Reprinted from EVOLUTION, Vol. VI, No. 3, September, 1952
Printed in U. S. A

SPECIATION IN THE FIELD CRICKET [1]

B. B. FULTON
North Carolina State College, Raleigh, N. C.

Received February 6, 1952

INTRODUCTION

The common American field crickets have had the generic names *Acheta, Gryllus* and *Gryllulus*. The name now accepted is *Acheta*. The reasons for these changes of name are explained by Gurney (1951). But by whatever scientific name we call the crickets, they are still the common field crickets and very easily recognized as a genus. Splitting the genus into species, however, has been one of the greatest stumbling blocks to taxonomists working on the Orthoptera.

From 1775 to 1903, forty-seven species were described from North and South America and the West Indies. Seventeen names were applied to species occurring within the United States. The diagnostic characters used to separate the species were coloration, size, wing venation and length of such parts as tegmina, wings and ovipositor. All of these characters are extremely variable. As this fact came to be realized a number of the species names were reduced to synonyms. Lutz (1908) published a biometrical study of some large series of specimens from several parts of the United States. He used the length of body, hind femora, ovipositor, tegmina and wings. He found that, with respect to any of these measurements, all specimens fell into one continuous series, except that for length of tegmina and wings they exhibited dimorphism. The species as they had been described and defined by these characters were shown to be mere arbitrary areas in a wide field of variation. Lutz also studied the collection of the British Museum which included specimens of the genus from many parts of the world. These extended the limits of variation of the characters studied but left no gaps. Lutz concluded that no specific entities exist in the genus *Gryllus*.

Rehn and Hebard (1915), who were experienced taxonomists, published a study of the genus seven years later and pointed out that Lutz overlooked certain characters of real specific value in the Old World species of the genus, but agreed with his conclusions as applied to the New World. Rehn and Hebard studied 1,504 specimens from the Western Hemisphere and devised a system of classes for 5 different variable characters. Each specimen was given a set of 5 symbols which roughly described what class of variant it was. While they found that certain variants are more common than others in any geographical region, they concluded that no variant or group of similar variants is sufficiently differentiated or constant to be considered even a geographical race. They reduced all names of indigenous American species to synonyms under the oldest valid name. Some orthopterists continued to use the old names as subspecific names but most of them have now come around to the idea of a single American species. This work greatly simplified the task of identification of field crickets by making it correct to apply the binomial *Gryllus assimilis* Fab. to every specimen of the genus, from Canada to Patagonia.

The present, study, however, shows that this is an over-simplification. It can be shown that even within the limits of the state of North Carolina, there is not just one, but at least four populations of field crickets [2] which may be so reproduc-

[1] Published with the approval of the Director as Paper 408 of the Journal Series.

[2] The approved common name of *A. assimilis* is "field cricket." In this paper the word "field" is usually omitted. It should be under-

tively isolated from each other as to constitute biological, physiological or ecological species, subspecies or races, whichever you prefer to call them.

Evidence for the Existence of Physiological Races

It has been known for a long time that field crickets in the northern states are present in the adult stage over a long period, starting in May and ending with the autumn frosts. It has also been known that crickets which mature in spring survive the winter as nymphs while those maturing in late summer pass the winter in the egg stage. Thus there are two broods of crickets which are prevented from interbreeding by the difference in time of maturity, although there may be a short period in midsummer when adults of both broods are present in small numbers. This isolation could be broken if the spring brood had either a partial or complete second generation, but there is no evidence for the existence of two generations of field crickets in the northern states. Severin (1935), who studied the life history of the field cricket in South Dakota, states that both broods have one generation per year and that they may represent two biological races. The spring brood probably contains less than 5 per cent of the total number of crickets.

Blatchley (1920) retained trinomials for several common variants, including two which he claimed were spring brood crickets in Indiana, namely *Gryllus assimilis pennsylvanicus* Burm. and *G. assimilis vernalis* Blatchley.

Cantrall (1943) analyzed his collections from the George Reserve, Michigan, by classing all specimens according to the symbols devised by Rehn and Hebard. He found that two variants, AVaw3, AVbw3, were the most commonly represented in both spring and fall populations, with 55% of the spring and 94% of the fall brood falling into these two classes. A wider range of variation was found among the spring brood specimens.

Cantrall studied the behavior of the crickets in the field and claims that spring crickets are more solitary in behavior, males being very aggressive, and apt to fight when two of them meet. The fall crickets are more numerous and more gregarious, as many as 26 having been found under a small pile of leaves. No difference in the songs of the two populations was observed. On June 9, 1939, Cantrall placed seven pairs of the spring brood in an outdoor cage. Innumerable young were reared but not one reached maturity by fall and on December 16 only half grown hibernating nymphs could be found in the cage.

