NUMBER 531 APRIL 27, 1951

OCCASIONAL PAPERS OF THE MUSEUM OF ZOOLOGY

UNIVERSITY OF MICHIGAN

ANN ARBOR, MICHIGAN UNIVERSITY OF MICHIGAN PRESS

VANISHING AND EXTINCT COLONIES OF TREE SNAILS, *LIGUUS FASCIATUS*, IN THE VICINITY OF MIAMI, FLORIDA[1]

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Submitted for publication June 15, 1950

THE once numerous tropical hardwood hammocks in the region of Miami, Florida, are rapidly being enveloped or destroyed by the growing metropolitan and suburban area. With the destruction of these hammocks the colonies of tree snails, *Liguus fasciatus,* characteristic of this type of vegetational association are doomed to extinction. Many colonies are completely lost; others are on the verge of extinction and must surely disappear in a few more years. In view of this prospect, I believe that the following notes on the location of the hammocks and their associated colonies of *Liguus* will be of value to future workers studying the distribution, ecology, or genetics of this group of snails.

The tree snails of the genus *Liguus* are colonial only because they are strictly limited to the subtropical jungle-hammock associes and to subtropical hammock associes with the corresponding climax associations of the Florida Keys and the southern mainland (see Davis, 1943). Clench and Fairchild (1939) have reviewed the taxonomy of the Florida forms, and the names used in the present paper are largely based on their work. In some instances I have retained names of variants placed by them in synonymy. These names express more clearly the

[1] Contribution No. 463 from the Department of Zoology, Indiana University.

concept of color patterns which I wish to discuss. In all such cases, however, the retained names are in quotation marks to indicate that they are merely used as labels and should not be so interpreted as to affect their status as synonyms.

All of the colonies in the vicinity of Miami included various color forms and variants of the subspecies *Liguus fasciatus roseatus* Pilsbry. Some of the colonies around Arch Creek contained in addition a small percentage of *Liguus fasciatus septentrionalis* Pilsbry. Forms of the first subspecies in the Miami area, with only a few exceptions, show a general resemblance in shape, texture, distribution of periostracal green lines, and other features. This general similarity probably reflects the relatively uniform environment present along the East Coast ridge. There seems to be no correlation between color pattern and the characters mentioned above, and there is considerable indirect evidence to indicate that the color patterns behave in accordance with genetic principles, although the mechanism has not yet been determined.

In the discussions of the hammock colonies which follow, names or combinations of names of forms are used as defined below:

Liguus fasciatus septentrionalis Pilsbry—the typically inflated, thin, white forms with well-developed periostracal green line or lines; characteristic of the hammocks around Fort Lauderdale.

Liguus fasciatus roseatus Pilsbry—the heavier, less inflated, and usually colored forms occurring on the East Coast ridge south of New River at Fort Lauderdale. The range of this and the preceding subspecies overlap in the area between Arch Creek and New River, and there is indication of intergradation. The color forms of this subspecies occurring in the Miami area may be divided as follows (not including all color forms found in Brickell Hammock):

1. Color forms with axial region white:
   - A. Color form *elliottensis* Pilsbry—a complex of variants all characterized by a white or nearly white ground color, with or without periostracal green lines. The principal named variants are: *"eburneus"* Simpson—Pure white or ivory forms with no markings except occasional green periostracal lines; *"mosieri"* Simpson—white forms, with or without yellow spiral bands on upper whorls; *"cingulatus"* Simpson—forms with spiral yellow banding extending onto lower whorls, sometimes complete to lip of last whorl.
   - B. Color form *lossmanicus* Pilsbry—all forms with a yellow-wash ground color and white axial region. The variant *"luteus"* Simpson is the

common type in the Miami area. The variation, however, is extreme, and individuals are not easy to classify. Some colonies contain forms with distinct spiral yellow banding, which, when the yellow ground color fades, makes them difficult to distinguish from *''cingulatus.''* Only a small percentage of specimens from the Miami area have orange or red flaming on the last whorl.

C. Color form *marmoratus* Pilsbry—forms with dark pigment distributed in blotches or in bands and blotches, but not confined to definite bands. The form in the Miami area is extremely variable, some variants differing from *testudineus* Pilsbry only in the white axial region.

2. Color forms with axial region colored (usually both tip and columella pink or purplish, but occasionally only the tip or the columella colored):

A. Color form *roseatus* Pilsbry—forms with spiral yellow banding, either complete onto last whorl or confined to upper whorls. A sutural brown or reddish brown line may be present or absent. Two intergrading variants occur in the Miami area: *''roseatus''* Pilsbry—spiral banding complete onto last whorl, periostracal green lines often reduced, sutural brown or reddish line usually present; *''livingstoni''* Simpson—spiral banding restricted to upper whorls, periostracal green lines usually strongly developed; sutural line usually lacking. The general appearance of *''livingstoni''* suggests that it may be the hybrid *roseatus* × *elliottensis.*

B. Color form *ornatus* Simpson—forms with a yellow-wash ground color, sometimes flamed on last whorl. The form is peculiar in sometimes having only the tip or the columella colored.

