# ANTAGONISTIC RELATIONSHIPS BETWEEN ANTS AND WILDLIFE WITH SPECIAL REFERENCE TO IMPORTED FIRE ANTS AND BOBWHITE QUAIL IN THE SOUTHEAST [1]

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## ABSTRACT

Nesting studies with penned quail were conducted during the summers of 1960 and 1961 in Lee County, Alabama. Approximately 30 hatches were obtained in close proximity to imported fire ant *(Solenopsis saevissima richteri* Forel) mounds. These were carefully observed for any instance of annoyance or predation by the ants. Similar observations were made on four cotton rat litters. A small number of nests of various species of wildlife occurring naturally near ant colonies were observed. Observations were also made on pipping and newly hatched chicks placed about imported fire ant mounds. Data was gathered incidentally on the following other ant species:

1. *Iridomyrmex humilis* Mayr
2. *Iridomyrmex pruinosus* (Rog.)
3. *Dorymyrmex pyramicus flavus* McCook
4. *Formica schaufussi* Mayr

Little damage to hatching chicks and newborn rats and mice was observed.

Twenty years of census data and ecological observations were used in making a comparison of quail populations on a sample area before and after invasion by imported fire ants. The implications of 7 years of statewide reproductive data from quail wing returns are also considered.

It is concluded that the ant species on which observations were made in this study are of little importance as predators on quail and cotton rats, and that the invasion by the imported fire ant has had little if any effect on total quail populations.

## INTRODUCTION

Past reports of destruction of hatching young birds by various species of ants have indicated that species of the genus *Solenopsis* were especially inclined to be destructive. Recent extensions in the range of the imported fire ant, *Solenopsis saevissima richteri* Forel, which was introduced near Mobile, Alabama about 1920, have revived interest in the question of ant predation on wildlife. Little was known of the ecology of this introduced species. The fact that it reaches such tremendously high population levels immediately following invasion in some areas resulted in concern on the part of some biologists that this invader might do considerable damage to native wildlife, particularly to the bobwhite quail.

Recent studies have shown that fall quail population density and percentage of juveniles in the hunters' bag bear a significant correlation to summer rainfall and temperature (Speake and Haugen, 1960, and Reid and Goodrum, 1960). Results of these and other studies indicate that, at least during some years, the degree of success of summer production is the major factor determining fall population density. Therefore, ant predation, or any other factor tending to lower annual production, might be serious during years in which unfavorable weather conditions occur during the nesting season.

The present study, therefore, was undertaken in an attempt to provide some contribution toward a knowledge and understanding of the ecological reactions resulting from the invasion of the imported fire ant. The general problem at hand was to determine any antagonistic relationships between the imported fire ant and wildlife species in general and to evaluate the net effect of this invasion on the vertebrate fauna of the area.

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More specifically, the objectives of the study were to determine the following:

1. the incidence of predation by imported fire ants on pipping chicks and newborn mammals,
2. the importance of the ants as a disturbing element on incubating birds, and
3. net effects of the ants on annual production and fall population density of wildlife species.

During the course of the study, it was recognized that other species of ants, notably the Argentine ant, *Iridoxyrmex humilis* Mayr, and a similar, related ant, *I. pruinosus* (Rog.), were also potentially destructive. Therefore information on these and other species of ants prominent on the area was collected incidentally as the opportunity was presented.

*History of the Problem and Review of the Literature*

Many popular and scientific articles published in the last 50 years have contained reports and statements concerning damage done to wildlife by various species of ants. Yet there has been very little reliable scientific data published on the question. The only serious studies of ant predation encountered in reviewing the literature are those of Stoddard and Travis (Rohwer, 1958; Stoddard, 1931:193-194; and Travis, 1938 a,b). In these studies losses of hatching quail to native species of fire ants *(Solenopsis molesta* and *S. geminata)* were reported.

The native fire ants were said to enter the pipped eggs at hatching time to eat the chicks. If an egg became cracked in any way, these ants swarmed into the nest, overwhelming the incubating bird and causing abandonment (Stoddard, *loc. cit.*). A 15.4 per cent loss of nests from these ants was observed one year in spite of an intensive control program (Travis, 1938a). Captive adult birds as well as newly hatched chicks in brooders were also reported to have been killed and eaten by native fire ants (Stoddard, 1931:194, 436 and Travis, 1938 a, b.).

Travis (1938b) also reported that the fire ants competed with quail for food by accumulating large stores of seed in their mounds.

The decline in numbers of certain ground-nesting birds, specifically the ground dove, in northwestern Florida was attributed to the presence of native fire ants by Travis (1938a). Later, Wheeler (1958) quoting an article by M. D. Bellomy [2] attributed this decline to "fire ants" without making clear to which species he was referring.

The significance of the effects of this destruction on the total quail population has been questioned because peak fire ant populations of the early 1930's were coincident with very high quail populations (George, 1958:8). It was during this period that the highest percentages of nests destroyed were observed. Stoddard maintained that high quail populations were obtained in spite of the heavy losses to ants because of exceptionally favorable breeding seasons during those years (Rohwer, 1958).

Prior to the work of Stoddard and Travis, Newell and Barber (1913: 22-25) reported that the Argentine ant was a serious pest in poultry yards, driving incubating hens from the nest and killing the chicks. This destruction was reported to occur among many species of birds, and "the number of young birds destroyed in this manner must be considerable". Records of human babies in cradles becoming covered with the ants, and possibly even being killed by the ants, were reported by these authors. Reports concerning destruction of birds' nests by Argentine ants were also mentioned by Smith (1936:4).

Gorsuch (1934) reported the destruction of nests of Gambel and scaled quail *(Lophortyx gambeli* and *Callipepla Squamata pallida)* by unidentified ant species in Arizona. One incident is described as follows: ". . . a nest of scaled quail was invaded when incubation was half completed. In an attempt to save the nest, the hen ate ants as fast as they approached until she died, possibly from formic acid poisoning; the carcass was quickly cleaned of meat and viscera, and several of the eggs were destroyed. How the egg shell is penetrated by these insects is not known, but it sometimes does take place. . . ." Species of *Solenopsis* have been reorted to be destructive to valley quail *(Lophortyx californica*

[2] "Frontiers" magazine; April, 1955.

*vallicola)* and California quail *(Lophortyx californica californica)* (Emlen, 1938; Emlen and Glading, 1945:45-46).

Graham (1937) made a survey of southern Alabama to observe concentrations of various fire ant species in relation to quail habitat. It was concluded that fire ants did not generally occur in sufficiently heavy concentrations on good quail habitat in southern Alabama at that time to be a serious problem.

In a study of 680 mourning dove nests in Alabama, Moore (1940) observed two nests invaded by unidentified ants. One was invaded during hatching, and the other at about 5 and 6 days after hatching.

Shillinger and Morley (1942) listed ants, specifically *Solenopsis molesta*, as being very destructive to quail in the Southeastern States.

Lehmann (1946) reported killing of chicks by fire ants *(Solenopsis* sp.) in 12 of 194 bobwhite nests under study in southwestern Texas.

Allen and Nice (1952) listed *Solenopsis* ants among mortality factors in bluebirds.

Fitch[3] observed a bobwhite nest near Auburn, Alabama in which one chick was eaten by unidentified ants. Speake[4] observed three nestling cottontail rabbits being stung to death by *Solenopsis geminata* also near Auburn. Two of these baby rabbits had only been dead a short time when observed, and their bodies were covered with inflamed areas caused by the ant stings. A third nestling had also been stung a number of times, and it died a short time later.

During the 1950's the imported fire ant suddenly began to spread rapidly over large areas of the Southeast with extremely high degrees of infestation being common during the first 2 or 3 years following invasion. Interest in the question of ant-wildlife relations was renewed, and the possibility arose that the imported fire ant might adversely affect wildlife populations.