On the question of whether the spring and fall broods constitute distinct biological races, Cantrall say that this is a conclusion which may be justified but with which he is not yet ready to concur without reservation. He thinks that possibly there is sufficient overlapping of the two broods to insure intermingling. Differences in behavior may be due to the differences in density of population and other environmental effects.

In North Carolina the first evidence for the existence of a separate race of field crickets came from a distinct type of song, which the writer had never heard in the northern states. This song is a continuous trill very much like that of the 4-spotted tree cricket, *Oecanthus nigricornis quadripunctatus*, but with certain distinguishing characteristics. It is heard in old fields, pastures, lawns, crop lands and roadsides. In North Carolina this song is most noticeable on warm nights in March or early April when the field crickets are the only insects singing. The song is often heard during the day also. Except for a short period in late June, the trilling crickets continue to sing until September. The trilling song was first described by Allard (1910) who heard it in the spring in northern Georgia.

stood, however, that the word "cricket" is commonly used for any member of the family Gryllidae.

All other races of field crickets in North Carolina sing with a chirping song like northern field crickets. These races were revealed by differences in habitat and seasonal occurrence. In late April or May a chirping song may be heard in woods at night. The notes are somewhat creaky and issue with an inconstant rhythm, the rate varying from 3 to 5 chirps per second, depending partly on temperature and partly on the "mood" of the singer. These crickets live among the dead leaves in or near woods and seldom sing in daylight. One can ride along a road at night and hear the chirping song while passing woods and the trilling song while passing fields and pastures. Low swampy woods as well as upland oak or pine woods and even the xeric sandhill woods are inhabited by the chirping woods cricket. The song becomes scarce in July and disappears in early August.

In the mountains of North Carolina from the Blue Ridge westward, only one type of field cricket song is heard. This is a loud vigorous chirping which is commonly heard in old weedy fields, clover fields, stony hillsides, and other treeless habitats. It is absent from the woods except where there are natural openings or small clearings. These crickets do more singing during the day than other races, but like other field crickets they are most apt to be silent during the middle of a hot day. This song has been heard every month from May to October.

Along the coast of North Carolina chirping field crickets are common during late summer and fall. They differ from the woods race by inhabiting the flat sandy area bordering the ocean beaches. This may be grassy or shrubby or largely bare sand, but is not wooded. These crickets are very large and usually sing in a leisurely manner with 2 or 3 chirps per second. Crickets assumed to be of the woods race may be heard in early summer in wooded areas which occur farther back from the ocean. Trilling crickets have also been heard near the beaches, especially in inhabited areas where grass is grown for lawns.

On the basis of field observations alone it appears that there are four races or populations of field crickets in North Carolina. The writer has not been able to identify most of these races as any of the old arbitrary species. For convenience of reference it seems desirable to give the races nicknames and to define them by characteristics of the living population as follows:

Triller. The only field cricket singing with a continuous trill. Found in fields and grasslands.

Woods cricket. The only field cricket found in forested areas; also found in shrubby second growth and near forest borders. Chirping song, seldom heard before dark.

Mountain cricket. A chirping cricket found in old weedy fields, stony hillsides orchards, clover fields and other non-forested areas in western North Carolina.

Beach cricket. A chirping cricket found in sandy, treeless areas along the coast.

A few chirping crickets have been heard from August to October at Raleigh and several localities on the coastal plain. Their racial status is uncertain because they do not fit into the known pattern of seasonal or ecological distribution and known range of any of the races. It is possible that the fringe of mountain cricket population extends eastward to the coast or that the beach cricket spreads inland over the coastal plain in reduced numbers. A few such specimens captured in the coastal plain have been of large size like the beach cricket.

Distribution of the Races of Field Crickets

The triller and the woods cricket have about the same distribution in North Carolina. They probably cover the entire state as far west as the foot of the Blue Ridge Mountains. Neither race has been found, within the state, from the

Blue Ridge westward. This area of higher altitude is inhabited by the mountain cricket only, which also extends eastward from the mountains in decreasing numbers to cover more than the western half of the piedmont, reaching points in the vicinities of Chapel Hill and Pittsboro. The beach cricket is known to the writer mainly in the vicinity of Carolina Beach, near Wilmington, N. C. It has also been observed at Smith Island and Holden Beach. Probably it has a much more extensive range along the coast and the shores of the sounds, but field observations are lacking. Chirping field crickets, probably beach crickets, were common in grass and about buildings in the village of Swanquarter on Pamlico Sound, on September 3, 1947. They were not heard there on July 24, 1947, when only trillers were heard. This agrees with what we know about the seasonal history of the beach cricket.