C. Color form *castaneozonatus* Pilsbry—all color variants with dark pigment not distributed in blotches. Three principal variants are separable in large series in the Miami area: *''elegans''* Simpson—forms with flecks of pigment on upper whorls only, and usually with a brown or reddish brown sutural line; *''miamiensis''* Simpson—forms with distinct dark bands on upper whorls, and usually with strongly developed periostracal green lines; with or without sutural brown or reddish brown line; *''castaneozonatus''* Pilsbry—forms with spiral dark banding extending onto lower whorls, with or without sutural brown or reddish brown line.

D. Color form *testudineus* Pilsbry—forms with dark pigment distributed in blotches or in bands and blotches, but not restricted to definite bands.

The subtropical jungle hammocks in the vicinity of Miami were of several types, but the various facies of the associes have not been clearly distinguished. In the northern part of the area the existing hammocks tend toward a temperate type, with red maple and other northern trees replacing or intermingling with the more strictly subtropical plant species. Tree snails range northward to near Pompano,

and Pilsbry (1946) gave a record for *Liguus* from near Yamato in southern Palm Beach County. This probably represents the farthest north that *Liguus* has extended along the East Coast of Florida. Inland there are records from south of Immokalee and local inhabitants say that snails of the *Liguus* type formerly occurred along the south edge of Lake Okeechobee. The tree snails are much more abundant and varied, however, in the southern part of their range in Florida. Forms with a colored axial region disappear from the colonies at about the latitude of Dania (southern Broward County), with the exception of a locality just south of New River in Fort Lauderdale.

The reasons for the extinction or reduction of the tree snail colonies in most of the hammocks are evident. The actual instances of extinction are owing to one or the other, or a combination, of the following: (1) Complete destruction of the hammock either by clearing, building of roads or houses, or removal of soil and rock. (2) Profound modification of the hammock floor resulting from burning or from deposition of rock, sand, or other material, either by man or natural agencies. (3) Reduction of the population below an undetermined critical point for reproduction by removal of snails by amateur or professional collectors, natural enemies, or fire. In general, natural factors are of little or no significance in regard to the rapid reduction and extinction which has gone on in recent years. I know of only one colony which seems to have been exterminated by natural causes—the colony of *Liguus fasciatus lignumvitae,* color form *dohertyi* Pflueger, which was apparently completely destroyed along with the hammock it occupied by the Labor Day hurricane of 1935.

In many cases it is difficult to determine whether or not a colony is extinct, if any significant part of the original hammock remains intact. The colony of the color form *aurantius* Clench in Pinecrest Hammock, No. 5, was considered extinct for some time, but occasional specimens have been obtained from there several times since, which indicates that the snails were able to withstand severe burning of the hammock and intensive collecting. Freezing does not seem to be an important cause of extinction, but it may have been more effective in the past. Even the severe freeze of 1934 did not produce significant changes in the colonies around Miami, although it did considerable damage to the apparently less hardy forms occurring in the Cape Sable region. Even

great change in the extent of the hammock, unless accompanied by other modifications, does not seem sufficient to exterminate the snails. In Great Hammock in the city of Fort Lauderdale occasional specimens were found at least until fairly recently in fringes of trees surrounding private homes, even though the main part of the hammock has long been destroyed. Similar conditions prevailed in Brickell Hammock at Miami for many years.

Because of this apparently great resistance of the snails to extermination, I have tried to use the following criteria for determining whether or not a colony was extinct: (1) Complete destruction of the hammock or such a profound modification as to make eventual destruction inevitable. (2) Repeated search over a period of years with failure to find either living snails or evidence of recently dead specimens; in some hammocks even the "bones" have long since disappeared. (The second of these criteria is not infallible, but along with it I have considered a third.) (3) Introduction of snails from other parts of the state. Introduction is not in itself a cause of extermination, but for all scientific purposes it destroys the value of the colony. Intensive collecting by amateur collectors does not seem to be a direct cause of extinction, but it modifies the colonies to a considerable extent and, together with any other adverse conditions, probably results in extermination.

The locations (see Map 1) of the extinct or nearly extinct hammock colonies which I discuss were between the latitudes of Arch Creek and the southern tip of Key Biscayne in Dade County. Most of them were on the East Coast ridge, but some were on the peninsula opposite and on offshore islands. The greatest destruction of natural environments anywhere in the state has taken place in this area and is particularly deplorable because the region seems to have been a center of distribution for a number of other organisms as well as the tree snails. This leads to the rather interesting surmise that the great urban centers of the world may have destroyed a vast amount of data basic to an understanding of the distribution of many organisms. It is logical to suppose that man is not unique in his habitat requirements, and a situation especially suitable for one of his cities might also be especially suitable for many lesser forms long since exterminated.

