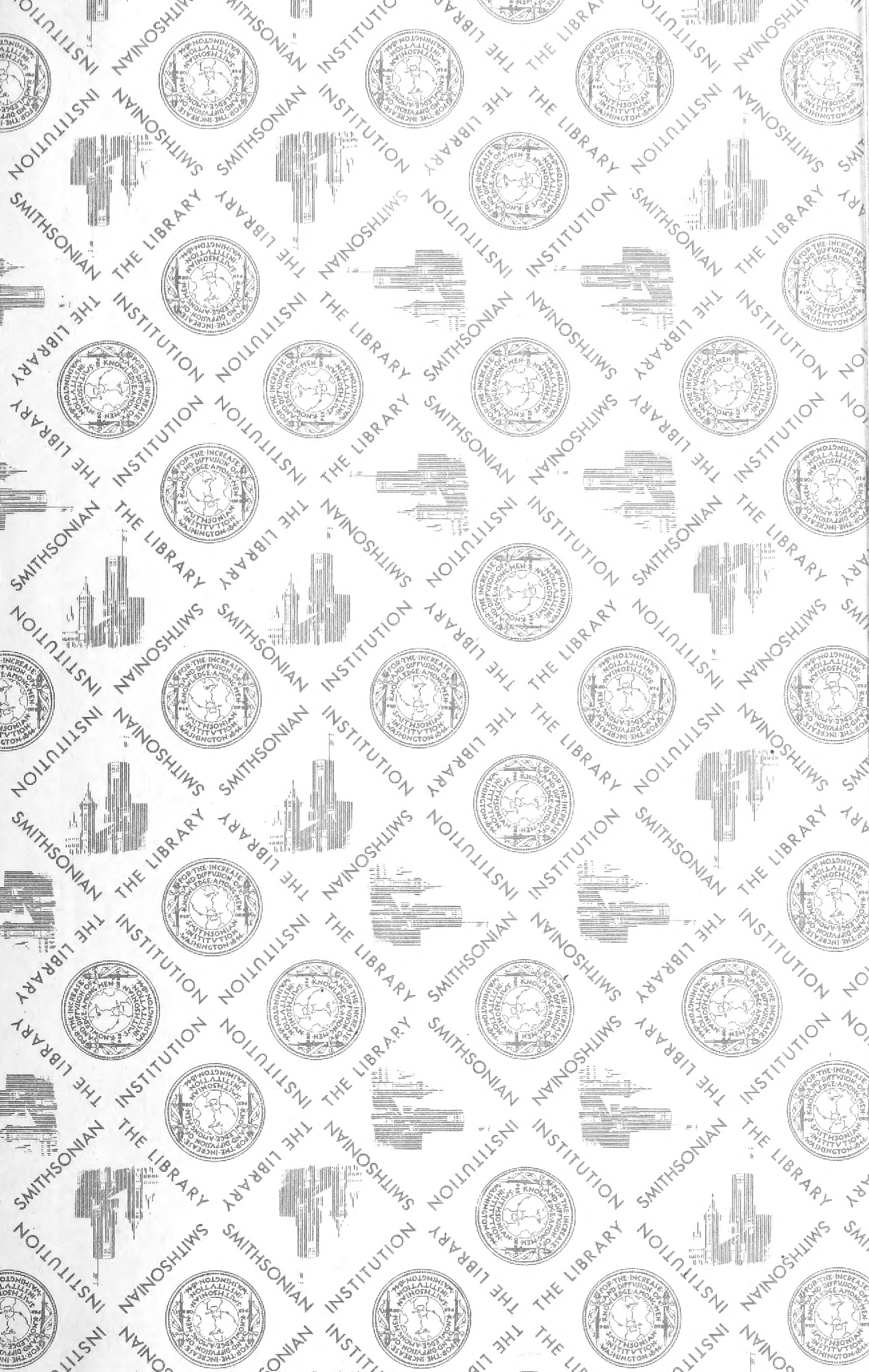

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J. C. Dickinson, Jr., *Editor*

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THE QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

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THE EFFECTS OF HURRICANE DONNA ON THE VEGETATION OF SOUTHERN FLORIDA[1]

FRANK C. CRAIGHEAD AND VERNON C. GILBERT
Everglades National Park

On September 20, 1960, a few days after Hurricane Donna crossed the tip of Florida, W. B. Robertson, Jr., Field Research Biologist for Region One, National Park Service, proposed a study of the biological effects of this hurricane in Everglades National Park. The writers undertook an appraisal of the damage to the vegetation of the area. In many ways the collection of the materials for this report has been a joint effort by the Everglades National Park Naturalists and Rangers, along with other members of the Park Staff. The help and suggestions of local botanists and agriculturists were sought. T. R. Alexander, of the Botany Department, University of Miami, John Popenoe and Carl W. Campbell of the University of Florida Subtropical Experiment Station, and others visited the area with us and offered many suggestions. Dr. Alexander and Dr. Robertson have both been very helpful in reviewing the manuscript. Gordon Dunn and Leslie Conover of the National Hurricane Center in Miami discussed with us many features of the storm in relation to our observations of damage to vegetation, and furnished a detailed chart of the hurricane's path and progress. Erdman West of the University of Florida has determined for us most of the plants mentioned.

THE GENERAL PICTURE

Hurricane Donna moved northward along the west coast of southern Florida on September 10, 1960, leaving in its path extensive damage to the vegetation and effecting many physical changes in the soil and local topography of the area. The storm track is shown on the map. Fig. 1.

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[1] Manuscript submitted for publication July 3, 1961.