The distribution of these four races of field crickets in other states is very uncertain because field observations on songs, habitats, and seasonal occurrence are lacking. Apparently no observations on the woods cricket have been made outside of North Carolina. The triller is definitely known only in Georgia, Florida and Tennessee, as recorded below. The writer observed trilling crickets on December 11, 1949, on the grounds of a tourist court at Waycross, Ga. He also reared a colony of trillers from a single female captured at Panama City, Fla. The Tennessee records are based on a few trillers heard in lawns in the town of Gatlinburg on June 24, 1947. The trilling song was first observed by Allard (1910) at Thompson's Mills, Ga., about 40 miles northeast of Atlanta. In the more mountainous Towns County, bordering North Carolina, Allard heard only chirping crickets. These were evidently the same as the mountain crickets of North Carolina. The mountain cricket has been heard by the writer at Gatlinburg, Tenn., and in the mountains of Virginia. On June 24 and 25, 1941, chirping field crickets were heard along the highways all the way from Ohio across West Virginia and southwestern Virginia and east of the Blue Ridge Mountains at least as far as Stokes County, N. C. At this time adult crickets would be of the spring brood. The beach cricket has been observed by the writer outside of North Carolina only at Cherry Grove Beach, near the northern end of the South Carolina coast.

Localities in North Carolina where the triller has been observed are listed as follows: Caswell Beach, Holden Beach, Carolina Beach, Wilmington, Lake Waccamaw, Castle Hayne, Burgaw, Wallace, Newton Grove, Goldsboro, Raleigh, Hamlet, Core Point, Belhaven, Swanquarter, Marion and North Wilkesboro.

North Carolina localities where the woods cricket has been observed are as follows: Carolina Beach, Lake Waccamaw, White Lake, Spout Springs, Newton Grove, Raleigh, Eagle Springs, Walkertown, Danbury and North Wilkesboro.

North Carolina localities east of the Blue Ridge Mountains where the mountain cricket has been observed are as follows: Marion, Morganton, Valdese, Statesville, Lexington, Siler City, Pittsboro, Mt. Airy, Danbury, North Wilkesboro, Graham, Kernersville and Chapel Hill.

North Carolina localities where the beach cricket has been found are all mentioned above.

The Races Have Different Seasonal Histories

Information on the seasonal history of field crickets has been derived from three sources, as follows:

1. Field notes on the presence of singing males, thus giving evidence on the seasonal occurrence of the adult stage, from which can be derived the probable periods when eggs and nymphs are present.

2. Direct observation or collection of different life stages in the field.

3. Rearing of crickets in cages. In most cases the cage was a four gallon earthenware jar with two inches of sand in the bottom. Unless otherwise stated the cages were kept entirely in a laboratory which was heated during cold weather.

The conclusions regarding the seasonal histories are shown graphically in figure 1 to permit comparison. The graphs agree with the main facts but are not quantitatively correct. The graph of the mountain cricket applies to the brood which is in the adult stage from May to July. The fall brood, mountain cricket probably has a seasonal cycle similar to the beach cricket but without hibernating nymphs.

The seasonal history of the triller has been closely followed by observations on life stages in the field and by observations on the singing periods of the adults for over twenty years. The singing starts with the first warm nights in March and continues to at least the middle of June. This is followed by one or two weeks during which the song is not heard. In early July the adults of the first complete generation start singing and continue until the middle of September. During warm fall seasons a few adults of the second generation sing in late October or November but most of the second generation hibernate as nymphs and become adults during the following spring.

Further information on the seasonal history of the triller has come from rearing records, as summarized below. A single female was captured and caged in early May, 1947. Young crickets hatched by June 3. They grew rapidly and some became adults of the first complete generation on July 17 after a nymphal period of 44 days. On July 29, some of the young adults of both sexes were placed in another cage. Young crickets of the second generation started hatching on August 11, 1947, after an incubation period of 13 days. A few adults of the