No scientifically collected material is available from a number of the

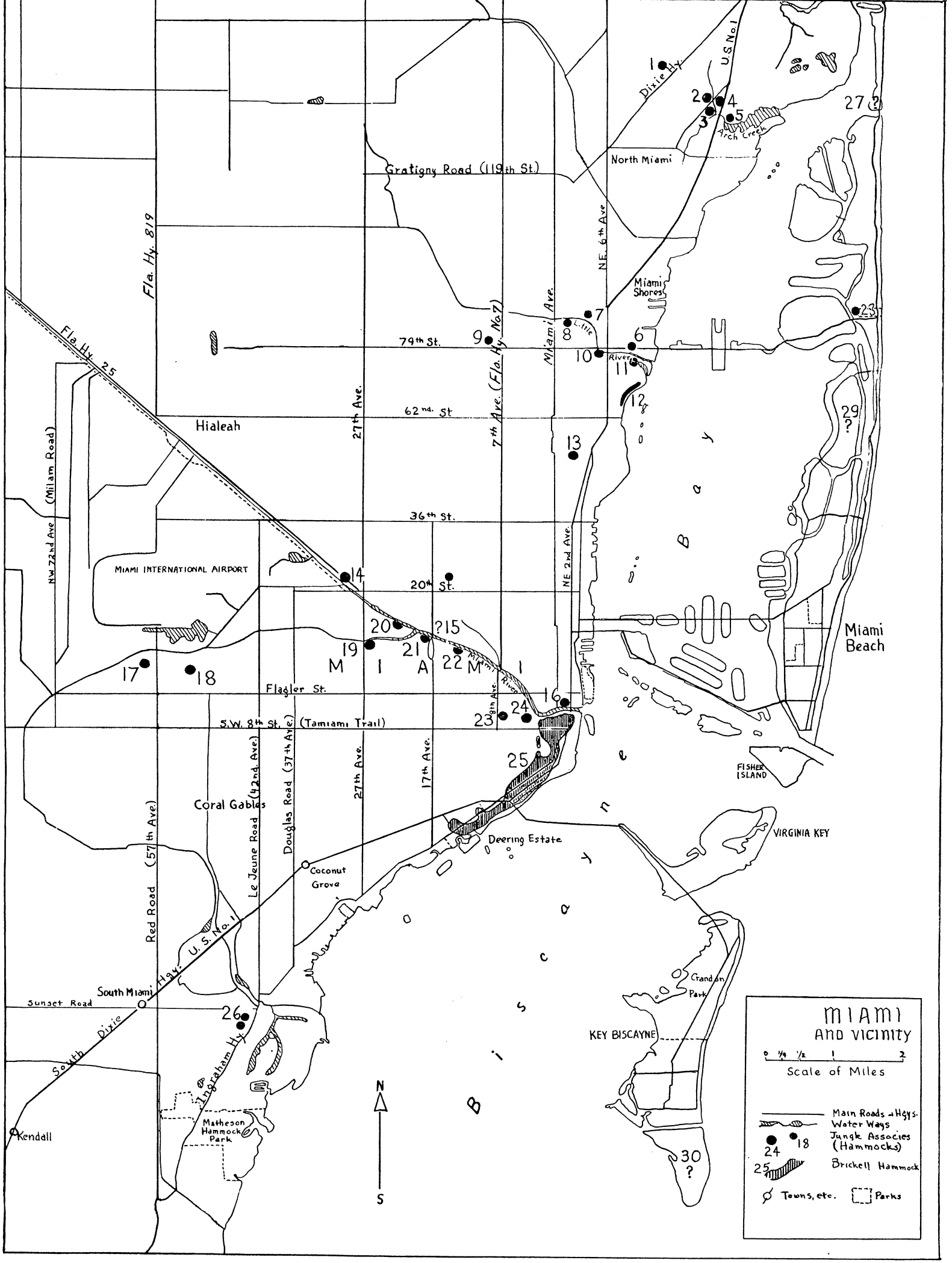
hammocks listed below. For others, material is available, but cannot be accurately placed because of the inadequacy of the data recorded with the material. Specimens from many very old localities are preserved in the C. T. Simpson Collection, now at the University of Miami, and in other collections. My personal collection, made between 1930 and 1942, is now part of the collection of the Museum of Zoology of the University of Michigan (cited as U.M.M.Z.).

ARCH CREEK AND VICINITY

The margins of Arch Creek and the edges of the transverse glade for some distance inland have supported a considerable number of hammocks for a long period of time. Patches of the original hammocks, materially altered by clearing and burning, still persist in the vicinity of the Natural Bridge on the Old Dixie Highway and elsewhere in the area. *Liguus* of the *castaneozonatus-* and *elliottensis-*type patterns persisted in these hammocks until recently, but all snails collected since 1930 show evidence of extreme age and were probably senile. It is unlikely that there are any living tree snails anywhere near Arch Creek, although it would take years to search completely the tangled, second-growth thickets.

The distribution of the hammocks around Arch Creek shows the same general pattern as those around New River to the north or Little River to the south. That is, the hammocks occur along the margins of the stream or its estuary, across the rocklands of the East Coast ridge, and fan out along the edges of the transverse glade. This pattern is apparently maintained by the nature of the soils and the periodic fires which sweep the bordering rocky pinelands and encroach upon the edges of the hammocks. The migration of hammocks along the edges of the glades may be, as suggested by Pilsbry (1946), a clue to the present (or recent) distribution of the tree snails.

Pilsbry (1912) remarked concerning *Liguus* in the Arch Creek area that C. B. Moore in 1904 and S. N. Rhoads in 1906 found 4 *elliottensis-*, 7 *roseatus-*, and 2 *castaneozonatus*-type snails and that C. T. Simpson collected the same forms in 1905. He stated further that at the Natural Bridge he himself found *Liguus* scarce (only 4 living specimens), although the hammock was extensive and seemed favorable.