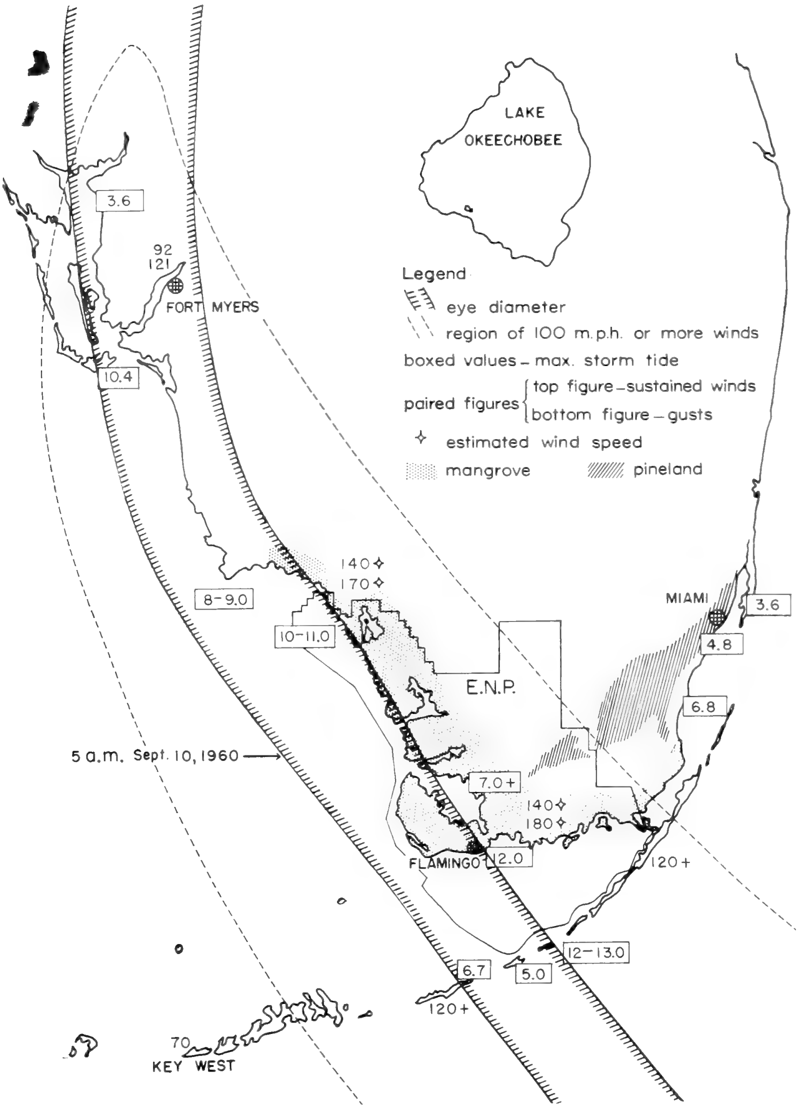

Figure 1. Track of Hurricane Donna in Southern Florida.

The slow forward movement of the hurricane in southern Florida, approximately 14 miles per hour, subjected the vegetation to damaging winds for nearly 36 hours. In the Flamingo area estimated sustained winds were 140 mph with gusts to 180 mph or more. High storm tides in Florida Bay and along the lower Gulf Coast also contributed greatly to the damage. Maximum storm tide at Flamingo was 12 feet above the normal high tide. At present, more than 9 months later, the damage can be only partially evaluated. Sample plots are being established for this purpose, and for long range observations of successional trends in areas where the vegetation is destroyed.

Hurricane damage to the vegetation was generally most severe in the mangrove belt and on the keys in the western portion of Florida Bay. This area, except for a small section from Little Madeira Bay eastward, was within the path of the wall cloud of Donna, where the strongest winds were located. Storm damage lessened inland away from the storm center and wall cloud. However, this was extremely erratic, depending on the eccentricities of the wind, the type and size of vegetation, character of the soil, and other factors, some of which are not clearly understood at this time (Dunn and Miller, 1960).

The Mangrove Belt

Hurricane Donna is the second severe storm to strike this area in recent years. In 1935 a hurricane virtually demolished the mature mangrove forest along the mainland coast of Florida Bay around Flamingo and Cape Sable. Estimated wind velocities up to 200 miles per hour and a hurricane tide of 11 to 18 feet have been reported for this storm. (Parker 1944) This forest in the Flamingo area was a fine mature stand of red, white and black mangroves, and buttonwood, called the "black forest" by some of the former residents. Trunks of many large dead trees killed in the '35 storm were still standing when Donna struck. Some living trees, survivors of the 1935 storm, were also present. Most of these were killed, but a small number are recovering. These large black mangroves are conspicuous above the broken remains of the second growth forest that developed since the 1935 storm. Fig. 2.

The most severe damage in the mangrove belt from hurricane Donna occurred from Madeira Bay westward to Shark River. Between Flamingo and West Lake there are many places where nearly all of the trees over 2 inches in diameter are sheared off 6 to 10 feet above the ground, suggesting that higher wind velocities occurred locally. The twisted trunks and limbs make a nearly impenetrable tangle.

Figure 2. Remnants of the "Black Forest" trees that survived the 1935 storm and second growth understory, 20-25 years of age, recently destroyed by Donna. Flamingo, Monroe County.

From Shark River northward a large part of the mangrove forest survived the 1935 storm. Now from the Shark to Lostman's River 50 to 75% of these mature mangroves, some reaching 80 feet in height and over 2 feet in diameter, are dead. Fig. 3. The damage is extremely erratic; in some places there will be sufficient recovery to form a closed canopy in several years, but in other places for many years there will be very open stands in contrast to the dark, well closed canopy so characteristic of this forest before the storm. Northward from Lostman's River to Everglades City the mortality drops to 10-25% except for small local areas.

The "scrub" mangroves along the inner fringe of the mangrove belt were damaged only slightly. Also throughout the extensive area of deadenings, the buttonwood hammocks suffered much less and are now sharply set out as green areas spotted through the dead mangrove stands. These hammocks usually occur on ground 6-18 inches higher than the mangroves.

Figure 3. Aerial view of mature stand of red, white and black mangrove along Shark River, mostly standing—practically 100% mortality.

The Florida Bay Keys

Over one hundred islands dot the shallow waters of Florida Bay. Most of these are remnants of the mainland marl rising from a few inches to 2 feet above mean sea level. In general, the severity of damage to Florida Bay keys increases from the eastern half of the Bay westward to Sandy Key. Fig. 4. This damage is erratic, but it is chiefly the southeastern portions of these keys where defoliation and breakage was most severe.