The only reported study of the effects of the imported fire ant on game animals is that of Wilson and Eads (1949), which consisted primarily of personal interviews. About 50 persons interviewed said they had seen wildlife destroyed by imported fire ants. Species attacked included quail, mourning doves, songbirds (especially bluebirds and meadowlarks), wild turkeys, rabbits, squirrels, and mallard ducks. In addition observations were made of three birds' nests near fire ant mounds. One hatched successfully, and the other two had been destroyed and appeared to have been partially eaten by ants. It was not known if the young birds had been killed by the ants, however.

Bruce, *et. al.* (1949) speculated on the damage by the imported fire ant to wildlife and domestic animals. Although some destruction by these ants was accepted, the possibility was mentioned that some other factor was often the primary cause of death. The importance of any damage to hatching chicks on total populations was questioned.

Following these two reports came numerous popular articles and several technical reports in which mention was made of the damage done to wildlife by the imported fire ant. Quail were considered by these writers to be the most vulnerable and most seriously affected species of wildlife, and Burgess (1958) estimated that up to 50 per cent of hatching birds may be destroyed by the ants. However numerous other species of birds and mammals were also mentioned in these discussions. Rabbits and squirrels were among the mammals most commonly mentioned (Mannix, 1958; U.S.D.A., 1958 b). Muskrats were said to have been driven from their houses in Gulf Coast marshes, and trapping was said to be ruined in those areas (Mannix, 1958; Burgess, 1958).

Large animals including domestic livestock were also reported killed (Mannix, *op. cit.;* Lyle and Fortune, 1948; U.S.D.A., 1954), and sheep producers were reported to have been driven out of business because fire ants took such a heavy toll of newborn lambs (U.S.D.A., 1958b).

The only published report of an actually observed case of imported fire ant damage to wildlife is that of a quail nest observed in 1951 in Mobile County, Alabama by a U. S. Department of Agriculture worker. Four chicks that had pipped their shells were reported destroyed by the ants. Nine chicks hatched were unharmed (U.S.D.A., 1958a).

[3] Observation made by Frank W. Fitch, photograph of nest on file at Wildlife Research Unit, Auburn, Alabama.

[4] Daniel W. Speake, personal communication.

Stoddard expressed concern that the imported fire ant might prove to be much more destructive than the native fire ant and that it may "prove to be the greatest threat to quail shooting that ever developed" (Stoddard, 1958 a, b). However Stoddard objected to the application to the imported fire ant of data from studies of the native fire ant (Stoddard, 1958b).

Others (George, 1958; Arant, *et. al.*, 1958; and Baker, 1958) have expressed doubts as to the importance of the imported fire ant as a factor affecting wildlife populations.

Recently several newspapers have reported extensive fish kills supposedly resulting from fish feeding on ants (Lee, 1960, and others). Results of laboratory experiments to determine the effects of feeding fire ants to fish have been reported by Green and Hutchins (1960) and by Prather (1960).

## PROCEDURE

A broad approach to the problem was adopted in an attempt to obtain fairly independent, unrelated results that could be compared with reasonable assurance that the same variables would not be influencing the results from the different approaches.

The procedure followed in this study was generally along two main lines of approach.

The first approach involved direct observations on ant predation.

Two seasons of reproduction studies were conducted with penned animals placed near colonies of imported fire ants and other ant species. The information obtained from this work is supplemented with records from a small number of birds' nests naturally occurring near ant colonies. Information was also gathered by placing pipping eggs near imported fire ant mounds.

The second approach involved studies of the net effects of the imported fire ant invasion on fall quail populations.

Previously collected data on statewide reproduction over a period of 7 years were analyzed and compared with imported fire ant distribution during this period.

Census data and ecological observations collected on a small area over a period of 20 years were utilized in comparing quail populations on an area before and after its invasion by imported fire ants.

Original plans included census work on selected areas for comparison of wildlife populations on fire ant-infested areas with those on areas not infested. These plans were abandoned after selected check areas were invaded by fire ants.

Ants were sent to a specialist, Dr. M. R. Smith of the United States Department of Agriculture, for positive identification.

## DIRECT OBSERVATIONS ON ANT PREDATION

*Experiments with Penned Animals*

Observations were made during spring and summer of 1960 and 1961 on reproduction of birds and mammals in pens located in natural cover near imported fire ant mounds. This work was done near Auburn, in Lee County, Alabama. The objective was to observe the incidence of predation by fire ants on hatching chicks and newborn mammals under conditions of forced proximity to ants.

Bobwhite quail, cottontail rabbits, and cotton rats were selected as representative species whose habitat requirements are similar to those of the imported fire ant. Importance as game animals, abundance, and previous references in the literature of destruction by ants, were factors in the selection of quail and rabbits for study. Cotton rats were chosen because of their suitability and availability for pen work and their importance as an ecological component of the type community in which fire ants and important small game animals are most abundant. Their use would also provide a comparison of the incidence of ant predation on precocial young with predation on the naked, helpless young of rabbits. Unfortunately, however, no reproduction of rabbits was obtained.

*Bobwhite quail.*—Data for all quail nests on which observations were made and on nearby ant colonies are included in Table I. Each quail nest was assigned a number to simplify reference in the text. Nests 1, 6, and 30 were observed under natural conditions and are discussed in a separate section of this paper.

During the 2-year period, 33 nests in which incubation was completed and eggs were pipped were obtained in the pens. Twenty-nine of these nests were located in an imported fire ant-infested area, and four were in an area heavily infested with Argentine ants. Low hatchability and low fertility of eggs limited the value of some nests.

TABLE I.

ANT DESTRUCTION OF PIPPING CHICKS IN QUAIL NESTS UNDER OBSERVATION AND DISTRIBUTION OF IMPORTED FIRE ANT MOUNDS ABOUT THESE NESTS.