MAP. 1. Miami, Florida, and vicinity, showing location of hammocks listed.

From these quoted remarks, the material in the Simpson Collection, and personal observation, it appears that the colonies which occurred in the hammocks about Arch Creek have not flourished in recent times. Like many of the colonies in the more northern hammocks, the tree snails were probably easily disturbed by climatic changes, and only slight intervention by man was necessary to cause their extinction. But it is surprising that no remnants of *Liguus* remain in what once must have been a very extensive hammock system.

The most conspicuous feature of the Arch Creek colonies was the presence of *septentrionalis,* which apparently hybridized with snails of the *roseatus*-type pattern. The specimens on which Simpson (1929) based the conclusion that *septentrionalis* hybridized with other types at Arch Creek are in his collection and certainly seem to show hybrid characters despite Pilsbry's (1946) unfavorable opinion on the subject (see hammock No. 2, below).

Another interesting feature was the occurrence of a peculiar mixture of variants of *castaneozonatus,* not duplicated elsewhere in the region, but having affinities with the mixtures occurring in the Ojus group of hammocks and in those to the south around Little River. At present no living *Liguus* having any dark pigmentation are known north of the Miami River along the East Coast ridge. West of Arch Creek only the *roseatus, lossmanicus,* and *elliottensis* forms still persist, and to the north *lossmanicus, roseatus, elliottensis,* and *septentrionalis* occur in a few scattered hammocks.

1. Hammock at N. E. 12th Ave., between 143rd and 144th St., sec. 17, T. 52, R. 42. Specimens in U.M.M.Z.

A small edge-of-glade hammock, now heavily burned and partly cleared, but with some large hammock trees. No living *Liguus,* but fragments numerous. Many of the fragments seem to be very old; others were apparently killed by fires and show evidence of charring. The latter may be evidence of the introduction of snails from other localities. Material obtained shows former occurrence of *elliottensis, lossmanicus,* and *castaneozonatus* types, characteristic of the Arch Creek area.

2. Hammock just south of McDonald Place at Arch Creek, SE. $\frac{1}{4}$ sec. 20, T. 52, R. 42. Specimens in Simpson Collection and U.M.M.Z.

Hammock once extensive, but now partly cleared and burned. No living *Liguus* in recent years, but occurred in isolated patches as late as 1937. Parts of hammock are still intact, and no good reason for the complete disappearance of the colony is apparent. Including material from a hammock north of McDonald Grove, probably once continuous with the one south of McDonald Place, the Simpson Collection contains:

4 *septentrionalis*—Small, but typical.

7 *septentrionalis* × *roseatus* type—These shells have some spiral yellow markings of *roseatus* pattern on upper whorls and a single strong, bronzy green line in the *septentrionalis* position on the lower whorls. All are rather inflated, and the axial region is more deeply colored than usual in the area. There seems little reason to doubt that these shells really represent hybrids between *septentrionalis* and a *roseatus*-type snail. They are distinctly different from any other variants found in the region.

3. Hammock southwest of Arch Creek stream, NE. ¼ sec. 29, T. 52, R. 42. Specimens in Simpson Collection and U.M.M.Z.

Hammock cleared and partly burned, but with a few large hammock trees. Most of present vegetation is second growth. No living *Liguus* in recent years, but fragments with *castaneozonatus* markings numerous.

1 *roseatus*—Inflated, and without strong yellow banding.

24 *castaneozonatus*—A mixture of variants "*miamiensis*," "*castaneozonatus*," and "*elegans*." All rather inflated.

4. Hammock northeast of Arch Creek stream, SE. ¼ sec. 21, T. 52, R. 42. Specimens in Simpson Collection.

Hammock entirely cleared, but large trees still standing among buildings and appurtenances of trailer camp now occupying the site. No living *Liguus*. Simpson Collection contains:

2 *septentrionalis* (?)—Small, but apparently typical.

2 *elliottensis*—Yellow banding on upper whorls distinct.

4 *roseatus*—Some with strong yellow banding.

18 *castaneozonatus*—Similar to lot from preceding hammock.

5. Hammock east of U. S. Highway 1, north of Arch Creek, N. ½ sec. 28, T. 52, R. 42. Specimens in U.M.M.Z.

A small but typical hammock showing evidence of extensive burning and tidal-wave action. No living *Liguus,* but fragments numerous.

Material obtained shows evidence of occurrence of *elliottensis* and *castaneozonatus* types.

In addition to the above localities there is a small lot of shells in the Simpson Collection marked "little hammock, S. W. of Natural Bridge." There is now no indication of a hammock in this area, but one may have existed there and been completely obliterated by fire or clearing. The lot contains:

3 *elliottensis*
4 *roseatus*
1 *castaneozonatus*—"*miamiensis*" variant, typical of Arch Creek area.

LITTLE RIVER AND VICINITY

A fairly large number of hammocks formerly existed along the margins of Little River, along the edges of the transverse glade inland, and along the coast south of the river. Most of these have now been obliterated by the growth of the urban areas, and no living colonies of *Liguus* are known from anywhere in the vicinity. The hammock along the coast south of the river probably represented a type similar to Brickell Hammock, but was much narrower and smaller. The other hammocks follow the same general pattern of distribution which was noted at Arch Creek.