Coconut palms, *Cocus nucifera* L., suffered severely. The large clump on the north end of Buoy Key was torn away. On Clive Key only seven out of about twenty coconuts are left standing. Palm Key, before this storm, supported about fifty large cabbage palms, *Sabal palmetto* (Walt.) Lodd. Many of these had survived the 1935 storm; now all but three of the larger palms are torn away. Sixty-seven of the younger trees 6-10 feet tall survived. Thatch Palms, *Thrinax parviflora* Sw., fared much better. On Clive Key some 30-40 remain standing. Four were blown down but will probably continue to grow. Many of the thatch palms in the vicinity of Fan Palm Hammock were flattened by the 1935 hurricane, but nevertheless many of these lived and developed new upright trunks. Measurements and comparisons of the relative length of the flat and upright portion indicated these palms to be over 100 years of age. The larger cabbage palmettos on Palm Key are probably about the same age.

Figure 4. Sandy Key showing the hammock trees scattered across Florida Bay.

Several larger islands in Florida Bay, including Palm, Oyster, Clive, Murray, Man o' War, and Otter Keys, were examined in more detail on foot. These keys are highest on the levee-like rim just inside the mangroves where they support some hardwood trees. The interior is covered by several species of grasses, *Sporobolus virginicus* (L) Kunth, *S. domingensis* (Trin.) Kunth, *Spartina spartinae* (Trin.) Merr. *Cenchropsis myosuroides* H.B.K. and *Monanthochloe littoralis* Engelm. and salt tolerant plants, *Batis maritima* L., *Sesuvium maritimum* (Walt) B.S.P., *Salicornia perennis* Mill., depending on the elevation, becoming more sparse toward the lowest central ground which is a bare marl flat covered with water in the rainy season. The mangrove rims were badly broken, especially on the east and south sides, and the broken trees carried across and piled up on the north and western fringe. This drift line of debris averaged about 8 feet high. All trees were defoliated except the low shrubs and an occasional clump of trees of the mangrove fringes. Observation in the early '50's and inquiries from people who knew the keys before and after the 1935 hurricane indicated the mangrove fringe on many keys was completely torn away by that storm.

The herbaceous and shrubby vegetation of the interior was little affected. Exceptions noted were on Man o' War and Oyster Keys where the top soil was washed off on the levee-like rim and the herbaceous plants uprooted. Many of the large key lily, *Hymenocallis* bulbs were found hanging in trees with the drift. Hundreds of these were carried to the mainland where they were left along the shore or hanging in the brush by their dried leaves.

The 10,000 Islands

Most of the 10,000 Islands were in the path of the eye of Hurricane Donna (Fig. 1), yet the damage here was very local compared to the Flamingo area. The outer keys facing the Gulf of Mexico sustained the most severe damage. Many of these were considerably altered along the shoreline, and in case of the smaller ones, most of the vegetation was washed away. Comer Key (formerly known as Pelican Key) was swept clean except for a few tree snags and sand was piled up 5 to 7 feet high in places on the small island. Almost as severely damaged were Pelican Key (formerly called Bird Key) and Duck Rock, two well known bird roosts. Fig. 5 shows the extent of damage to the vegetation on Duck Rock. Many of the trees were torn from this key and washed across the shallow water almost to the mainland. On the keys with beaches, the sand and shell was piled up and washed back into the mangroves to depths of one to five feet.

Cape Sable

Northwest and Middle Capes project into the Gulf of Mexico to the west, and East Cape faces Florida Bay to the south.

The vegetation on the Cape, exposed to the full force of the hurricane wind and tides, was markedly affected, primarily by a tidal wave 6 to 8 feet high, as indicated by debris hanging in the trees. The beauty of the Cape was temporarily enhanced by the storm. Beach sand was washed inland covering low vegetation and widening the beach in many places. The low dune area, studded with cabbage and coconut palms, was stripped of much of its

Figure 5. Duck rock one month after storm. Formerly a heavily wooded bird rookery.

Figure 6. N.W. Cape Sable showing the windrow of vegetation piled up against the hammock by Donna.

shrubby growth, yuccas, agaves, cacti, grasses, and small scattered hardwoods. These were piled up in a row against the hammock growth of the higher inland dunes. Fig. 6. Formerly this area was difficult to walk through; now it is easily traversed and the low dune and trough structure is readily apparent.

Cabbage palms were scarcely harmed except for fraying of the leaves and an occasional prostrated one. Apparently these were not blown over, but were toppled by the force of water against the accumulation of debris collecting on the lower 6 to 10 feet of the trunks. The coconut palms, remnants of an old coconut plantation, were more susceptible and greater numbers were swept over. Many of the slender-trunked thatch palms, fairly abundant in the hammock areas on Middle and East Capes, were bent over and the leaves shredded, but most of these will survive.

Pineland

The pines on Long Pine Key, on the outer edge of the wall cloud, seemed to be just about as resistant to hurricanes as they are to fire. Tallies along the Long Pine Key fire roads indicated 1 or 2 windthrown or broken trees per acre. In general, there were more fallen trees on the better sites at the east end of Long Pine Key. Throughout the pineland fresh branches and needles covered the ground. However, pineland nearer the center of the storm path in the Ft. Myers, Naples-Corkscrew area west of Immokalee, Collier County was more severely damaged.

Open Everglades

Of the major vegetative types in South Florida, the Sawgrass Everglades suffered the least. There was wind breakage and general defoliation of larger trees in the bayheads and willow heads, but no apparent damage to low vegetation of the 'glades. About the only effect which may prove to be of some future interest was the piling up of grasses and other vegetational debris into windrows up to 4 feet deep. These were formed along the road, against trees, bay heads, hammocks, or any other obstruction. They form slight elevations of humus accumulation and will serve as a base for the invasion of hardwoods. Spider lily, *Hymenocollis,* fruits were found in abundance in these windrows.

Cypress and Willow Stands

Damage to cypress in Everglades National Park occurred mostly in the more mature cypress heads and sloughs where a few of the taller trees near the centers were toppled. The lower vegetation and the epiphytes seemed to be less disturbed in these thick stands. Outside the Park in the Corkscrew area mature timber was badly broken. Nearly all such trees at Corkscrew Swamp were defective and hollow. Windthrow was much less than breakage. The open "scrub" stands of cypress suffered little damage. These stands were defoliated, but they leafed out within three weeks after the storm.