| *Nest No.* | *No. eggs pipped* | *No. successfully hatched* | *Percent hatchability of fertile eggs* | *Eaten by ants* [1] | *Nearest fire ant mound* | *No. of mounds in 60 ft. radius* |
|---|---|---|---|---|---|---|
| *Normal hatches occurring under favorable weather conditions:* | | | | | | |
| 1[2] | 14 | 14 | 100 | 0 | 21 ft. | 10 |
| 2 | 5 | 5 | 100 | 0 | 26 ft. | 8 |
| 3 | 5 | 4 | 80 | 0 | 28 ft. | 3 |
| 4 | 1 | 1 | 100 | 0 | 19 ft. | 5 |
| 6[2] | 12 | 12 | 100 | 0 | 67 ft. | 0 |
| 10 | 9 | 9 | 100 | 0 | [3] | [3] |
| 11 | 9 | 9 | 100 | 0 | [3] | [3] |
| 12 | 12 | 12 | 100 | 0 | 2 ft. 2 in. | 10 |
| 13 | 11 | 10 | 91 | 0 | 11 ft. | 6 |
| 14 | 12 | 11 | 92 | 1 | 3 ft. 6 in. | 7 |
| 15 | 3 | 3 | 75 | 0 | 32 ft. | 8 |
| 16 | 10 | 9 | 90 | 1 | 9 ft. 2 in. | 2 |
| 17 | 12 | 12 | 100 | 0 | 2 ft. 10 in. | 3 |
| 22 | 11 | 11 | 100 | 0 | 13 ft. | 4 |
| 23 | 9 | 8 | 90 | 0 | 10 ft. | 4 |
| 24 | 12 | 11 | 92 | 1 | 11 ft. | 1 |
| 26 | 9 | 9 | 100 | 0 | 12 ft. | 5 |
| 30[2] | 7 | 7 | 100 | 0 | 5 ft. | 16 |
| 33 | 3 | 3 | 75 | 0 | 6 ft. 8 in. | 4 |
| 34 | 3 | 3 | 75 | 0 | 4 ft. | 1 |
| 35 | 7 | 7 | 87 | 0 | 6 ft. 10 in. | 4 |
| | | | (av.) 92.7 | 0 | | |
| *Deserted nests* | | | | | | |
| 19 | 1 | 0 | 0 | 0 | 2 ft. 10 in. | 3 |
| 25 | 3 | 0 | 0 | 3 | 2 ft. 10 in. | 3 |
| *Irregular hatches and hatches following periods of drought* | | | | | | |
| 5 | 5 | 5 | 100 | 0 | 1 ft. 8 in. | 4 |
| 7 | 3 | 2 | 66 | 1[4] | [3] | [3] |
| 8 | 4 | 2 | 29 | 2[4] | [3] | [3] |
| 9 | 9 | 9 | 100 | 0 | 24 ft. | 8 |
| 18 | 3 | 1 | 9 | 0 | 21 ft. | 4 |
| 20 | 5 | 1 | 8 | 1 | 10 ft. | 4 |
| 21 | 5 | 3 | 21 | 1[5] | 32 ft. | 8 |
| 27 | 4 | 3 | 30 | 1 | 32 ft. | 8 |
| 28 | 6 | 3 | 43 | 3 | 11 ft. | 6 |
| 29 | 6 | 4 | 50 | 2 | 6 ft. 3 in. | 7 |
| 31 | 5 | 3 | 61 | 1 | 9 ft. 1 in. | 5 |
| 32 | 5 | 5 | 100 | 0 | 10 ft. | 2 |
| 36 | 2 | 1 | 50 | 1 | 29 ft. | 3 |
| Totals | 242 | 212 | (av.) 60.6 | 19 | | |

[1] Imported fire ants unless otherwise indicated.
[2] Wild nests observed in the field.
[3] No fire ants in area; Argentine ants only.
[4] Argentine ants.
[5] Ant species not yet identified.

Of 242 eggs pipped in these nests 19, or about 8 per cent, were eaten by ants. Fifteen were eaten by imported fire ants, and 4 were eaten by ants of other species. Hatches in which 16 of these 19 eggs were included occurred under conditions unfavorable for hatching, and hatchability was low. These unfavorable conditions included desertion of the nest by the parents, periods of drought preceding the hatching date, and irregularity in time of hatching.

In the 29 nests observed on the fire ant-infested area, there were 27 in which at least one chick hatched successfully. The remaining two nests were deserted. Although some chicks pipped the shell in these two nests, none hatched successfully. A total of 184 eggs were pipped; 157 of these hatched successfully. Twenty-seven chicks pipped, but either did not hatch or hatched but did not survive to leave the nest with the brood. Of these 27 chicks 15 in 10 nests were covered with fire ants when first observed. This was 8.2 per cent of the total number of chicks pipping. In no case were more than three chicks in a nest eaten by ants. Of the remaining 12 chicks, 11 pipped but died in the shell. These chicks were all vulnerable to ants, and most of them later became covered with ants.

It is not known how many of the chicks on which fire ants were observed may have died before the ants arrived. It is quite possible that this was the case with all of these chicks, since it was impossible to determine in advance the exact hatching time of the chicks. In some cases as much as 18 hours may have elapsed between hatching and time of first observation.

Half of the hatching chicks that were covered with ants had been removed from the nest by the parent bird and carried several feet away. An infertile egg which had become broken in one of the nests was removed in this manner and, when observed, was covered with fire ants. It is not known if the ants were attracted to the eggs and chicks before or after they were removed from the nest. At least one pipped egg was known to have been removed by the adult before the ants were attracted to it, although a dead chick, that appeared to have also been removed from the nest, lay covered with ants nearby when first observed. No ants were found in the nests from which these chicks and eggs were removed.

In five cases dead chicks were found covered with ants within the nest. In three of these (nests 14, 24, and 27), only one dead chick was found in each nest, and a total of 25 chicks hatched successfully. This indicates that the attacked chicks were weak or late hatching and that the ants were probably attracted to them after the broods had left the nests.

In a fourth nest (28) three chicks hatched successfully, and three were eaten by ants. It could not be determined whether the ants had killed these chicks.

The remaining nest (25) had been abandoned by the parent bird, and only three chicks pipped. These were all eaten by fire ants. In this case the ants were in the nest in fairly large numbers while at least two of the chicks were still alive in the shell. It seems likely that these chicks were killed by the ants.

In every case all hatchable eggs hatched, and no case was observed in which the incubating bird was driven from the nest by fire ants. No ants were ever observed in a nest when the parent bird was incubating. After the hatches were completed and the broods had left the nests. partially incubated eggs were broken in several of the nests. Fire ants were usually attracted within a few minutes.

No correlation was apparent between ant destruction and distance of ant colonies within a 60-foot radius of the quail nests.

Eight nests, with a total of 54 chicks hatching, were completed at less than 5 feet from imported fire ant mounds. Only four chicks were eaten by fire ants in these eight nests. Three of these were in a deserted nest. Successful hatches were obtained at 20 and 26 inches from imported fire ant mounds (nests 5 and 12) without disturbance by ants, and a total of 17 chicks hatched successfully.

Another eight nests were located at distances of 5 to 10 feet from fire ant mounds. A total of 50 chicks pipped in these nests; 40 hatched successfully, and 5 were eaten by fire ants.

The remaining 17 nests in the pens were at distances of 10 to 32 feet from fire ant mounds. Of 119 chicks pipping in these nests, 108 hatched successfully, 6 were eaten by imported fire ants and one was eaten by ants of a species not yet identified.

One nest (17) was observed in which fire ants were in the nest during hatching. Eggs from an incubator had been substituted for those in the nest; this was sometimes done in an attempt to assure a good hatch. Following this disturbance, the cock deserted the nest. The eggs com-

pleted incubation in the heat of the sun and began hatching at noon of the 24th day. By 3 p.m. most of the eggs were pipped, and at 4:20 p.m. about a dozen fire ants were observed in the nest. One egg, which had been pipped about one-third of the way around, was examined, and several fire ants ran out of the pip hole; others could be seen inside. The chick was still alive. At 5 p.m. the cock was back on the nest, the broodiness instinct apparently having been stimulated by the peeping of the chicks plainly audible in the shells. There were no ants in the nest at this time. By 11 p.m. 12 chicks had hatched successfully, including the one on which the ants had been observed. Apparently the cock had eaten the ants or had driven them from the nest.

One chick that was eaten by fire ants (nest no. 20) had been observed alive earlier, but it was trapped in the shell by the membrane, which had shrunken and dried in the hot sun. This chick had been moved from the nest by the hen when it was next observed, dead and covered with ants. Three more eggs in which the chicks were trapped remained in the nest. The hen continued to incubate the nest for another 24 hours, and the ants did not disturb the nest until she left it. One of the trapped chicks remained alive in the shell for 10 hours or more.

During 1960 studies five pens were placed in an area free of imported fire ants. These were intended to be used as a check on nesting behavior. It was later discovered that the area was very heavily infested with Argentine ants. Four hatches subsequently occurring on this area resulted in some interesting observations on the effects of Argentine ants on hatching of quail.

The first two successful nests on this area became infested with Argentine ants following hatching, and several pipping chicks were eaten. In nest no. 7, the first to hatch, two chicks successfully hatched. When the nest was first observed following hatching, it was covered with a tremendous number of Argentine ants, and one egg that had been pipped was filled with the ants.