The tree snails from the Little River localities have no particular peculiarities not shared with others of the Miami area. Simpson (1929) reported *septentrionalis* from south of Little River, but examination of his specimens leave this identification open to considerable doubt. Shells of the blotched patterns (*testudineus* and *marmoratus*) are not represented in any collections seen, although *marmoratus* should occur, since it was formerly found farther north beyond Ojus. The *elliottensis-*, *lossmanicus-*, *roseatus-*, *ornatus-*, and *castaneozonatus*-type patterns occur, the first and third being most common in collections.

6. Hammock north of Little River near N. E. 8th Ave., sec. 8 near center, T. 52, R. 42. Specimens in U.M.M.Z.

Patches of a small hammock on N. E. 79th St. near 8th Ave. persisted until recently, but are now mostly cleared. No living *Liguus* in recent years, but fragments indicate the occurrence of *elliottensis*,

roseatus, and probably *castaneozonatus.* This locality may be represented by one of the lots in the Simpson Collection for which no exact localities are given.

7. Hammock in Sherwood Forest, SW. ¼ sec. 6, T. 52, R. 42. Specimens in Simpson Collection (?) and U.M.M.Z.

Remnants of a hammock persist around an Indian mound in Sherwood Forest subdivision around N. E. 85th St. near 4th Ave. A single *elliottensis*-type shell in the Simpson Collection marked "Page Place, Town of Little River," may represent this locality. Fragments give no indication of color pattern.

8. Hammock south of Little River, NE. ¼ sec. 12, T. 53, R. 41.

There are traces of the existence of a small hammock between N. E. 83rd and 84th St. between 2d Ave. and Miami Ct. No living *Liguus* and no fragments, but tree snails doubtless occurred.

9. Hammock on edge of glade west of N. W. 7th Ave., NE. ¼ sec. 11, T. 53, R. 41. Specimen in Simpson Collection?

There are indications of the existence of a small edge-of-glade hammock just west of N. W. 7th Ave. north of 79th St. The Simpson Collection contains one very old dead shell marked "Soars Nursery, 2 mi. W. of Little River," which may be from this location.

10. Hammock south of Little River near N. E. 5th Ave., NW. ¼ sec. 7, T. 53, R. 42.

A small hammock formerly existed along the margins of Little River in the area around N. E. 5th Ave. and 77th St. No indications of *Liguus,* but tree snails probably occurred there and may be represented in the Simpson Collection.

11. Hammock south of Little River, near mouth, east of Dixie Highway, SE. ¼ sec. 7, T. 53, R. 42. Specimens in Simpson Collection and U.M.M.Z.

Small patches of a hammock persist along Little River north and south of 76th St. between 8th and 9th avenues. A small area of hammock formerly existed on Belle Meade Island opposite this point, and may have been continuous with it before dredging operations were completed. This locality was visited a number of times by Simpson, and his collection contains a fairly large lot of shells:

49 *elliottensis*
1 *lossmanicus*?—Badly faded.
3 *roseatus*
43 *castaneozonatus*—All of "*miamiensis*" pattern.

All shells seen from this locality, including fragments, are small and rather inflated. Some of the smaller *elliottensis* have intense green bands suggestive of *septentrionalis,* but the bands are not in the characteristic place, and none can be called typical of *septentrionalis.*

12. Coastal hammock south of Little River, E. ½ sec. 18, T. 53, R. 42. Specimens in Simpson Collection.

A single large or several small hammocks formerly existed along the edge of Biscayne Bay south of Little River, and extended for some distance north and south from about N. E. 67th St. Large hammock trees still remain in yards and along streets in the area, and small patches of hammock persist in a few places. Most of this area was cleared many years ago, and tree snails from other localities were introduced by Simpson about his home, "The Sentinels," north of 67th St. Numerous small lots of shells marked "The Sentinels," are in the Simpson Collection, but most of these represent introduced forms. Other lots marked "native" or not indicated as introduced contain:

7 *elliottensis*
2 *lossmanicus*
5 *roseatus*
2 *ornatus*
32 *castaneozonatus*—Mostly of variant "*castaneozonatus,*" but some "*miamiensis.*"

A small lot marked "Ogden's Place," which was apparently near the present site of the American Legion Home, contains:

8 *elliottensis*
2 *castaneozonatus*—Fairly typical "*castaneozonatus.*"

13. Hammock near N. E. 54th St. and Florida East Coast Railroad, NW. ¼ sec. 19, T. 53, R. 42.

A small hammock which supported a colony of *Liguus* existed near this point until a short time ago, when the area was cleared for a housing project. Little is known of the composition of the colony. A small lot of snails in the Simpson Collection marked "Hammock near Chas. Mosier's" may be from this locality:

5 *elliottensis*
2 *castaneozonatus*—Both of "*miamiensis*" pattern.

MIAMI RIVER AND VICINITY

The margins of the Miami River, the edges of the transverse glade inland, and the coastal area south of the river formerly supported a number of hammocks, practically all of which contained colonies of tree snails. Most of these hammocks have now been partly or wholly destroyed by the growth of the city. The only considerable areas remaining are in Brickell Hammock along the shore of Biscayne Bay south of the river.