Hammocks of the Pineland

Hammocks of the pineland on the Everglades Keys are rich in tropical plants including many rare species which grow nowhere else in southern Florida. Some 25 of the 125 hammocks on Long Pine Key have been traversed, but more observation and detailed sampling are needed to appraise the storm damage.

Most of the large trees on Paradise Key came through relatively well. The worst damage was along the eastern side of the key facing Taylor Slough where several of the large live oak trees and Royal Palms were blown over in a westernly direction. The north end around the Gumbo Limbo Trail suffered most in limb breakage, resulting in an opening of the forest to light and completely altering its former jungle-like appearance.

The trees of Palma Vista I and II, the large hammocks along the road approaching Paradise Key, were both badly broken on the eastern side facing the glades and almost completely defoliated. This gave them the appearance of a northern hardwood forest in winter. Brush and broken tops litter the ground, opening these deeply shaded hammocks to intense sunlight. This will markedly alter the relative abundance of the species in the future stand. Already dormant seeds, such as wild papaya, are sprouting and low suppressed seedlings are elongating in response to the increased light and warmth of these openings. The greatest loss in these hammocks was to the orchids, bromeliads and ferns as described later. Several months after the hurricane, damage to these hammocks is not conspicuous to the visitor who is not familiar with the area, but the botanical and ecological changes will be of great interest for years to come. In general, these conditions apply to all the hammocks that were examined.

Mahogany Hammocks

Several mature mahogany hammocks lie in the southwestern Everglades near the transition zone between the glades and mangrove forest. The characteristic rolling-dome skyline of these hammocks has been leveled off. Figs. 7 and 8 show the Mahogany Hammock—through which a nature trail passes—before and after Donna. The extent of the debris torn from the trees was well illustrated in this hammock trail. The elevated boardwalk with railings about 4 feet high was filled for most of its length with leaves and branches. Fig. 9.

Alexander (1953) in calling attention to the large mahogany trees in Mahogany (trail) Hammock pointed out that repeated hurricane damage was evident in the numerous broken tops and windfalls. These tall, exposed, and shallowly rooted trees are susceptible to wind breakage. A locally severe storm in 1958 broke many branches and threw several trees in this hammock. In view of the susceptibility to storm and the extreme damage resulting from Donna, it seems probable that these hammocks have escaped the most severe hurricanes in the past, for some of the large trees are estimated to be over 200 years old.

Several clumps of Paurotis palms *Paurotis wrightii* (Grisib & Wendl.) Britton were badly broken. This palm was damaged badly throughout the mangrove belt. Growing tips were broken out and many stems bent over or sheared off. These slender, hard and tough stems would be expected to show greater storm resistance. They were formerly used by fishermen for net racks and pounds.

Coastal Hardwood Hammocks

East from Flamingo to Crocodile Point and northwestward to behind Cape Sable are small to extensive areas of tropical hardwood hammocks on the slightly higher marl deposits of this coastal area. *Sabal palmetto* (Walt.) Lodd., *Piscidia piscipula* (L) Sarg., *Coccoloba diversifolia* Jacq., *Randia aculeata* L., *Eugenia myrtoides* Poir., *Erythrina herbacea* L., *Sapindus saponaria* L., *Ficus aurea* Nutt., and *Swietenia mahogoni* Jacq. are the characteristic trees of these hammocks. Many trees are broken or uprooted, by

Figure 7. Mahogany Hammock before Donna.

Figure 8. Mahogany Hammock a month after Donna.

the wind and the tidal wave. In general, these appear to be recovering well, as seen from the air. It has not been possible at this time to examine much of this extensive hammock area. A nearly pure stand of several acres of manchineel, *Hippomea mancinella* L., was badly broken and many trees were killed. A very large (nearly 12″ in diameter) caper tree (*Capparis cynophallophora* L.) located near Monroe Lake, was blown over.

Figure 9. Mahogany Hammock trail to show storm debris.

Buttonwood Hammocks

These hammocks are scattered through the mangroves on slight elevations of marl or on humus accumulations of 6-18″. They were battered and broken much as the mangroves were, but all show more rapid recovery. The mortality probably will be less than 50%. In many of these hammocks the prostrate trunks of trees blown over by the 1935 storm are still present; some are dead, but many are still alive, bearing numerous new stems extending upright from the old procumbent trunks. Some of these old trunks are 4 ft. in diameter. The succulent, shrubby cacti, *Acanthoceus floridanus* Small, *Harrisia simpsonii* Small, and *Opuntia dillenii* (Ker.) Haw, characteristic of these hammocks, were badly broken and scattered. Many of these broken pieces, lying on the forest floor, are now growing.

Hurricane Effects on Epiphytes and Ferns

One of the special attractions of the Park is the great number and variety of the epiphytic plants. These suffered extensive damage that will not be corrected in many years, especially in the coastal areas. Most of these plants were torn from the limbs along with the foliage or were carried to the ground with the broken branches and the tree tops. Many of those falling to the ground in the mangrove forest were covered with silt Fig. 10 and salt water and rotted within 2 or 3 weeks; others were severely sunburned and killed gradually. In the hammocks, glades and pinelands over 50% of the epiphytes are believed to be destroyed and in the mangrove belt the loss may exceed 90%.

Some specific cases are as follows:

The mule ear orchids, *Oncidium luridum* Lindl., in the Flamingo area were decimated. Nearly all large plants were destroyed except those well above the tidal wave and those attached on the shaded north sides of wind firm trees.

All clumps of the dollar orchid, *Epidendron boothianum* Lindl., seen to date were killed or so badly sunburned that only an occasional plant will survive.

About half the plants of the leafless vanilla vine, *Vanilla barbellata* Reichb., examined were destroyed.

Nearly half the plants of the rare *Macradenia* orchid in the only known colony were badly burned and destroyed.

Only three plants of the rare spider orchid, *Brassia caudata* (L.) Lindl. remain in fair condition.

Figure 10. Dead bromeliads filled with silt. These were nearly all killed when submerged by the silt bearing tidal wave.