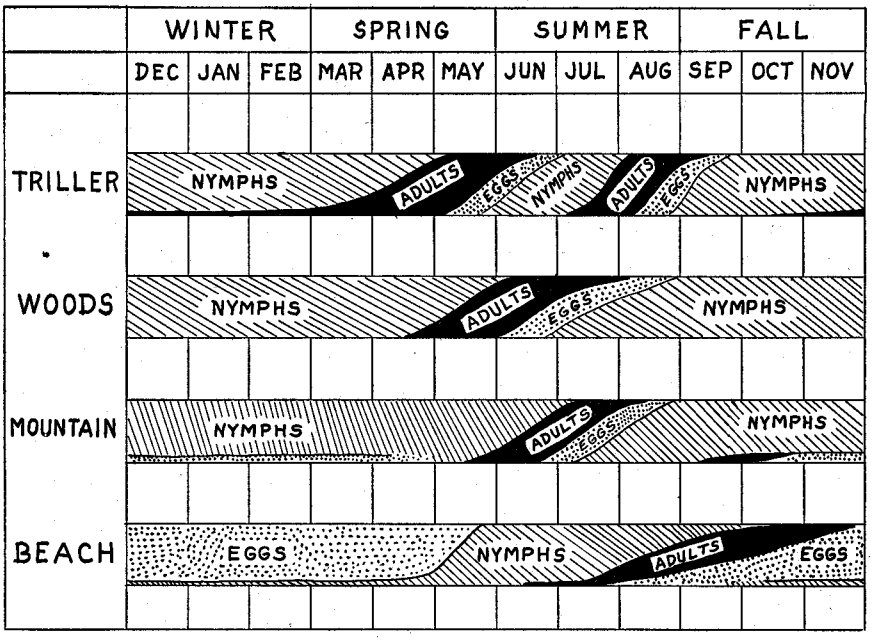

FIG. 1. Seasonal histories of four races of field crickets in North Carolina. The graph for the mountain cricket applies to that part of the population which reaches the adult stage in May and June.

second generation appeared on October 9, showing a total nymphal period for some individuals of about 60 days. However, most of the second generation crickets went through the winter as nymphs, even though the cage was in a heated room.

By April 15, 1948, many of the overwintering crickets had become adults and were depositing eggs. On June 3, young crickets of the first generation were found. Some of these matured by July 28, and young crickets of the second generation started hatching August 12, 1948. Thus for the second year the two generation cycle repeated itself on nearly the same dates. The rearing records agree closely with the cycle observed in the field. The normal cycle was modified very little by keeping the crickets in a heated room. The few adults singing in late fall out of doors probably hibernate as the nymphs do, and may be among those heard singing in March. Some late fall adults reared in the laboratory were paired on December 9, 1947, and produced young by February 20, 1948. The writer has seen no evidence that eggs are laid out of doors in the fall.

Information on the seasonal history of the woods cricket is also based on many years of field notes. The singing period starts with adults appearing in late April, from nymphs that passed the winter under dead leaves in the woods. The singers are most numerous in late May and June but the song is still heard until late July or early August. During fall and winter only nymphs are found in the woods.

Rearing observations on the woods cricket started on June 18, 1947, with adult crickets collected in the middle of a woods. Three pairs were caged. Young crickets appeared on July 8 after an incubation period of 20 days. All of the female adults were still alive on August 20 but the last male died about August 1. On August 26 all crickets in the three cages were found dead, due to high temperature or an invasion of ants. The study was continued a few days later by collecting a number of nymphs from the same woods where the original adults were taken. They varied in length from 8 to 15 mm. and were about the same size as the ones that died. These passed the winter as nymphs although kept in a heated room. The first adult was recorded on March 30, 1948, which was about a month earlier than normal for the race. By April 15, several adults had appeared in the cage and by June 15 young started to appear. These nymphs grew as slowly as those of the previous year and by November 4, 1948, they were mostly about 15 mm. long. No adults had appeared by March 18, 1949. Most of this lot matured in April and May, thus completing two cycles of one generation per year and agreeing very closely with events in nature.

The song of the mountain cricket has been heard during every month from May to October. Field crickets do not live this long in the adult stage, so it is reasonable to assume the existence of two seasonal broods as in the northern states, but field observations for midsummer are lacking and we do not know whether there is a period between broods when adults are scarce or absent. Field observations have been more extensive in spring and early summer. At Glenville in the southern part of North Carolina at an elevation of about 3,500 feet, the mountain crickets did not start to sing before May. In April large nymphs were observed, but no adults. By June adult crickets were fairly numerous, and there are a large number of June records of the song in other parts of the mountains and in the piedmont areas inhabited by this race. After July 3, 1941, when adult crickets were noted as common in the northern North Carolina mountains, there are no more observations until August 16, 1950, when chirping crickets were very scarce near Hendersonville. On August 19, 1945, they were heard along the roadsides from Boone to Asheville. Other field records are September

9, 1948, and September 20, 1945, when numerous crickets were heard singing, both in the upper piedmont and in the mountains. The latest seasonal record is October 9, 1941, when the crickets were heard, but not in great numbers near Blowing Rock. By turning over loose rocks, two adult males were caught, but adults appeared to be less common than half grown nymphs.