Hatching was very irregular in the second nest (8). After hatching a single chick, the cock continued incubation, and 4 days later the remaining fertile eggs were pipped. At 9 a.m. the cock was on the nest, and a single chick had hatched. When the nest was checked again at 2 p.m., it was found to be covered with Argentine ants and two pipped eggs were filled with the ants. Superficially it appeared that the tremendous number of ants had overwhelmed the incubating cock, forced him from the nest and poured into the nest to kill and eat the pipping chicks.

Later examination revealed three of the remaining unpipped eggs to contain well developed chicks. Unfortunately the eggs were not opened and examined until about 24 hours after the nest was deserted, and it was not definitely determined whether the chicks were alive when the cock left the nest. However observations made later on other nests demonstrated that chicks in abandoned eggs may still pip and hatch after being deserted for a week. Had the chicks in these shells been alive, they would undoubtedly have pipped the shell, even though the cock may have left the nest.

In nest no. 8 it seems likely that the chicks were killed, or were so weakened that they could not escape the pipped shell, by a prolonged hot, dry period preceding hatching, and that the ants filled the nest after the cock had left it. Official air temperatures the preceding day had reached 94° F. The nest was unshaded and exposed to the direct rays of the sun. Under these conditions temperatures at the nest probably exceeded 120° F. Earlier in the season nine embryos at about 12 days of development in a nest similarly located appeared to have been killed by a long dry period with gradually increasing air temperatures that finally reached 98° F., on the day the developing chicks died.

The hypothesis that drought was the primary cause of death of the chicks rather than attack by ants is strengthened by the fact that later, following more favorable weather conditions, two more hatches (10 and 11) were obtained in the same area with no ant damage whatever. The entire area was covered with foraging Argentine ants, many of which were in both nests during hatching. One nest (10) was built directly on top of the mound housing the Argentine ant colony. Eighteen of the

20 eggs in the two nests hatched successfully. The remaining 2 eggs were infertile.

A successful hatch of six wild turkeys occurred on the area in pens being used for another study. One poult that had apparently been mashed and killed during hatching attracted a large number of Argentine ants to the nest after the hen and her brood had left. Another poult that had pipped but could not get out of the shell unassisted remained alive in the nest for some time unmolested by the ants feeding on the mashed bird. Had this weak poult not been finally removed from the shell by hand, it would later have been eaten by the ants, and the remaining evidence could easily have been misinterpreted in later observations.

The following is a list of ant species other than imported fire ants which were observed in the vicinity of successful quail nests:

| | |
|---|---|
| *Iridomyrmex humilis* Mayr— | very numerous near nests 7, 8, 10, and 11. Nest number 10 was located directly on top of a colony of these ants. |
| *Iridomyrmex pruinosus* (Rog.)— | very numerous about nests 13, 26, and 28. |
| *Dorymyrmex pyramicus flavus* McCook— | very numerous about nests 13, 26, 28, and 29. |
| *Formica schaufussi* Mayr— | nest number 16—colony at 32 feet; nests 20 and 23—colonies at 13 and 14 feet; nest number 31—colonies at 52 and 54 feet. |

About 12 very small, unidentified, yellow ants were found with imported fire ants inside one egg shell feeding on the chick (nest no. 29).

*Small mammals.*—Cottontail rabbits were live-trapped and placed in pens for study during February and March, 1961. Shortly after the rabbits were placed in the pens, all except two pairs were destroyed by wild dogs which succeeded in tearing into the pens. The remaining two pairs of rabbits failed to reproduce. Studies with penned rabbits were then abandoned because of the difficulties of live-trapping rabbits in late spring.

Studies with cotton rats were more successful. Live-trapped rats were placed in small pens located near imported fire ant mounds. After early losses to dogs and the loss of one pen to thieves, four litters of rats were born in the pens. In each case the nest in which the young were born was quite close to imported fire ant mounds, and a number of other mounds were nearby. Two litters were born only 9 inches from a large, functioning imported fire ant mound. No evidence of attack or

TABLE II.

LITTERS OF SMALL MAMMALS BORN IN THE VICINITY OF ANT COLONIES

| *Litter No.* | *No. in litter* | *No. eaten by ants* | *Ant species and distances of colonies from nests in which young were born.*[1] |
|---|---|---|---|
| 1.[2] | 4 | 0 | *Iridomyrmex humilis:* (very numerous) |
| 2.[3] | 7 | 0 | *Solenopsis saevissima richteri:* 9 in. 34 ft. 34 ft. 35 ft. 45 ft. 51 ft. |
| 3.[3] | 5 | 0 | *Dorymyrmex pyramicus flavus:* (very numerous)<br>*S. s. richteri:* 3 ft. 8 in. 8 ft. 2 in. 11 ft. 22 ft. 24 ft. 27 ft. 33 ft. 41 ft. 42 ft. 42 ft. 43 ft. 54 ft. 59 ft. |
| 4.[3] | 6 | 0 | *S. s. richteri:* 9 in. 8 ft. 6 in. 9 ft. 3 in. 10 ft. 34 ft. 34 ft. 35 ft. 45 ft. 51 ft. |
| 5.[3] | 3 | 0 | *D. p. flavus:* (scattered colonies)<br>*S. s. richteri:* 8 ft. 6 in. 9 ft. 3 in. 22 ft. 23 ft. 27 ft. 38 ft. 38 ft. 40 ft. 42 ft. 42 ft. 44 ft. 51 ft. |

[1] Measurements were made from the middle of the rat nest to the nearest edge of all functioning fire ant mounds within a 60-foot radius of the nest. Distances of less than 10 feet were measured to the nearest inch, and those 10 feet or beyond were measured to the nearest foot.

[2] Peromyscus sp.

[3] Sigmodon hispidus.

molestation by ants was observed. All young rats survived in apparently good health for as long as they were allowed to remain in the pens.

An incidental observation was made on the successful birth of a litter of *Peromyscus* sp. in one of the quail pens in which Argentine ants had eaten several pipped eggs during the previous season (nest no. 8). Although the Argentine ants were active and extremely numerous about the nest, no harm was done to the young mice.

Information on all births of small mammals and on nearby ant colonies is summarized in Table II.

*Observations on Birds' Nests Naturally Occurring Near Ant Colonies*

Data on wild birds' nests were collected only incidentally. Several nests under observation were destroyed by vertebrate predators before time for the eggs to hatch. Five nests were observed in which chicks hatched near imported fire ant mounds, and one group of eggs hatched in an area where Argentine ants were particularly abundant. Data on three quail nests are included in Table I as nests, 1, 6, and 30. Quail nest no. 1 was observed in Escambia County, Alabama, and quail nest no. 30 was observed near Gulfport in Harrison County, Mississippi. All other nests were observed in Lee County, Alabama. Information on nests of birds other than quail is summarized in Table III.

All nests were 100 per cent successful. Imported fire ants were seen foraging over the empty shells in quail nest no. 6 after the brood had left the nest; otherwise no ant activity was observed about the nests.

*Observations on Pipping and Newly Hatched Quail Chicks Placed Near Imported Fire Ant Mounds*

Six bobwhite chicks, which were too weak to pip, were removed from the shell by hand and used in a series of observations. These chicks were all too weak to stand or to hold up their heads. They were still thoroughly wet, and remnants of the embryonic tissue clung to their down. In this condition the chicks were placed on the ground, lying in the fluids from the egg with the empty shell beside them. Three of these were placed among foraging imported fire ants, two directly beside the mound and one at about 10 feet from the mound.

The chick at 10 feet was found by several imported fire ants within a few minutes, but it was about 10 minutes before a large number of ants gathered. A number of *Dorymyrmex pyramicus* and *Formica schaufussi* were also foraging about the scene. Most of the fire ants that had been attracted foraged about on the ground cleaning up the

TABLE III.