The few known plants of the sweet-scented fern, *Adiantum melanoleucum* Willd., were exposed and badly sunburned. A shade was erected over those remaining. Possibly some will survive.

A colony of the hand fern, *Ophioglossum palmatum* L., was largely torn from the palmettos, but a few plants on the lee of the trunks survived. Others may sprout from roots. The trunks of many palmettos were completely cleaned of leaf stubs and polished by the wind and moving fragments of debris. Even exposed dead pine snags were polished and the grey patina removed down to the hard reddish summer wood.

The yellow catopsis, *Catopsis berteroniana* (Schult) Mez., a conspicuous yellow-green air plant growing on shrubs along the highway, was quite wind resistant and few plants were torn from the branches. The stiff-leafed airplant, *Tillandsia fasciculata* Sw., likewise held firmly in most places, especially in the open "scrub" cypress stands. The peperomias, *P. obtusefolia* (L.) A. Dietr., and *P. humilis* Jahl, which grow on low logs in the mangrove area, were practically all submerged and many plants killed. Only one clump was found where new growth had started 4 months after the storm.

WIND TOLERANCE, DEFOLIATION AND REFOLIATION

One of the first impressions on observing the tangled mass of vegetation immediately after the storm was that several species of trees were distinctly more resistant to winds of 100-150 mph than most. This impression is verified after checking in all vegetation types. However, any rating of species for wind tolerance must be made with qualifications. Soil conditions and exposure seem to be important. The trees when growing directly on rock that is not deeply pitted with solution holes were more often toppled. This was especially true where the surface rock had previously been pulverized for annual crops or orchards. There seems to be less damage to pine on the west end of Long Pine Key than on the eastern end, where the rock is less honeycombed.

Trees standing alone and those growing on the east and southeast sides of hammocks, facing glades, along roads or other openings where they received the full force of the wind, were much more severely damaged.

Vine-covered trees or groups of such trees in the hammocks were often toppled or broken off.

A slight rise such as the bridge at Flamingo deflected the wind and prevented defoliation of a few acres of buttonwood immediately southwest. Low vegetation up to 4′ or so in all areas was not seriously injured.

Seven species of trees stand out as conspicuously wind resistant after the storm. These are: Cabbage palm; royal palm; live oak, *Quercus virginiana* Mill; strangler fig, *Ficus aurea* Nutt; mastic, *Sideroxylon foetidissimum* Jacq; lysiloma, *Lysiloma bahamensis* Blenth; and pine, *Pinus elliottii* Engelm. The cabbage palm might be rated first. On exposed sites such as Cape Sable, the Flamingo area, and in hammocks as badly damaged as the Mahogany Hammock, this tree stood up well. Extremely few were uprooted or broken. Even the recently planted trees around the Flamingo developments resisted the high winds of this area; most of those that fell were pushed over by quantities of debris caught against them as the tidal wave came inland.

Royal palms in 4 of the 5 areas where they are known to occur within the Park were likewise resistant. In each area some trees were broken off or uprooted. Several tops were badly damaged, probably by heavy branches falling into them.

Pines proved to be highly resistant within the Park. Few trees were windthrown and very little defoliation occurred. Simpson (1932) reported complete defoliation and death of pine following an earlier storm in Cuba.

Lysiloma, fig, mastic and oak were the most resistant species among the hardwoods. In addition oak held its leaves in many places where all other species were defoliated; this no doubt increased windthrow. Many hardwoods lost branches and some were overthrown, but the above species in general stood up well.

The winter-like appearance of the hardwood trees immediately after the storm was a striking characteristic of the landscape. Probably 50 to 90% of the foliage of exposed trees was torn off in the inland areas and nearly complete defoliation resulted in the coastal regions. One week later, September 18, 1960, many plants showed new buds breaking and by the 24th of September new leaves were conspicuous on inland trees and on hammock trees of the mangrove area. Any slight elevation, such as the berm of the road beds, affording a better site and more vigorous growth, stood out conspicuously in the early refoliation. These beautiful pastel shades of green gave the forest the appearance of spring in the northern U. S. Indian mounds in the mangrove belt stood out as green islands of refoliating hardwoods in the brown mangrove forest. By October 10, the trees of the fresh water areas and in hammocks in the mangrove areas presented a uniform green that practically concealed all superficial damage. In the mangrove type refoliation of surviving trees was much retarded and many of the trees which put out leaves from adventitious buds later died.

Among the trees that responded most rapidly with new leaves were lysiloma, gumbo limbo, *Bursera simaruba* (L.) Sarg., pigeon plum, mahogany, wildlime, *Zanthoxylum fagara* (L.) Sarg., mulberry, *Morus rubra* L., and hackberry *Celtis laevigatta* Willd. Buttonwoods growing in hammocks were the earliest and most conspicuous refoliating tree in the mangrove area.

Several odd plant responses were noted following defoliation by Donna. The new leaves were usually much larger, 2-3 times the area of normal leaves, and as a rule much thicker.

Several species of plants that normally bloom in the spring and summer were observed flowering a few weeks after defoliation. Among these were a grape, *Vitis Simpsonii;* willow, *Salix longipes* Shuttl.; yucca, *Yucca aloifolia* L.; sweet bay, *Magnolia virginiana* L.; and woman's tongue, *Albizzia lebbek* (Willd.) Benth. Several species of plants that are deciduous, among them willow, persimmon, and cypress, refoliated and held much of the new foliage into January. Normally this would have been shed in November. Persimmon set fruit that ripened in January and was nearly normal in size, and *Albizzia* and *Magnolia virginiana* also developed some fruits through the fall and winter.

