water usually lay eggs during the night or early morning and the eggs are usually found on the bottom of the jars. Females have been observed ovipositing in these jars while resting on the water surface, the tip of the abdomen being thrust beneath the surface of the water and the eggs sinking as they are extruded. One female was observed to lay a few eggs on a twig *beneath* the surface of the water after she had deposited the majority of her eggs while resting on the water surface, and on one or two occasions eggs have been found stuck to the side of jars above the water. This last incident occurred in jars which were being transported by car and the splashing of the water may have occasioned it. The activities of these females in captivity may, of course, bear little relation to their normal habits.

The eggs taken from the rivers by plankton net appear to be identical with those laid by captured females of *E. pecuarum* . However, as no hatching has occurred in the eggs taken, positive identification cannot be made. The numbers of eggs strained from the rivers have not seemed to be in proportion to the numbers which must have been laid somewhere by the immense numbers of females which occur over the rivers as each female lays from 200 to 400 eggs. As Mr. Webster apparently had no trouble in observing the egg laying as reported by him, and as the method he describes is similar to that of other *Simuliidae*, the writer is not at all satisfied that his own observations on this matter are complete. In this

connection it may be stated that during the gnat season large numbers of apparently dying and dead gnats are found floating down the rivers. If these gnats are examined some will be found to display considerable activity and numbers of them will be females which have well developed eggs in the abdomen. It might be that the eggs which are found in the rivers are laid by these nearly spent females in the same manner as that observed for captive females and that the writer has not yet found the place where egg laying by active adults occurs.

In making the plankton catches the net was tied so that it floated just below the water surface. He catches were thus made in the top foot of water. No quantitative data were obtained on these catches, the net was usually left in the river while other examinations were being made; these varied from 30 minutes to several hours. The catch was then taken to the laboratory, diluted and searched for eggs. Complete examination of catches were usual only when no eggs were found. When eggs were found their abundance was noted as abundant or few, or the number found in a short examination given. Only at Prichard, Mississippi were plankton examinations made with any regularity, a record of these will be found in Table No. 7.

In addition to these records, a few eggs were found in mud and trash taken from the river bottom at two places near Prichard on June 17, no signs of young *pecuarum* larvae being found. Eggs were taken from the Coldwater River at Birdie, Mississippi on April 25 and June 12. None were found in a six hour catch at Arkabutla on April 27.

During the season eggs were also recovered from plankton caches made in the Tallahatchie River at Money on May 9 and June 7, and at Swan Lake on June 12; from the Yalobusha River at Whaley on May 1 and 11, June 2 and 6; from the Yazoo River at Greenwood on May 9 but none on June 15; from the Yazoo River at Rising Sun on May 9 but none on June 10 or 15. Eggs were not found in the Yazoo River in plankton catches made on May 26 and 27 at Belzoni, Belle Prairie and Yazoo City. In the Quiver River 1 egg was reported in a catch near Schlater on May 16, but none at Ruleville on May 17. No eggs were found in the Sunflower River in catches made on May 17 at Ruleville and at Holly Bluff on May 26. In the Big Black River no eggs were taken in the catches made on May 22 and 23 at Pickens, Durant and Edwards.

The foregoing may be summarized as follows: gnat eggs were readily found during the season in certain rivers at those places where larvae of *E. pecuarum* were found or had been found in abundance, a few eggs being taken long after all signs of adult and larvae had disappeared. Plankton catches in the Sunflower, Big Black and in the Yazoo River below Rising Sun showed no eggs, but these catches were made late in the season.

Eleven lots of eggs from captured females were obtained during March and April, 6 of which were kept in still water in small jars and 5 of which were put into jars through which a stream of air was passed to keep the water aerated and in motion. Also, 4 lots of eggs which were strained from the rivers were put into aeration jars. The jars were frequently examined with hand lens for signs of young larvae and occasionally with the microscope for signs of hatched eggs. None were observed. On June 15 these jars were taken to Starkville, Mississippi, and on June 26 all were given a superficial examination and no signs of hatching found.