A number of partial seasonal histories of the mountain cricket were obtained, over a period of years, by caging adult crickets collected in June. Five lots were collected at different points in the North Carolina Mountains and one lot from Gatlinburg, Tennessee. Young crickets started to hatch within 15 to 27 days after the adults were caged. All of the parents died in July or early August. With two lots no further observations were made. With two other lots, from Highlands and Weaverville, N. C., the young crickets were kept for a longer period but none of them matured by December. Under natural conditions they would all have hibernated as nymphs. The fifth lot, from the Blue Ridge Mountains east of Jefferson, N. C., had a small number of offspring which matured in September, although the great majority went into the winter as nymphs. All the early adults and a large number of nymphs were placed in an outdoor cage early in October. Both adults and nymphs were observed on November 4, but when the cage was opened the following April, only one nymph could be found. The others had died or escaped and it was not known whether the adults had deposited any eggs. The crickets from Tennessee also had a few offspring mature in September. Two pairs of these early adults were segregated on September 12 and kept in the laboratory. Their offspring started to appear on October 20. It is doubtful whether eggs deposited as late as these would hatch under natural conditions. The last two records suggest the possibility that a small proportion of the offspring of the spring brood adults may, under natural conditions, mature early enough to join the fall brood. Such individuals, however, did not appear numerous enough to account for the whole of the fall brood, but further investigation is needed to clear up the relationship of the two broods.

Only one attempt was made to rear any of the fall brood of adults from the mountains. A single pair, captured September 9, and caged September 11, died sometime in October. A large number of eggs were deposited, but after the adults died the cage was overlooked and the sand dried. Later it was discovered and kept moist and in the laboratory for the winter. Three young crickets were found on January 16 but no more appeared. If this female had deposited eggs on Grandfather Mountain, where she was captured, it is very probable that the eggs would have remained unhatched during the winter.

The mountain cricket was the most difficult to rear in the laboratory during the winter. Mortality was high and many developed stunted abnormal wings, especially the males. Some wings also appeared to have been chewed off by other crickets.

Evidence on the seasonal history of the beach cricket indicates that the adults are most abundant in late summer and fall and that the winter is passed mainly in the egg stage. The eggs hatch in spring and there is only one generation per year. A few individuals get out of step with the main population as shown by field notes on chirping males. In the vicinity of Carolina Beach, the earliest noted was May 13 when one cricket was heard. One or two crickets were heard on two occasions in June. Even in July only a few beach crickets have been heard.

On April 28, 1948, the only beach crickets that could be found near Carolina Beach were first or second instar nymphs. On July 23, 1947, a large number of medium sized and large nymphs

were found but only two adults, both males. On August 18, 1948, nymphs still outnumbered the adults but a considerable number of males could be heard singing. On October 20, 1948, only two nymphs were seen but a large number of adults were observed or captured, the females greatly outnumbering the males. At Cherry Grove Beach, South Carolina, on August 1, 1946, both large nymphs and adults were present, the former more abundant.

Rearing records of the beach cricket agree largely with what has been observed in the field, but show also that this race may be somewhat more plastic in its seasonal history and more readily influenced by changed conditions. Laboratory rearing started with two adult males and a number of nymphs collected on July 23, 1947. The first female adult appeared about August 20 and the last matured September 6. The last surviving adult, a female, died about October 31. Offspring appeared September 15 and again in December, February and April from the same lot of parents. The first adult cricket of the new generation matured on March 23, 1948. By April 17, several adults were present. These had been growing since September 15. Later hatched nymphs continued to mature until the last of July.

Under outdoor conditions there would have been no hatching in December or February, but eggs could have hatched in September or April when outdoor temperatures are high. If September nymphs could survive the winter, they probably would mature ahead of those hatching in April and might explain the few early summer adults heard singing on several occasions.