BIRDS' NESTS [1] SUCCESSFULLY HATCHED UNDER NATURAL CONDITIONS NEAR ANT COLONIES

| *Species* | *No. of chicks hatching* | *No. of chicks eaten by ants* | *Height of nest above ground (feet)* | *Ant species and distances of colonies from base of tree or bush containing nest (feet).* |
|---|---|---|---|---|
| Cardinal | 4 | 0 | 8 | *Iridomyrmex humilis*—8, 9, 13 |
| Sparrow (unidentified species) | 3 | 0 | 3 | *Solenopsis saevissima richteri*—28, 30, 31. *Dorymyrmex pyramicus flavus* and *Iridomyrmex pruinosus*—(numerous colonies) |
| Mourning dove | 2 | 0 | 10 | *S. s. richteri*—23, 27, 43 |

[1] Three quail nests observed under natural conditions are not included. These may be found as nests 1, 6, and 30 in Table I.

fluids from the shell. Most of the ants did not bother the chicks. However a few ants did crawl over the chicks, some of the ants biting them. Only one ant was actually observed stinging a chick. There were never more than two or three ants on a chick at any one time. The two chicks placed directly beside the ant mound were removed by hand after 10 minutes. The other chick was removed after 25 minutes; most of the ants that had been attracted were gone by this time. None of the chicks showed signs of any effects from the ants. However the effects of the ants were difficult to determine since the chicks were in such a weakened

condition. Healthy, normal chicks would have been able to leave the area under attack by the ants. However these weakened chicks were used to more nearly approximate the condition of a pipping chick within the shell.

Three other helpless chicks were similarly placed among foraging *Iridomyrmex pruinosus*. Results were similar to those obtained from chicks placed near imported fire ant mounds. However, a larger number of ants were on the chicks due to the much larger number of these ants in the vicinity.

The following study of pipping coturnix quail eggs was made by Walter Rosene *(in litt.,* 1961). Six pipping coturnix eggs were taken from an incubator and placed about two imported fire ant mounds. Distances ranged from 0 to 12 feet from a mound that appeared not to be in use and from 6 to 19 feet from a definitely occupied mound. The weather was hot and dry, and water was dripped on the eggs at 15-minute intervals so that the inner membrane would not dry out and trap the chicks.

Three of the chicks became covered with ants after hatching, but most rid themselves of the ants before they were picked up and returned to the incubator about 1 hour after hatching.

About 6 hours after hatching, three chicks could not stand up to eat, were unable to hold up their heads and were not able to walk. However all chicks recovered and appeared healthy except one which died. The cause of its death was unknown.

*Observations on Broken Eggs*

Partially incubated eggs were broken and placed near ant colonies. These eggs were readily eaten by the imported fire ant, both species of *Iridomyrmex* under observation, and *Formica schaufussi*. Rotten eggs were not eaten by the imported fire ant, but were readily accepted by both species of *Iridomyrmex*. Fresh eggs were accepted, but were not favored as much as partially incubated eggs. *Dorymyrmex pyramicus* would not eat broken eggs in any condition.

No case was observed where ants made any progress in chewing through the shell of an uncracked egg, as had been reported for certain other ant species (Stoddard, 1931; Gorsuch, 1934).

On one occasion a partially incubated egg was cracked and placed beside an imported fire ant mound. It quickly became covered with *I. pruinosus*, and several imported fire ant workers that tried to approach the embryo were driven back by the smaller ants.

Cracked eggs in various stages of development were placed directly on occupied imported fire ant mounds and at various distances from the mounds. The purpose was to determine the foraging habits of these ants and the distance from the mounds to which they could be expected to find birds' nests.

Broken eggs were readily found by the imported fire ants at distances up to 100 feet from the mound. No eggs were placed at greater distances. Therefore the maximum distance that the ants would forage was not observed. Wilson and Eads (1949:18), however, reported fire ants foraging to a distance of 500 feet from the nearest mound.

Imported fire ants were obviously most active on moderately warm, rainy days. Cracked eggs were quickly found at all distances at which eggs were placed on these days. On hot, dry days eggs were often not found for hours even when placed directly on the mounds. Ants were much less active during dry weather even at moderate temperatures.

## NET EFFECTS OF THE IMPORTED FIRE ANT INVASION ON QUAIL POPULATIONS

*Comparison of Fall Quail Populations Before and After Fire Ant Invasion on a Sample Area*

Each year since 1940 (except 1946-1948) the Alabama Cooperative Wildlife Research Unit has conducted a complete census of fall quail populations on the old Evans Tract of the North Auburn Area of the Auburn University Agricultural Experiment Station in Lee County, Alabama. The data resulting from these population studies, together with information on all major habitat changes during the period of study, were obtained as part of a long-term study of quail ecology in the Piedmont soil province (unpublished). About 1957 the area was invaded

by the imported fire ant, and since quail census data and other pertinent ecological information were available for before and after the invasion, an opportunity was afforded to observe any possible reaction to the ant invasion by the resident quail population.

Being small in size (257.6 acres), this area is subject to movement of quail to and from the area. Food shortage or more intensive hunting pressure outside the study area might result in a fall influx of quail. This may have happened in 1954, probably because of winter food shortages resulting from the severe drought of the preceding summer. However, it is assumed that this influx generally has been fairly constant from year to year and that it has not changed drastically since the ant invasion. Much of the area is bounded by more University-owned land on which hunting has been limited and on which drastic overall habitat changes have been few. The locality surrounding the study area was invaded by ants at about the same time as the study area, and ant populations have been comparable to those on the study area. If the fire ant invasion resulted in any changes in the quail population in relation to the carrying capacity, these changes should have been typical for the general locality, both on and off the study area. In this respect the study area may be considered as a sample from the entire newly infested locality.

The study area has undergone numerous major changes in habitat. Fortunately, however, since 1950 the changes favorable and unfavorable to quail seem to have been approximately compensating, with the overall carrying capacity having changed but little and remaining on a slight incline.

Ant populations are rather unstable on this area, there being generally the rapid turnover in colonies characteristic of the early years of infestation. Ant populations are quite high on some portions of the area. Around ponds, access roads, powerlines, and similar open areas densities of over 100 mounds per acre were recorded in April, 1961 when the inventory was made. In general these areas made up the best quail-nesting territory. The ants were rather localized, however, and large wooded portions of the area had no fire ants at all. Other areas in woodland, bicolor lespedeza, or kudzu may have had only 1 to 10 mounds per acre. Therefore, in considering these data, the density of the ant populations should be taken into account.

The quail census data (Table IV) show no abnormal decrease in actual fall populations since the fire ant invasion, but rather show a slight upward trend since 1956. Fall populations on the area during the 4 years preceding the fire ant invasion averaged 21.1 birds per 100 acres as compared with 22.8 birds per 100 acres during the 4 years following the establishment of the ant population on the area. Relative to trends in carrying capacity, fall quail populations have fluctuated much as they did prior to the invasion (Figure 1). Separate data have been kept for portions of the area that are periodically burned; on these burned areas quail populations now approach the saturation point (one bird per 1-2 acres).

TABLE IV

FALL QUAIL CENSUS DATA—NORTH AUBURN AREA AUBURN UNIVERSITY AGRICULTURAL EXPERIMENT STATION.

| Year | Birds per 100 acres | Year | Birds per 100 acres |
|---|---|---|---|
| 1940 | 5.0 | 1951 | 10.8 |
| 1941 | 23.7 | 1952 | 15.6 |
| 1942 | 13.2 | 1953 | 23.2 |
| 1943 | 9.7 | 1954 | 30.7 |
| 1944 | 40.8 | 1955 | 20.2 |
| 1945 | 38.4 | 1956 | 10.1 |
| 1946 | * | 1957 | 26.6 |
| 1947 | * | 1958 | 19.5 |
| 1948 | * | 1959 | 15.6 |
| 1949 | 21.7 | 1960 | 29.6 |
| 1950 | 25.6 | | |

*No figures available.