The colonies in the vicinity of the Miami River show a consistent resemblance in texture, shape, and general coloration. Brickell Hammock has furnished types for nearly all the variants named from the East Coast ridge section since Pilsbry's original work. Living tree snails are not now present in any hammocks north of the river, but some still persist in a few localities in the coastal area to the south.

In general, the Miami River hammocks follow the same pattern of distribution already noted at Arch Creek and along Little River. None of the hammocks discussed below is in the open pinelands; all are along the margins of the streams of the area or along the edges of the glades.

14. Hammock on Miami River Canal just west of 27th Ave., SE. ¼ sec. 28, T. 53, R. 41. Specimens in various collections, principally U.M.M.Z.

A small hammock, locally known as "Watson's Hammock," formerly centered around N. W. 28th Ave. and 21st St., but has been completely obliterated by building developments. Only a few scattered trees mark its previous extent. No *Liguus* in recent years. The collection in the University of Michigan Museum of Zoology contains 160 specimens from here, of which 48.1 per cent are of form *roseatus* and 51.9 per cent of *elliottensis*.

The shells taken in this hammock in 1933 have a very chalky texture and the tips are soft and easily broken. This seems to be correlated with the pumping of several thousand cubic yards of limestone and sand out of the Miami River Canal directly into the middle of this hammock during dredging operations in the preceding year, so that

only the tops of the larger trees were above the surface. This chalky condition of the shells persisted until after the hammock floor had been re-covered with leaf mold; then the snails which still remained in small patches scattered among houses and other buildings were observed to have developed shells of texture similar to those from other hammocks in the region.

15. Hammock 2½ miles up Miami River on the north side (Pilsbry, 1912).

Pilsbry (1912) noted that specimens of *Liguus* were taken on the north side of the Miami River, about 2½ miles up: "There are 8 *castaneus,* 5 *roseus,* and 6 *crenatus* . . ." There is now no hammock, nor any indication of the former existence of a hammock, on the north side of the river that distance from the mouth. The locality and its colony of tree snails seem to have been completely lost.

16. Hammock where city of Miami now stands, SE. ¼ sec. 1, T. 54, R. 41. Specimens in Simpson Collection.

A hammock, mentioned by Pilsbry (1912) and others, formerly existed just north of the Miami River near its mouth. It has now been completely obliterated by the construction of a number of hotels and other buildings. Only a few large hammock trees mark the former extent. The Simpson Collection contains shells secured by J. A. Stevenson, probably before 1900. These represent the following types, but are probably only part of a larger lot:

2 *castaneozonatus*—One of these shells is the variant "*miamiensis*"; the other is "*castaneozonatus,*" but not typical of the type from the Brickell Hammock just south of the river.
3 *elliottensis*
1 *roseatus*—Lacking heavy yellow banding.
1 *ornatus*—Small, but characteristic of Brickell Hammock type.

Pilsbry (1912) mentioned that *Liguus* collected north of the Miami River (near its mouth) are typical of the Miami area, but that there are no *testudineus* types.

17–18. Hammocks in the vicinity of Red Road. Specimens in the U.M.M.Z. and probably in the Simpson and other collections.

Several small hammocks apparently occurred in the vicinity of Red Road near N. W. 4th St. One of these contained a pure colony of *elliottensis,* and I have been told that there was also a colony of *loss-*

manicus in the vicinity. The Simpson Collection contains a lot of about 10 *elliottensis* with an almost indecipherable label which seems to read, "Franiage's Hammock, near Miami River." These snails may be from one of the hammocks of which traces can still be seen in the area.

19. Hammock at head of Miami River, SW. ¼ sec. 34, T. 53, R. 41. Specimens in Simpson Collection, the U.M.M.Z., and other collections.

The small hammock near the old head of the Miami River has been considerably changed by burning and clearing, but small patches still persist and *Liguus* occurred there as late as 1937. Before about 1934 the colony was fairly large and specimens were frequently found on cypress trees along the stream (now a canal). Part of the types of Simpson's *livingstoni* apparently came from this location and one is figured in his 1929 paper. An examination of all lots of specimens obtainable shows the following proportions of forms:

18 *elliottensis*—Apparently more common on the cypress trees than were the other types.

5 *lossmanicus*—Badly faded specimens.

20 *roseatus*—All except one of Simpson's form "*livingstoni.*"

15 *castaneozonatus*—Although these shells show flecks of dark pigment on the upper whorls, they are little more than *roseatus* with traces of pigment.

20. Hammock at N. W. 22nd Ave. and Miami River, sec. 34 near center, T. 53, R. 41. Specimens in Simpson Collection.

A small hammock persisted at this location until fairly recently, when all except a few larger trees were removed. The Simpson Collection contains 3 shells attributed to this locality and collected by Karl Squires:

2 *elliottensis*—Very inflated.