Another record was kept of the rearing of three small nymphs collected at Carolina Beach on June 10, 1948. The first adult (male) appeared on August 12 and the others, including one female, matured a little later. By October 20, no offspring had appeared and the jar containing the sand, with deposited eggs, was moved out of doors, where it remained all winter partly buried in the soil. Young crickets started to hatch on April

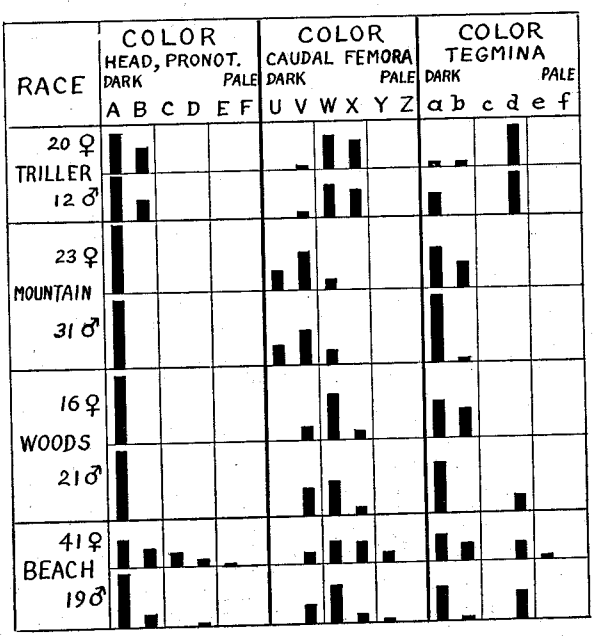

FIG. 2. Proportions of the four races of field crickets falling into the color classes of Rehn and Hebard.

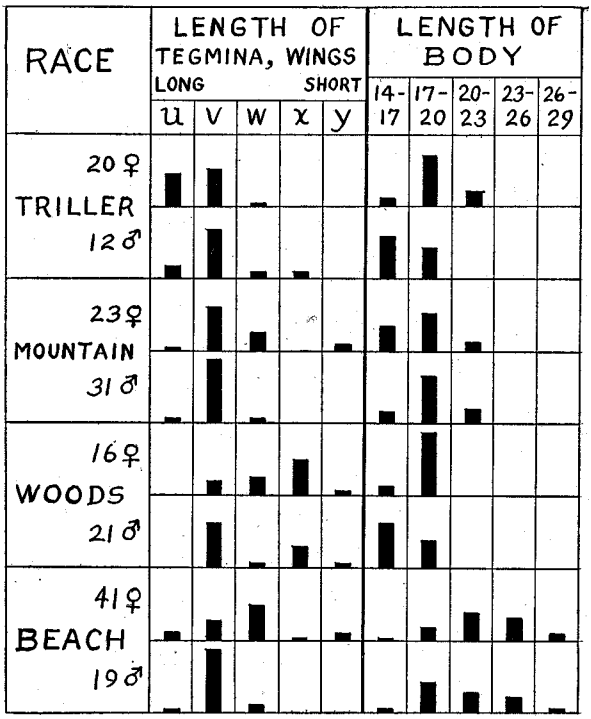

FIG. 3. Proportions of the four races of field crickets falling into the classes of Rehn and Hebard based on length of wings and tegmina; and five body length classes in millimeters.

21, 1949, and the first adult appeared July 25. The others matured in August and September. This rearing record agrees closely with observations in the field.

On October 20, 1948, two large females collected at Carolina Beach were caged in the same jar. They deposited eggs which hatched in the laboratory from February 24, 1949, until April. The duration of the egg state is shortened by being kept in a warm room in winter.

ANALYSIS OF THE RACES ACCORDING TO THE CLASSES OF REHN AND HEBARD

In order to find whether it would be possible to define the races of field crickets by visible characters the collections of specimens known to be of a certain race were analyzed according to the classes devised by Rehn and Hebard (1915). According to this scheme each specimen is given a set of five symbols according to the observer's personal interpretation of its place among the several defined classes of five different sets of characters. These classes will not be defined here except to name the characters and the complete range of variation.

A to F—Coloration of head and pronotum. Black to pale.

U to Z—Coloration of caudal femora. Black to buffy.

a to g—Coloration of tegmina. Unicolorous dark to unicolorous very pale.

u to z—Macropterism and brachypterism. Tegmina large, wings fully developed to tegmina (and wings) greatly reduced.

1 to 5—Length of body. Very large to very small. In place of Rehn and Hebard's symbols for body size, these five classes are here defined by length in

millimeters, starting with 14 to 17 and ending with 26 to 29.

The individual classes are defined by Rehn and Hebard in such terms as to permit considerable latitude in interpretation. It would be nearly impossible for two observers to analyze a series of specimens and come out with exactly the same set of symbols. If the same observer analyzed more than one series, however, he would tend to interpret each series by the same standards. Differences between series would then show up as differences in the symbols used.