Due to the rapid turnover in quail populations, the size of the fall population is largely determined by the degree of success of the previous nesting season. A sizeable population of fire ants has been present on the area since 1958 or 1959, and the present quail population is composed almost entirely, if not completely, of birds hatched since the fire ant population reached its peak. In the light of this information, it would appear that the occurrence of the imported fire ant has had little if any effect on the local fall quail population.

*Analysis of Statewide and Regional Reproductive Data in Relation to Fire Ant Distribution*

Since 1953 quail wings have been collected from over the state of Alabama by the Cooperative Wildlife Research Unit at Auburn. Results and methods of obtaining wings and data have been reported by Haugen and Speake (1958) and Speake and Haugen (1960). The data collected from wings submitted by hunters include adult-juvenile ratios and date of hatch of birds less than 150 days old. These data have been grouped to correspond with the various soil regions of the State (Table V).

Fall and winter quail populations vary from year to year in close correlation with the percentage of young birds in the population. This is true since these populations usually contain about 80 per cent young birds. That this correlation actually exists in nature is indicated by the significant relationship between juvenile percentages and hours per covey-find observed by Reid and Goodrun (1960).

Within limits then, the size of the fall and winter population over large areas is dependent on production and survival during the preceding nesting season, assuming only a few old birds are held over from winter to winter. If this is true, then age ratios from hunter kills may be used as an index of the past summer's reproduction and rearing success over large areas.

An attempt has been made here to relate year to year and region to region variation in adult-juvenile ratios obtained from quail wing returns to variation in imported fire ant distribution over Alabama.

In studying the implications of these data, the question of the relationships between winter population and breeding population of quail must be considered. Since these relationships were not known, the data were subjected to separate and independent analyses for each of two opposing assumptions.

1. Spring breeding population is fairly constant from year to year, being independent of the fall population; that is, winter mortality will reduce the fall population, regardless of its size, to a constant level each spring.
2. More logically, spring population is related in some manner to fall population, and a large fall population will result in a larger number of birds surviving to the following breeding season.

The first assumption, that breeding population is independent of fall population, provides a basis for making comparisons between adult-juvenile ratios on imported fire ant-infested areas and uninfested areas and before and after infestation on the same area. If this assumption is valid, roughly the same number of adult birds will be included in the fall population each year, differences in age ratios as well as total population being dependent on the success or failure of summer production and rearing.

In studying the effects of the imported fire ant on quail reproduction, little can be gained from direct comparisons of age ratios. For example, the Tennessee Valley and Piedmont regions may be considered to have been practically free of the imported fire ant until about 1958. Preinfestation percentages of young birds averaged, respectively, 2.1 and 1.6 per cent less than the average since the ants began to spread into these regions in 1958. These figures are meaningless, however, since post-invasion ant densities are low. Also the increased juvenile percentages since 1958 were statewide in occurrence. During the preinfestation period of these two regions, two other regions within the state, the Black Belt and the Lower Coastal Plain, were generally infested with ants. Of these four regions one of the uninfested regions (Tennessee Valley) had the highest percentage of juveniles and the other (Piedmont) had the lowest.

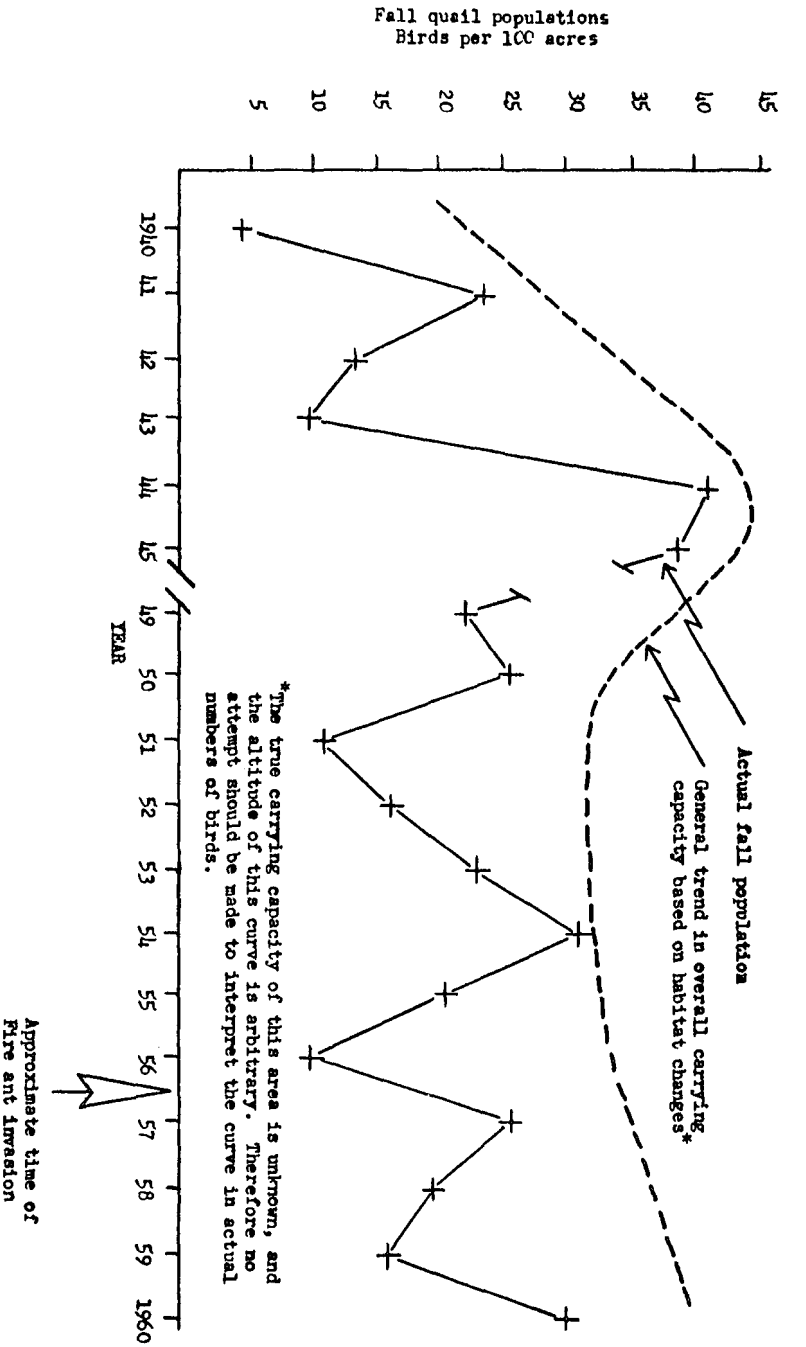


Figure 1. Trends in fall quail populations and estimated carrying capacity on the North Auburn area of the Auburn University Agricultural Experiment Station.