1 *roseatus*—Variant "*livingstoni.*"

21. Hammock in Lawrence Park, SE. ¼ sec. 34, T. 53, R. 41. Specimens in Simpson Collection.

A small plot of hammock is preserved in private grounds on an elevation overlooking the Miami River near N. W. 17th Ave. No living *Liguus* from this area in recent years, although they persisted there until about 1933–35. A small lot in the Simpson Collection contains:

2 *lossmanicus*—Badly faded.
1 *marmoratus*—Badly faded, and may represent a *testudineus* type.
2 *ornatus*—Both of these shells have white tips, but pinkish columellas; one is highly colored on the last whorl.
2 *castaneozonatus*—Both variant "*miamiensis*" and similar to shells from Brickell Hammock.

22. Hammock on Miami River just west of N. W. 12th Ave., SW. ¼ sec. 35, T. 53, R. 41.

Patches of hammock still persist along the edge of the river in this area, and large hammock trees are common in the vicinity. C. N. Grimshawe told me that he formerly collected fragments from this area, which probably represented the original colony. Nothing is known of the color forms or other characteristics of the population.

23. Hammock near Ada Merritt School, SW. ¼ sec. 1, T. 54, R. 41.

A small hammock around the present site of the Ada Merritt Junior High School was cleared about 1921. Large hammock trees still remain in the vicinity, but no *Liguus* are known from the locality although they probably occurred.

24. Hammock near S. W. 6th St., west of 3rd Ave., SW. ¼ sec. 1, T. 54, R. 41.

Areas of second-growth hammock occur at several places in this vicinity and may have been continuous with Brickell Hammock. A small lot of shells in the Simpson Collection marked "W. of RR on Miami River, S. of River" may be from this area:

2 *elliottensis* (1 dead)
1 *castaneozonatus* (dead)

25. Brickell Hammock, the Big Hammock, or the Great Miami Hammock, secs. 1, 12, 14, 15, T. 54, R. 41. Specimens in many collections, including the Simpson Collection and U.M.M.Z.

This large hammock, which formerly extended from just south of the mouth of the Miami River almost to Coconut Grove, was probably the most extensive jungle hammock which has occurred in Florida within recent times. It is today a badly dissected remnant, of which only a few scattered patches, such as that in Simpson Park or in the confines of private estates, have any chance of being preserved. The former abundance of *Liguus* in this hammock is legend. One collector

is supposed to have gathered a washtub full of snails following the 1926 hurricane. The abundance of dead shells in certain areas is astounding, indicating an enormous population. This population was rich in color forms as well as in individuals, a reflection of the great age of the hammock as well as the generally favorable environmental conditions.

The great decrease in abundance of the tree snails, which now approach extinction, has been owing to many factors. Undoubtedly, within recent years the activities of collectors have served to deplete the numbers, but the principal factors seem to have been the dissection of the hammock by roads, the clearing of land with subsequent burning of the plant material, and the opening of paths and trails through the denser parts.

There was probably never a single uniform colony occupying the entire Brickell Hammock. Within recent times a number of distinct colonies have been recognizable, and it is hoped that a study of these may help to untangle some of the problems of the inheritance of color patterns. Unfortunately, in most collections from the hammock there has been no attempt at localization, so that recent changes cannot be correlated with original conditions.

An attempt to determine the exact original extent of Brickell Hammock has been tedious and disappointing. Considerable data have been accumulated, but no satisfactory map can yet be drawn. According to a map published by Allen R. Parrish in 1905, the "Big Hammock" extended north along Brickell Avenue (U. S. Highway 1) to just north of old Broadway (now S. E. 15th Road). This probably indicates that the northern end of the hammock was already cleared before 1905. *Liguus* occurred, before 1905, as far north as the Miami River, which can be determined by old records and the actual occurrence of shell fragments in the vicinity of the S. E. 2nd Ave. Bridge. There are shells in the Simpson Collection from the vicinity of S. E. 11th St. and Brickell Ave., and practically all the shells in older collections probably came from the northern parts of the hammock. Today *Liguus* survive only south of 15th Road, principally in protected areas, such as Simpson Park and the Deering Estates, and even there the dark color forms, most cherished by amateur collectors, have been almost completely eliminated.

The Brickell Hammock colonies are peculiarly uniform in texture and general facies, which makes them unique among the South Florida groups. The hammock seems to have served as a center of distribution for the color forms of the whole Miami area, northward and southward, and probably represents the first colony established on the mainland. An analysis of the population, based on all available collections, would be extremely valuable in interpreting the recent distribution of the genus in the East Coast ridge section.

In the collections examined, the following color forms recognized by Clench and Fairchild (1939) have been observed: *elliottensis, cingulatus, lossmanicus, ornatus, roseatus, lineolatus, castaneozonatus, deckerti, testudineus, castaneus, marmoratus,* and a questionable *fuscoflamellus.* Pilsbry (1946) gave data on the proportions of color forms in the McGinty Collection, which adds a doubtful record of *matecumbensis.* This list of forms does not, however, represent the multiplicity of color-pattern types or variants. Almost every possible combination is represented, even patterns represented elsewhere only on the lower Florida Keys, such as a negative xanthistic form corresponding to *cingulatus.*

HAMMOCKS SOUTH OF MIAMI RIVER AREA

In general, the hammocks south of the Miami area have suffered less than those north of the river. Because of their accessibility, many of them have been repeatedly depleted of tree snails, and the colonies are greatly reduced. Only a few known colonies, however, have been completely exterminated or been reduced to a point where extermination seems inevitable. A number of hammocks in the pinelands north of Homestead have been completely cleared, and all records of their location and tree snails, if any, have been completely lost. Mention of several of these is made in the various botanical papers of J. Kunkle Small.