After each specimen was given a set of 5 symbols the next step was to count the number of times each symbol was used for each race and determine the percentage of the collection falling into each class. This was done independently for each sex. The results are shown in figures 2 and 3. The height of the bars indicates the percentage of the total number of specimens falling in each class. A single tall bar means that all specimens of that race and sex are alike for that character. Several short bars indicates that the race exhibits great variability for that set of characters. The number of specimens examined for each race and sex is shown at the left. The number is small in some cases because only specimens known to be of a certain race could be used. Many had been reared in the laboratory.

The results show plainly that all four races have one or two classes in common for each group of characters. The differences between races are only differences in the percentage of the population falling into the various classes. No race is sufficiently well defined by any combination of characters to make it possible to identify most specimens. If the four collections were scrambled after removing the labels, it would be impossible for anyone to sort them out again, although a few specimens probably could be correctly placed, such as large pale specimens of the beach cricket.

Although the races cannot be defined in terms of visible characters, a few generalizations can be drawn. In the triller race, the largest class in the color of tegmina was interpreted as class d, "unicolorous, slightly pale." This is the most characteristic feature of the triller, but it does not hold true for all specimens and the beach cricket also has a rather large proportion in class d. The triller also has more long winged individuals than other races.

The mountain cricket has the least pale color on the caudal femora and is the only race in which solid black hind femora appear among the specimens examined. The tegmina average the darkest in the mountain cricket.

The woods cricket is very close to the mountain cricket in the color of the tegmina although a larger proportion of individuals show a wider reddish area on the caudal femora. No long winged forms were found among the 37 specimens of the woods cricket. This race also has a higher proportion than other races in class x "tegmina slightly reduced, wings very much reduced."

The beach cricket shows more variability in color, with a large proportion in the paler classes, although many dark individuals are also present. This race has the largest average size but is also represented by a few individuals in the smallest size class.

Crossing Experiments

Having discovered that there are four populations of field crickets in North Carolina the question arose as to how much racial interbreeding takes place in nature. There are times and places where the adults of different races may come in contact and where hybridization might possibly occur. Crossing experiments were planned to see whether hybrids could be produced by caged crickets.

The first crossing experiments were with the triller and the woods cricket, both being plentiful around Raleigh. Adult virgin females of both races were obtained by segregating female nymphs

which are easily recognized in the later stages by the protruding ovipositor. After the virgin females matured they were paired with known adult males in glass jars containing moist sand. They were provided with food and water until they died. The sand was kept moist for periods varying from 7 weeks to 4 months to give the eggs a chance to hatch if they were viable. Usually one female of each lot was paired with a male of her own race. Such pairs produced offspring after periods varying from 13 days to about a month depending mainly on the age of the female at the time of pairing.

No offspring were obtained from a total of 19 crosses of the triller and the woods cricket. Later the experiments were extended to include all four races by pairing one or both sexes of each race with the opposite sex of the other three races. The results are shown in figure 4. A total of 50 attempts to hybridize different races gave negative results. On the other hand, out of 25 cases where a cricket was paired with its own race, only two failed to produce offspring. In one of these the male apparently failed to inseminate the female, as revealed by post-mortem examination of the spermatheca. In the other case both sexes were defective specimens, entirely lacking tegmina and wings, from an overcrowded cage.

In several of the matings where a triller was paired with its own race, the male and female were from widely separated localities in North Carolina. Raleigh trillers were paired with trillers from near Wilmington, Lake Waccamaw and Swanquarter and all produced offspring. Offspring were also obtained when a North Carolina triller was paired with a descendant of a female cricket from Panama City, Fla., whose sons sang with the trilling song.