Edaphic and Physical Changes in Features

Donna profoundly altered some of the physical features of the area. A deposit of silt varying from a trace to 5″ was carried over the area inundated by the tidal wave. Fig. 11. Along the road a trace was left 5 miles inland, as far as West Lake. The deposit was heavier in the denser vegetation near the shore, building up the coastal flats of the mainland and adding to the higher rim

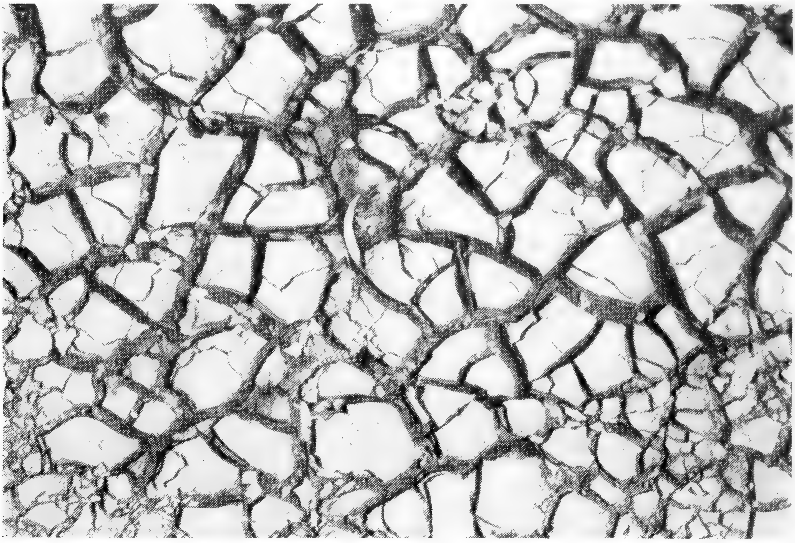

Figure 11. Marl deposit of about 4″ depth after it had dried. Thin deposits of this were extremely hard. Pieces tested in ceramic oven made excellent pottery, suggesting a source for the numerous chards in these local Indians mounds.

characteristic of the Florida Bay keys. This deposit is an important factor in raising the elevation of the land formation of the coastal prairie and hammocks and especially the Florida Bay keys, (Davis 1940), some of which are 18 to 24 inches higher than the interior land. An appreciable deposit was left in the coastal mangrove areas where 2 to 5 inches elevation is an important factor in the encroachment of other plant species into this type. This deposit is high in nutritive values as indicated by the luxuriant growth developing on it during the past few months.

Locally, coastal deposits were altered. The sand and shell beaches were often enlarged or pushed back farther into the mangroves. On Lostman Mound the shell deposit was reformed, the beach material removed and deposited on the rear of the mound in a drift about 12′ wide and 6′ deep. This buildup of coastal areas by the storm has undoubtedly contributed to, or in some cases accounted for, the shell mounds in the region. There is certainly ample evidence of Indian occupation, but in all probability storm activity has contributed greatly to the origin of some of these elevations, located inland from the oyster bars.

The low dune ridges of Cape Sable stand out more prominently now than before the hurricane removed the vegetation. These are apparently ancient beaches, storm-built ridges of the past. The low beach dune left by Donna is very conspicuous. Fig. 12. On Northwest Cape some two dozen of these ridges can be counted now that the low, shrubby vegetation is removed. As the water receded after Donna, a shallow deposit of marl was left in the low spots, varying from 3 inches behind the beach to ¼ inch inland. Layers of this marl silt have been deposited by successive storms. The deeper troughs, sealed by this marl, hold water during rainy periods.

On some exposed keys and coastal hammocks the entire humus deposit and surface soil was removed and the debris carried inward to form a moraine 2-5′ high where the vegetation acted as a barrier. This will stimulate hammock formation.

Some smaller keys were practically obliterated. Sandy Key was cut in two, and Cape Sable beaches were altered considerably. Inland, practically all the small mangrove creeks and canals were clogged with windthrown trees. The Bear Lake Canal, formerly 4-6′ deep, is now filled to within 6-12″ of the surface with organic deposit from the mangrove forest and marl from the Bay. This action will hasten the obliteration of those creeks where the currents are not strong enough to prevent further deposits of humus and silt. Many such filled creeks are present in the mangrove belt.

Figure 12. Northwest Cape Sable showing a new beach dune formed by Donna.

Many of the Florida Bay keys have moats up to 10′ deep and 50 feet or so wide on the northeast, east, or southeast side directly against the mangrove fringe. Dildo Key is nearly surrounded by such a moat. It seems likely that these were formed by storm waves beating against the solid wall of mangroves and scouring out the marl down to the Miami oolite bedrock.

Hurricane Effect on Plant Succession

Already it is obvious that this hurricane will have profound effects on plant succession throughout the area. Possibly just as important a factor as fire (Egler 1950, Harshberger 1914), frost or water levels that have previously been described and accepted (Davis 1940, 1943; Robertson 1953). A few obvious effects at this time are the altered species composition of the dead mangrove area. White mangrove seeds were abundant at the time of the storm and have been floated over much of the devastated area where they are now germinating. Many red mangrove seedlings survived and may form a high proportion of the new stands. Likewise the floating seedlings of this species have been distributed generally over the area and carried several miles back into the scrubby red mangrove stands in the brackish and fresh water glades, thus explaining the source of these inland mangroves. The marl deposit of 2 to 5″ in the low mangrove area will stimulate the transition to buttonwood hammocks and other hardwoods. The slight defoliation of the pines, permitting more sunlight to reach the forest floor, is already stimulating the growth of pine and hardwood saplings.

The more pronounced defoliation, windthrow, and breakage of the buttonwood hammocks are stimulating shrubby growth such as blueweed, *Borrichia,* and in the inland hammocks of the glades and pinelands the shade tolerant seedlings are putting on vigorous new growth and these will soon occupy the openings. The extensive destruction of epiphytes and ferns that formerly grew in shade has already been mentioned.

Many herbaceous and shrubby plants are occupying the denuded, defoliated areas in a surprisingly short time. For example, wild papaya seeds stored in the duff are germinating in the hammock openings. On the marl flats of the mangroves, extensive areas are turning green with the new growth from roots or seedlings of - - *Poinsettia, Cissus, Physalis, Melanthera, Rivina, Bidens, Solanum, Cardiospermum, Kosteletzkya, Momordica, Capraria, Sida, Heliotropium, Batis, Dondia* and several grasses.