TABLE V

PERCENTAGE OF JUVENILE BIRDS IN THE HUNTERS' BAG IN ALABAMA AS DETERMINED BY WING SAMPLES

| Soil Region | Year 1953 | 1954 | 1955 | 1956 | 1957 | 1958 | 1959 | 1960 | Av. |
|---|---|---|---|---|---|---|---|---|---|
| Tennessee Valley | *79.2 | 76.4 | 84.5 | 75.7 | 83.3 | 81.4 | 86.8 | 77.6 | 80.6 |
| Appalachian | *79.8 | 74.9 | 82.5 | 83.6 | 82.8 | 83.5 | 86.5 | 75.4 | 81.1 |
| Piedmont | *80.0 | 64.9 | *79.8 | *76.3 | *80.8 | *79.6 | 81.5 | 72.8 | 77.0 |
| Upper Coastal Plain | *78.7 | 67.5 | 83.4 | 76.4 | 80.1 | 81.5 | 79.3 | 75.0 | 77.7 |
| Black Belt | 81.0 | 67.7 | 84.9 | 77.4 | 76.2 | 79.1 | 77.8 | 75.4 | 77.4 |
| Clay Hills | *74.2 | 64.4 | 82.4 | 74.5 | 77.7 | 78.0 | 74.2 | 72.7 | 74.8 |
| Lower Coastal Plain | 71.6 | 69.7 | 83.5 | 79.5 | 79.7 | 81.5 | 77.3 | 77.1 | 77.5 |
| Statewide | 77.8 | 70.0 | 83.4 | 78.7 | 80.2 | 81.1 | 80.8 | 75.7 | 78.9 |

*Sample size not large enough for statistical validity at the 5-per cent confidence level as determined by Haugen and Speake, (1958).

Fairly reliable data [5] were available on the progress of spread of the imported fire ant in Alabama at 4-5 year intervals. An attempt was made to interpolate between these intervals to obtain rough approximations of the distribution of the ant during each year for which wing data were available. A scatter diagram was then constructed of the regression of percentage of young birds in the bag on percentage of the region infested by imported fire ants. Combined data for all regions were used. The points on the diagram were widely scattered and showed little tendency to cluster about the regression line. However, regression analysis yields a highly significant negative association between these data for the state as a whole. An attempt was then made to examine this relationship on a regional basis by plotting the data for each region independently, thereby largely eliminating variation due to regional differences in climate and soils. Regional samples were in most cases statistically adequate at the 5 per cent confidence level. Scatter diagrams of percentage of young birds plotted over percentage of the region occupied by imported fire ants show no pattern of correlation whatever, but fluctuate in close correlation with annual fluctuations in summer temperatures and rainfall. If any effects from fire ant infestation exist, they are not of sufficient importance to be apparent through the masking effect of weather conditions.

The extremely high correlation obtained from using the statewide wing data is very impressive. However, this association is not here believed to be one of cause and effect. This conclusion is prompted by the comlete lack of correlation between these data when broken down upon a regional basis and by the fact that the limits of imported fire ant distribution happen to coincide generally with divisions between major natural climatic, physiographic, and edaphic regions. Since the limits of fire ant's range in Alabama generally follow the fall line, the analysis essentially shows only that there is a significant difference between quail production in northern and in southern Alabama. These differences in production may be the result of any or all of the natural differences existing between the northern and southern portions of the state.

The evapotranspiration zones of the state, as recognized by Ward, *et. al.* (1959:7-8), are separated by the fall line, which roughly approximates the limits of the fire ant's range. That portion of the state largely uninfested by imported fire ants is within the zone of lower evapotranspiration losses. Therefore, it is suggested that the significant difference obtained from the regression analysis is due, not to fire ant damage, but to more frequent and more severe droughts affecting quail reproduction in southern Alabama. These drought conditions are primarily the result of the hydrologically shallow soils and higher evapotranspiration rates in southern Alabama rather than solely to differences in temperature and rainfall. The hypothesis that climate is responsible for differences in production is strengthened by the fact that the difference between production in different regions appears to increase gradually as the north-south distances and differences in elevation between the regions being compared are increased.

Interpretation of these age ratios based on the second assumption, that breeding populations are to some extent dependent on fall populations, limits the analysis to examination of regional trends in reproduction for sudden, dramatic changes.

If a new limiting factor is suddenly applied to summer production on an area, it will result in a decrease in the percentage of juveniles in the fall population of that year. Within 1 or 2 years, all old birds hatched before the new limiting factor was in action will have disappeared. The population then becomes balanced at a lower density with the new limiting factor in action. If the factor is density-dependent, age ratios will return to near their previous values. If the factor is density-independent, age ratios will remain low.

Therefore, in those regions of the state wherein the fire ant invasion took place rapidly and extensively, any reaction on the part of the quail population should be reflected in the age ratios of the fall populations of

[5] Compiled from various sources including U.S.D.A. 1958a, Bruce, et al., 1949, state and federal quarantine notices, and unpublished distribution map prepared by G. H. Culpepper Feb. 3, 1953 on file with Walter H. Grimes, Extension Entomologist, Auburn, Alabama.

the first year of reaction. This would be true only if the reaction were sharp enough to make itself shown through any possible masking factors such as weather. However, since a correlation with weather on these data has already been established (Speake and Haugen, 1960) and the general trends of the regions are known, any significant reaction in one of these regions should make itself shown. It has been observed that the fire ant exhibits the population explosion typical of a species entering a new area. Fire ant populations explode to extremely high densities, then probably because of competition decline to much lower densities and level off. During these years of greatest ant concentrations, any reactions of any general significance should be especially pronounced.

Graphs of percentage of juveniles in the bag plotted against time in years were examined together with information on the invasion and spread of the fire ant within each region. No incidences of declines in production were observed except those that occurred simultaneously with declines in most or all other regions of the state. These declines have already been found to be correlated with adverse weather conditions (Speake and Haugen, *op. cit.)*, and they show no correlation with fire ant invasion and spread.

## GENERAL DISCUSSION

Results of this study indicate that the imported fire ant does not prey upon normally hatching precocial chicks to any appreciable extent. Although occasional instances of ant predation may occur, this appears to be confined mostly to chicks which do not hatch normal and healthy. To whatever extent this destruction may occur, it has almost certainly been greatly over-estimated in most cases.

Although most observations on the hatching of quail chicks were made under artificial conditions, the fact must be considered that the circumstances under which the chicks hatched in the pens greatly favored the possibility of damage by ants. The adult birds were confined, unnaturally, to small plots close to fire ant mounds. They had little opportunity to choose a nesting site. In some pens several broods were hatched in rapid succession within a few feet of the same spot. Feeders, broken eggs, and insects living beneath the feeders and watering boards, undoubtedly concentrated imported fire ants in the pens to some extent. However, the constant supply of quail feed in the pens is not believed to have affected the appetites of the ants for animal matter. The bird feed was taken by the ants only in minor quantities. Dead birds or broken eggs, when available, were readily taken by imported fire ants.

Direct observations on ant predation were largely confined to the Alabama Piedmont, and it is conceivable that differences in food supply, soil type, or climate might somehow result in greater damage in the Coastal Plain. However, this is not believed to be the case. The imported fire ant has only recently spread into the Piedmont, and it is quite unlikely that it would have made a rapid change in its biology and feeding habits. Results of analysis of statewide production data and observations on quail nests nos. 1 and 30 also indicate little destruction by imported fire ants in the Coastal Plain.

Independently obtained evidence that the imported fire ant invasion has not affected summer production and fall populations further strengthens the conclusion that the number of quail chicks killed by imported fire ants is unimportant in effect on overall populations. It appears, therefore, that the imported fire ant is not a serious pest of quail, and that excellent quail hunting can be maintained on areas heavily infested with these ants.

Although only a limited number of observations were made on the reproduction of small mammals, the evidence is fairly conclusive. The high degree of density of ant colonies about the pens, the close proximity of imported fire ant mounds to the nests in which the young were born, and the complete lack of ant disturbance indicate that the imported fire ant does not normally prey upon the young of cotton rats. We might assume that this would also be the case with other mammals having precocial young.

Other species of ants on which observations were made during this study, with the possible exception of the Argentine ant, appear to present no threat at all to wildlife. It is possible that the Argentine ant

may present a special case because of the tremendous numbers in which it usually occurs. Evidence from this study, however, indicates that the Argentine ant is not an important predator on young birds and mammals.