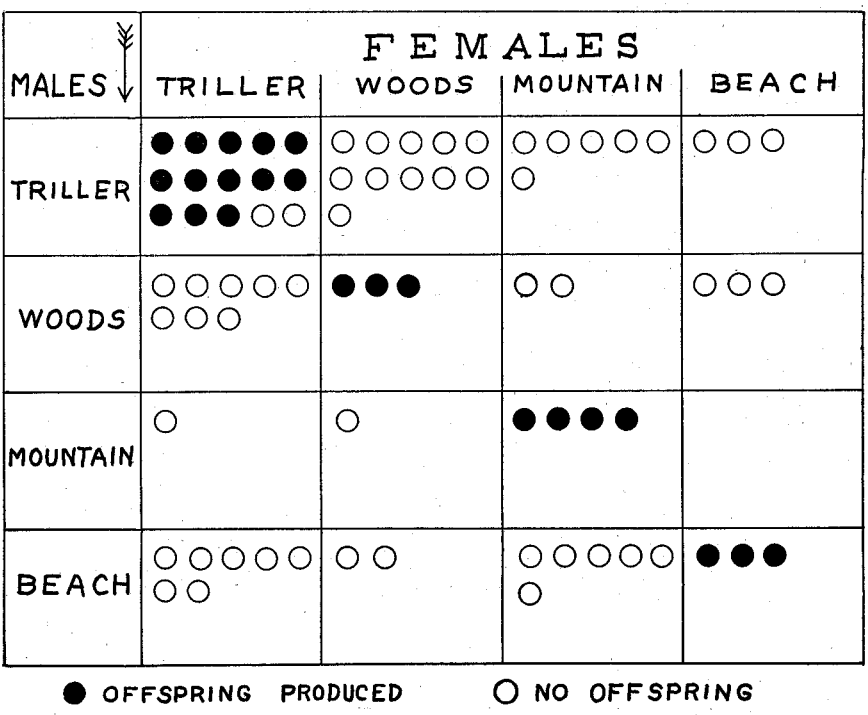

FIG. 4. Results from segregated pairs of field crickets of four races. Each pair is represented by a circle, solid black if offspring were produced and white if no offspring were produced.

In another series of experiments, seven males were given a choice of mating with a female of their own race or of some other race. Each male was confined with two marked virgin females. The females were killed after several days and their spermathecas were examined. In three cases the female belonging to the same race as the male had sperms while the other female had no sperms. In one case the female of the same race had sperms but the other female had been devoured. In the three other cages no sperms were found in either of the females. The result of these experiments as well as the observed behavior of certain males, suggest that the males may show some preference for females of their own kind. Such psychological isolation, if it exists at all, is not strong enough to prevent a male from mating with a female of another race when not given any other choice. In four instances females were observed with a spermatophore which came from a male of another race. Three females, which were paired with a male of another race, were killed and dissected for evidence of insemination. All of them had sperms in the spermatheca.

The failure to produce hybrids by crosses of different ecological races of field crickets apparently is not due to lack of insemination nor is it due to a failure to produce and deposit eggs. Virgin females and females confined with males of another race usually deposited a few eggs but seldom more than a hundred. The bodies of such females usually became more distended with eggs than females paired with their own race. One virgin beach female had 975 fully developed eggs in her ovaries.

The foregoing experiments and observations may not be extensive enough to prove that hybridization between races of field crickets never occurs, but at least they show a high degree of reproductive isolation due to a failure of the eggs to become fertilized by sperms of another race or to a failure to produce a viable zygote.

It is probably useless to speculate on the origin of the field cricket races. Ecological conditions must have changed greatly from the wilderness habitats in which the crickets evolved. The triller, woods cricket and beach cricket are evidently isolated from each other by habitat. It is not unreasonable to assume that the original isolation was along ecological lines. The mountain cricket and the triller, however, both occur in fields in the central and western piedmont. Rather limited observations in this region show the triller to be more partial to grass than the mountain cricket which is most often heard singing in weedy fields. The mountain cricket may prove to be a northern geographical race.

The evidence presented in this paper seems to show a degree of reproductive isolation between the four races of field crickets as complete as between true species. Speciation has not proceeded along morphological lines to the point where the races can be identified by visible characters. The writer does not believe that anything is to be gained at the present time by giving the races scientific species names. Old names formerly used would still be available and any attempt to identify them with the races as here defined would lead to as much confusion as former attempts to split the American field crickets into species. Until the number and distribution of such races is better known over a wider area, it is better to use the proposed nicknames, which are not subject to the rules of nomenclature.

Summary

Early attempts to split the genus *Acheta* (*Gryllus*) into species resulted in much confusion. The works of Lutz (1908) and Rehn and Hebard (1915) showed that the characters used for separating the indigenous New World species were too variable to be of any value. All species were reduced to synonyms

under the oldest valid name, *A. assimilis* Fab.

The present study shows that this is an over-simplification and that *A. assimilis* does not conform to the present day concept of a species as an interbreeding population. Even within the limits of the state of North Carolina, four races or populations have been recognized, which differ by such characters as song, seasonal history and choice of habitat.

A study of certain color and structural characters showed some statistical difference between races, but no visible character or combination of characters was found which would make it possible to identify specimens.

When males and virgin females of different races were paired, mating occurred and eggs were laid but no offspring appeared. A total of 50 attempts to hybridize different races all gave negative results. Pairs of the same race rarely failed to produce offspring. Some intrinsic isolating mechanism apparently exists, which prevents fertilization or the formation of a viable zygote.

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