Mortality of Storm Damaged Vegetation

What will happen to this storm-torn and defoliated vegetation? This question, in the mind of everyone viewing the desolation a few days after the storm, was answered in the fresh water areas of the Park one month later. Here refoliation was rapid, beginning in 7-10 days, and from the overall appearance the storm damage was obscured after 2 months. There will be little or no further mortality among the hammock trees. Likewise, the pines are in good shape, having lost little foliage.

The mangrove belt throughout the Park presents an entirely different picture. Over some 26 townships involving possibly 100,000 acres of forest land, 25 to 75% of the mangroves are dead.

In 12 townships nearly 90% of the mangroves have died on the lowest ground. In more local areas even the salt tolerant shrubs of the mangrove type such as *Batis, Dondia, Salicornia, Sesuvium* and *Lycium* were likewise killed. On the other hand, throughout this area plants of all species rapidly refoliated on the somewhat higher ground such as marl and humus elevations of 6 to 12″, road berms, canal banks, Indian mounds, buttonwood and hardwood hammocks. Much of the new growth was from adventitious buds along the larger branches and stems. Usually the inner bark (phloem) was bruised and destroyed on the smaller branches or these were broken off. One month after the storm only a very small percentage of the standing red, black, and white mangroves in the low devastated areas had developed foliage. This foliage on some 10% of these refoliating trees was withering by November 22, and many more trees died through the drier winter season. In general, most of the trees on slight elevations appear to have survived. This condition applies to all species, hammock hardwoods, buttonwoods, and all three mangroves when present on these sites, as well as the salt tolerant and hammock shrubs.

Throughout the low areas of nearly total mangrove mortality there are a limited number of trees of all three species surviving. These are seedlings 1 to 6 feet high that were not defoliated and larger trees that were windthrown early in the storm and not entirely defoliated. Also, some trees were held bent over during the storm by the wind, water, and the weight of fallen trees and so escaped more severe defoliation. Often 50-75% of the foliage on these trees remained intact. Also, by April 1961, it appears that a few widely scattered large black mangroves that were not windthrown but were defoliated have survived and are now refoliating. In Whitewater Bay and along the creeks and rivers, subject to tidal fluctuation, the perimeter of all land masses, i.e., larger islands and river banks, and the entire area of smaller islands is now green, the trees having survived and completely refoliated. Fig. 13. Apparently these narrow, rarely over 100′ wide, tide-washed strips of vegetation and smaller islands have fully recovered. This presents a very deceptive appearance from a boat cruising on these waterways. The green wall suggests little mortality, but actually much of the interior vegetation is dead as is readily seen from the air. Fig. 13.

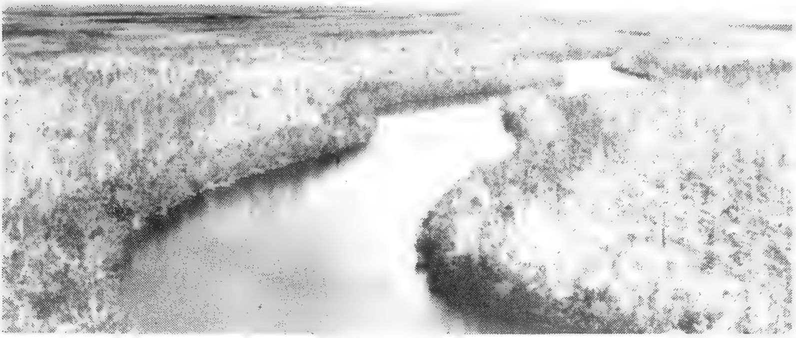

Figure 13. Green fringe of mangroves surviving along the tidal washed edge of a Shark River tributary. Inland 75-90% of the three mangrove species are dead and still standing.

Surprisingly little information describing this condition can be found in the literature. Simpson (1932) refers to dead stands of trees following hurricanes. Both mangroves and pines are discussed, and the theory advanced, based on an earlier report by the physicist Flammarion, is that these trees were killed by "silent" electricity passing between the storm and the earth, the trees acting as conductors (Douglas 1958). This may occur in some storms but does not seem to apply here. No observations of considerable electrical activity have been reported from the questioning of three men who remained through the storm at Flamingo. Furthermore, in areas of almost complete deadening the survival of a few large trees and many seedlings would refute this theory. This theory was discussed with Mr. Gordon Dunn, Director of the National Hurricane Center, Miami, Florida, who discounted the possibility. He did say that some hurricanes are accompanied by intense electrical disturbance at the time of their origin.

Another possibility considered was that of mechanical injury. The trunks and branches were whipped and shattered by the constant thrashing over a period of 36 hours. Many trees showed areas of separation of phloem and wood, but never the extensive separation described by earlier writers (Davis 1940). This separation of the bark from the wood is a later phenomena of the dead trees. On small trees 2-3″ in diameter and branches, some separation of annual rings was present resembling so-called "windshake" of northern forests. Examination of the bark of many of the dead trees immediately after the storm showed numerous transverse breaks in the phloem, from the twisting and bending. This inner bark was loosened at these breaks and bruises and necrotic areas formed in the phloem. Numerous wounds of this type together with massive disruption of the vascular system from constant bending in all directions, would appear to be sufficient to prevent the movement of liquids and stored food in the stems, and thus restrict its utilization for new growth. That such a simple mechanical explanation does not apply generally is evident from the survival of all species of plants on slightly higher ground within a few feet of extensive deadenings.

Much information is available on the effects of defoliation of trees by insects (Swaine 1924), frost, hail, and chemicals. Little damage results from a single defoliation. Repeated defoliations. depending on prior vigor, will gradually kill both deciduous and evergreen trees. The mortality of these mangroves is obviously not a direct response to defoliation. If this alone was the primary injury all the trees would put out adventitious growth, whereas very few of the dying plants refoliated or sprouted. This definitely indicates that the root system was quickly destroyed and was not functioning. Unfortunately the condition of the roots was not recognized immediately after the storm. Examination several weeks later, during November and December, indicated that the roots of all species of plants in the areas of high mortality were extensively destroyed. Some were broken by the twisting, but most of the root systems apparently were killed intact by some toxic factor, such as an abundance of hydrogen sulphide generated by anaerobic decomposition of the organic material present in the marl soils in these low, inundated areas, or by the lack of oxygen.