On June 26 and 27 two of the still jars, tow of the aerated jars containing eggs obtained from caged females, and two of these jars with eggs from the rivers were brought to Orlando. Examination of these jars the latter part of July shows several eggs in one still jar which have a longitudinal split down one side which certainly appear to be hatched. These eggs were laid April 7. In this and in two other lots of eggs several apparently empty shells have been found, these shells show no signs of being broken or having any contents. An examination of eggs which were laid in a jar and allowed to dry show, when immersed in water, this empty condition. In the other three jars all eggs appear intact. No signs of young larvae were noted in any of the jars, this of course would be unlikely in the still jars, as without current even the larger larvae die in a short time. On account of the fact that so few of these split shells have been observed the writer hesitates to make any conclusion at this time as to whether or not these are eggs which have hatched. Carful search was made for small larvae during May and June in the rivers where *pecuarum* were known to occur. None were found, but a few eggs were taken from the mud and trash in the stream beds as late as June 17.

Very small larvae of what appear to be *E. pecuarum* were collected at Prichard, Mississippi, on November 22, 1932, and at Mikoma, Mississippi, on November 23, 1932. Only a few of these were obtained, and at these places in March, 1933, the larvae were very abundant.

Pupal Stage

The following records were obtained from gnats, the larvae of which pupated and from which adults emerged in aeration jars.

No. larvae	Date pupated	No. adults	Date emerged	Length of pupal stage (days)
5	9 Apr	5	12 Apr	3
2	9 Apr	2	13 Apr	4
6	10 Apr	4	13 Apr	3
		2	14 Apr	4

Larvae may pupate and adults emerge in still water as is shown by the following record. Nine full grown larvae were put into jars with still water on April 7, and the following record obtained:

No. larvae	Date pupated	No. adults	Date emerged	No. adults died	Length of pupal stage (days)
2	8 Apr	1	14 Apr	1	6
1	8 Apr	0		1 (8 Apr)	
1	9 Apr	0		1 (10 Apr)	
1	10 Apr	1	14 Apr		4
4				4 (10 Apr)	

Adults may emerge from pupae which have been left stranded a short time previously, as is shown by the following record:

On March 21 a large lot of pupae were taken from the river at Greenwood, Mississippi and put into a lantern globe cage, with no water at 12 noon. By 8 A.M. on March 22, 22 adults had emerged. No further emergence average occurred.

Summary

During 1933 adults of *E. pecuarum* were first noticed in Mississippi about February 1. They were present in large numbers during March, after which the abundance gradually decreased until by the middle of April the use of repellants was in general unnecessary.

The abundance of this gnat was believed to be much less than during the 1932 season. The gnats appeared gradually in increasing numbers and only an isolated instance of stock killing was reported.

A preliminary study of environmental factors in river areas in which larvae of *E. pecuarum* were found and those in which they are not found was made. Observations included temperature, pH, turbidity, current rate, and oxygen content.

No larvae were found in the rivers after the temperature of the water reached 67*F. The pH of the water in both breeding and non-breeding areas was similar, ranging from 6.4 to 7.1.

The turbidity readings were not believed to be of value on account of the few records at hand and the constantly changing nature of this factor at any given location.

During the season when larvae of *E. pecuarum* were found, the average current rate in the non-breeding areas was slightly higher than in the breeding areas (1.31 ft. per second against 0.95 ft. per second) while the oxygen content averaged slightly higher in the breeding areas (4.95 p.p.m. against 4.71 p.p.m.). After the larvae had dispersed the producing areas showed a slightly increased current rate while the non-producing areas showed a decrease, and the oxygen content decreased in both classes of waters.

Tests made with repellants for protecting animals from gnat attacks showed a 5 per cent pine tar oil emulsion to be of value. When gnats were abundant and persistent in their attacks, from 2 to 5 applications of this material were necessary during the day to protect the animals. The emulsion is, however, easy to make and apply, can be either sprayed or mopped on the animal, is cheap, and no injury to the animal results from its use as does from a heavy coating of tar and grease, which is the repellant most commonly used.

A few experiments on the toxicity of gnats to animals were made by Dr. Bishopp from material collected during March and shipped to Washington; these were inconclusive.

A discussion is given of the observations made on the egg laying habits of *E. pecuarum* . No hatching of eggs was observed in experimental hatching jars, although a few eggs with longitudinal splits were found in one jar during July which may indicate hatching. Intact eggs were located in the rivers as late as June 17. No small larvae were found.

The pupal stage was found to last from 3 to 4 days in water which was kept agitated and aerated. Pupae taken from the river and allowed to dry produced adults during an ensuing period of 20 hours. A

single experiment shows that larvae may pupate and adults emerge in still water although the larval and pupal mortality was high.

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