26. Twin Hammocks, just south of Coral Gables Canal near Ingraham Highway, sec. 32, T. 54, R. 41. Specimens in U.M.M.Z. and probably other collections.

Two small hammocks, visible from the highway, in this area formerly supported colonies of *lossmanicus.* The shells were moderately in-

flated, rather heavy, and more or less typical of the East Coast ridge type. No living *Liguus* have been found there in recent years, but specimens from other localities have probably been introduced. These hammocks differ from all others listed in that they are in pinelands, and apparently developed around potholes rather than on a stream or glade margin. They may be remnants of a larger hammock which once occurred in the vicinity.

HAMMOCKS ON THE PENINSULA OPPOSITE MIAMI AND ON OFFSHORE ISLANDS IN THE VICINITY

There are records of small hammocks on Indian mounds and other situations along the bay shore of the peninsula opposite Miami, and for Key Biscayne. Most of the hammocks have been completely destroyed. Little is known of the colonies of tree snails which probably inhabited most of them.

27. Hammock north of Baker's Haulover, sec. 23, T. 52, R. 42.

I have been told that a small strip of hammock formerly occurred in this area and that shell fragments have been collected there.

28–29. Hammock on Indian mound in Surfside, sec. 24, T. 52, R. 42.

According to Goggin (1948) the Indian mound, of which traces still exist in the area, was a small hammock-covered island in the mangrove swamp before filling operations were carried out. Shell fragments have been found there, but show no indication of pattern. Simpson (1929) mentioned a locality on the "Peninsula opposite Lemon City," from which he obtained the variant "*eburneus.*" The specimens are in his collection and may have actually come from the Surf-side locality, but his label places the situation in the La Gorce Golf Course area farther south in Miami Beach.

30. Hammocks on Key Biscayne.

Binney and Bland (1869) figured a specimen apparently *elliottensis*, supposed to be from Key Biscayne. Pilsbry (1912) reported that he found no hammock on the south end of the island, but he was given a specimen of *Liguus* of the Miami type that was said to have been collected on the island. It is possible that these and other records represent shells actually from Brickell Hammock across the bay.

RECORDS FROM MIAMI AREA FOR WHICH NO DEFINITE LOCATIONS ARE KNOWN

Besides the localities listed in this paper, there are snails in the Simpson Collection and elsewhere from localities which cannot now be exactly determined. Some of these doubtlessly are from one of these hammocks, but exact correlation has not been possible. If the locality seems to be identical with one of those given above it has already been mentioned there.

Merritt's Island northwest of Little River.

A single fragment with no indication of pattern which bears this label is in the Simpson Collection.

?Shultz Hammock, N. of Little River.

A small lot of shells in the Simpson Collection bears an almost indecipherable label which seems to read "Shultz Hammock":

3 *elliottensis*
1 *roseatus*
3 *castaneozonatus*—Variant *"miamiensis."*

McViegh Hammock, Little River.

Another small lot in the Simpson Collection is labeled "McViegh Hammock":

2 *elliottensis*
1 *roseatus*
3 *castaneozonatus*—Variant *"miamiensis."*

ACKNOWLEDGMENTS

I wish to acknowledge the kindness of Dr. F. G. Walton Smith and Dr. E. M. Miller of the University of Miami, who gave me access to the collections of that university, which include the C. T. Simpson Collection. I also wish to thank Dr. I. J. Cantrall and Dr. Henry van der Schalie of the Museum of Zoology of the University of Michigan for suggestions and criticisms of the manuscript.

SUMMARY

Localities in and around Miami, Florida, in which tree snails, *Liguus fasciatus,* occur or formerly occurred were studied in order to determine the nature and composition of the colonies. Study of preserved

specimens was supplemented by search for fragments or other indications in the localities cited.

Extinction of the tree-snail colonies has been due to many factors, but was mainly caused by the destruction of the stands of the jungle-hammock associes in which they occur. There is some evidence that *Liguus* was characteristic of a subclimax phase of the development of the hammocks and, therefore, became rare and finally disappeared in old hammocks such as those around Arch Creek.

Jungle-hammock associes in the region considered have a typical pattern of distribution: they occur along the edges of streams which cut across the limestone East Coast ridge or rim of the Everglades and along the edges of transverse glades inland. This peculiarity of distribution does not seem to have been mentioned in ecological studies of plants. A few hammocks do not conform to this pattern, but have developed along the coast, on Indian mounds, or around potholes in the pinelands.

Destruction of tree snail colonies has been almost complete north of the Miami River. Color forms with dark pigmentation appear to have been completely exterminated.

Brickell Hammock south of the Miami River seems to have been a center of distribution for color forms of *Liguus* along the East Coast ridge.

Examination of Simpson's specimens from the vicinity of Arch Creek confirms his statement regarding the occurrence of apparent hybrids between *Liguus fasciatus septentrionalis* and *L. f. roseatus.*

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