Unfortunately, very few observations were obtained on birds and mammals having altricial young. The limited evidence available is inconclusive, and further studies should be made. Species most likely to be affected by possible ant predation are meadowlarks and cottontail rabbits.

While the imported fire ant appears to rarely attack normally hatching quail, heavy losses to native ant species of the same genus have been reported. Reports of observations on *Solenopsis geminata* by Stoddard and Travis (Rohwer, 1958; Stoddard, 1931:193-194; Travis, 1938a, b) are especially impressive. On the basis of presently available evidence, it appears that there may be a basic difference in the feeding habits and biology of these two species. Also, most of the data on *S. geminata* were collected on intensively managed plantations where unusually high quail populations are maintained. If ant predation is density-dependent in action, destruction would be much greater under these circumstances than under normal conditions. Predation is generally a density-dependent action, but whether this is true of ant predation is not definitely known.

It is also likely that in some cases in which death of hatching chicks has been attributed to ants, the primary cause of death may have been some other factor, the ants being attracted to the nest by the dead birds. Situations that could be most easily misinterpreted are those involving desertion and the effects of drought on hatching.

Ant invasions of quail nests appear to be most common when hatchability of eggs is lowest. In these studies on quail reproduction only three of the chicks that were eaten by ants of any species were found in nests that had hatched under normal conditions (nest nos. 14, 16, and 24). The remaining 16 chicks eaten by ants were from 10 nests, in each of which the eggs hatched under some unfavorable condition. One nest had been deserted, and all others were either irregular hatches or else they hatched following rather severe periods of drought. Stoddard (*op. cit.*:38-39) reports that seasons of drought may cause eggs to hatch at irregular intervals, and that chicks delayed in emerging may be abandoned when the brood leaves the nest.

Lehmann (1946) reported high hatchability in May and early June with no fire ant predation. Hatchability was lower in July, and some chicks were too weak to pip the shells. Some fire ant damage was observed during this period. Percentage of hatch was further reduced in late summer, and some eggs contained dead embryos. Fire ant destruction was highest during this period. The ants were reported to have destroyed no clutch completely.

Observations made during the course of the study reported here suggest that low hatchability resulting from drought may result in conditions that tend to increase the incidence of invasion of nests by ants. Several periods of drought of varying intensity that occurred during the two nesting seasons appeared to have had an adverse effect on hatchability of eggs. During the driest period of the 1961 nesting season six nests were being incubated in the pens. Seventy-four eggs from a total of 150 eggs that had been in an incubator for 20 days were substituted for those under the incubating birds in the six nests. The remaining 76 eggs from the same source were left in the incubator. At termination of the normal incubation period, only 3 days later, three complete clutches of the eggs in the nests, a total of 36 eggs, failed to be pipped. Eleven chicks pipped in the remaining three nests that contained a total of 39 eggs. Of those pipping only four hatched. Some of the remaining seven pipped the shell and then died; others were trapped alive inside the shell by the inner membrane which had dried in the hot sun. Those eggs not pipped all contained chicks that had died after being placed in the field. About 90 per cent hatchability was obtained with the 76 eggs remaining in the incubator. During the preceding month and later in the summer when weather conditions were more favorable, partially incubated eggs were taken from the incubator and similarly placed under broody adults with good results.

It is known that hot, dry weather during the nesting season has an adverse effect upon quail production as indicated by percentage of young

birds in the winter harvest and by fall census of populations (Reid and Goodrum, 1960 and Speake and Haugen, 1960). The exact mechanism by which production is inhibited has been more a matter of speculation, however. It is suggested here that this adverse effect may result in part from the direct effect of the heat and drought on the embryo and on the drying of the inner membrane during hatching. The latter effect is well known among quail-raisers and is frequently mentioned in regard to hatching eggs in incubators (Hart and Mitchell, 1947, and others).

If this situation occurs in the wild to the extent that it is indicated by these observations, it would sometimes result in a large number of nests in which many eggs would be pipped, but the trapped chicks would not be able to get out of the shells. If fire ants were present in the area, they would be attracted to the nest within a short time. An observer coming upon the scene a few hours, or even days, later could easily misinterpret the evidence and conclude that the ants had attacked the nest, perhaps driving the incubating adult away.

Desertion of nests may also contribute to some cases of ant predation. Observations on several nests in the pens demonstrated that the chicks developing in the eggs of a deserted nest may remain alive for a week or more after desertion. Under favorable weather conditions, these chicks may complete incubation and pip the shells. The observations on nest no. 17 and those nests in which dead chicks were not bothered by ants as long as the parent bird was on the nest indicate that the adult is able to keep limited numbers of fire ants out of the nest. Without the presence of the adult bird, the chicks may be attacked by ants when they normally would not be. In this case the ants would only hasten death, as it is quite unlikely that these chicks would survive with no adult bird to care for them should they hatch.

## CONCLUSIONS

1. Imported fire ants rarely attack and kill normally hatching quail chicks. Most incidents of attack are confined to chicks that are not normal and healthy.
2. Death of chicks in many cases may be attributed to predation by ants when the actual cause of death was some other factor, the ants being attracted to the nests after the chicks had died.
3. Drought may prevent some chicks from escaping the shell after pipping. Ants may then be attracted to the nest, covering the living chicks trapped within the shells as well as those that have already died.
4. Adult birds can keep limited numbers of ants out of the nest. Deserted nests in which the chicks have survived to pip the shell may become covered with ants, and the chicks may be killed in the shells.
5. The limited destruction of hatching chicks by imported fire ants has no significant effect on overall quail populations.
6. Newborn young of cotton rats are rarely if ever harmed by imported fire ants. It seems likely that this would also be true of other mammals having precocious young.
7. Other ant species studied cause little or no damage to hatching chicks and newborn rats and mice. The Argentine ant is a possible exception because of the tremendous numbers in which it usually occurs on infested areas. Evidence available, however, indicates it is not an important predator on wildlife.

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# RESIDUES OF HEPTACHLOR EPOXIDE IN WILD ANIMALS

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In the winter of 1957-58, the United States Department of Agriculture, Plant Pest Control Division, started aerial applications of insecticide in Alabama and Georgia to eradicate the imported fire ant *(Solenopsis saevissima richteri* Forel). An estimated 27 million acres in nine southeastern states had populations of this ant when the program began. Heptachlor, one of the more toxic chlorinated hydrocarbons, was the insecticide most frequently used. Studies of DDT, a hydrocarbon of much lower toxicity, had already shown that 3 pounds of DDT per acre caused direct mortality of birds (Mitchell, Blagbrough, VanEtten, 1953), and that 0.5 pound per acre on water drastically reduced aquatic insects (Springer, 1957).

Chlorinated hydrocarbon insecticides are relatively stable compounds. Their insolubility results in soil residues that can be recovered over relatively long periods of time (Young and Rawlins, 1958). Davidow and Radomski (1953) were first to recognize that heptachlor changes to heptachlor epoxide and is stored in animal lipids in that form. More recent papers on the residual amounts of epoxide in soils (Gannon and Bigger, 1958) and on plants (Gannon and Decker, 1958) suggest that wild animals living in an area treated with heptachlor might accumulate the material.

DeWitt, et al. (1960) demonstrated that pesticidal residues in tissues of starlings, rats, pheasants and mallard ducks are "roughly proportional to the degree of exposure," and that "these species differ in their capacity to store residues in tissues."

The present report is based on analyses of 245 animals collected from February 1958 through April 1960, either from areas treated at the rate of 2 pounds of technical heptachlor per acre or from untreated land. Specimens were analyzed for heptachlor epoxide content. Specimens came from treated areas in Decatur County, in southwest Georgia; from