Apparently the increase of sodium chloride over the flooded mangrove areas was not of importance. Mr. W. R. Llewellyn, of the Dade County Extension Service, obtained a series of soil and water samples of the inundated area along the Flamingo road from Florida Bay to a station 16 miles inland, 5 days after Donna passed.

He reported the chloride content of these compared with other samples taken at the same stations in 1958 and 1959 during the summer rainy season, indicating that no abnormal increase followed the receding tidal water. Probably the copious rainfall during and just after the storm diluted the sea water.

The marl silt settling over a considerable part of the dead area probably played a part. Dr. Taylor Alexander suggested the possibility of an oxygen deficiency resulting from the sealing of the soil by this impermeable covering. Another possibility is that toxic materials such as hydrogen sulphide were able to pass directly into the vascular system because of the many broken roots and root hairs. The likelihood that this did happen is suggested by discolorations in the cross sections of smaller trees, cut 2 to 3 weeks after the storm. On these sections small areas of brown staining showed in groups of vessels soon after exposure to air. Some aspects of these relationships are discussed by Mitts 1960, Bergman 1959, Bowman 1918, Brown 1946, Scholander and van Dam 1955, Watson 1928.

Examination of the roots of trees in the mangrove flats, where about 90% of the trees were dead, and in the more inland areas of 25-50% mortality, was made in mid November. Unfortunately, this was too late to see the early stages of root deterioration. In the low areas all the smaller roots on dead trees had disintegrated. Here surface roots of seedlings and windthrown trees that were not defoliated or were only partially defoliated during the storm and had since put on new growth, were normal and functioning but many of the roots two inches below the surface were dead. Farther inland, some 5-6 miles, on slightly higher ground, where mortality ran from 25 to 50% the extent of the root mortality was much less. Here also there was less defoliation to begin with, and many more trees including buttonwood, red, black and white mangroves, had already put on much new foliage from adventitious buds along the larger branches and stems. Most of the smaller branches and twigs were decorticated and dead. Here the marl deposit was insignificant. At this time (mid November) the new leaves were withering on about 10% of these refoliated trees and practically all the roots were dead except some few surface roots near the base of the trees. This applied to the 3 species of mangrove and buttonwood, when the latter was mixed with the mangrove. Many of the seedlings had the tap root dead and the surface roots living. The pneumatophores on the dead and dying black mangroves were dead, also the aerial roots on red mangroves, were dead below the surface but often still green between the ground and trunk. An interesting phenomenon observed in the dead white mangrove was the coincident mortality of an unknown wood borer (Cerambycid) common in the living stems. Locally as high as 20% of the one to two inch saplings contained these borers. All larvae found in the dead and dying stems one week after the storm were dead.

So many variables are presented by these observations covering conditions over the 7-month period after the storm that any satisfactory physiological explanation for the extensive mortality in the mangrove flats is difficult to advance at this time. Further examination and certain experimental treatment should narrow the problem and it is hoped that some such studies may be carried out.

Probably all of the several types of injury observed contributed a certain part to the mortality. Bruising and destruction of the phloem, in the tops and branches, complete defoliation, and above all, destruction of the root systems from toxic materials or from lack of oxygen, are important. Where the root systems were quickly and completely destroyed, refoliation did not occur as in much of the low mangrove area. But where a few surface roots escaped these could be supplied with oxygen from the new leaves and thus survive. The amount of refoliation from adventitious buds would be correlated with the prior vigor of the tree, (Craighead 1925) notably those on slightly higher ground. Here also the oxygen content of the top few inches of soil would be greater. Partially defoliated trees probably survived because a supply of oxygen was available immediately to those roots that were not killed within a few days after the storm. The heavier deposits of silt may have prohibited oxygen exchange between air and roots in the coastal areas. The living fringes of trees in the areas of tidal fluctuation probably survived because of the better aeration provided by the moving water, or because toxic elements were not retained in this narrow strip. These green tidal fringes are usually not over 100 feet wide.

Fire Hazard

Very severe fires followed the 1935 hurricane. After this storm much of the extensive hammock growth from Crocodile Point to Flamingo was burned and practically all living mahoganies destroyed. Many of the inland hammocks were totally or partially destroyed.

A tangle of debris now covers the ground throughout most of the Park. A good illustration of the depth of this is seen in the collection of leaves and branches on the boardwalk trails. Should dry years follow, much of this area will burn again unless most vigilant protective measures are taken.

Every effort should be made to take advantage of this unique opportunity to follow and record revegetation of the denuded areas. A number of sample plots are being established, and permanently marked for future observation. Additional work is needed to more precisely explain the basic factors responsible for the high mortality in the low mangrove stands.

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LAND USE IN DADE COUNTY, FLORIDA

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In the most southerly and tropical part of Florida, south of Tamiami Trail, a unique form of land use and related economic structure is developing. Everglades National Park covers the western two-thirds of the area. The remaining and smaller portions are put to urban and agricultural uses, together with a large area of idle land.

The final boundaries of the third largest national park in the country were set by law July 2, 1958. With its establishment 1,337,800 acres were allocated to wilderness land usage. All towns and communities, including those occupied by the Seminole Indians, were excluded from the park. Low in elevation the water table is at or near the surface over most of the area. Vast fresh and salt water prairies sprinkled with cypress sloughs, mangrove bays, and hammocks cover the land. Rivers move lazily to the gulf through intricate meandered channels, embayments, and islands. The area abounds with numerous forms of wildlife, many of which are scarce or non-existent elsewhere in the United States. To those who have an affinity for God's handiwork, the park offers much of interest (Dambaugh, 1960).

In the eastern third of the extreme tip of the Florida peninsula an entirely different pattern of land use has evolved. The mosquito infested swamp, that all but drove the early settlers away, held several prime attractions for economic development. Prevailing southeasterly winds, that produce balmy weather during the winter months, provided the element of comfort. Once the mangrove gave way to man's onslaught, followed by reclamation, the eastern gladelands produced essential foods. A rock ridge, some four to five miles in width with a maximum height of 22 feet and an overall elevation of eight feet, above sea level, extends some 30 miles in a northeast-southwest alignment from Miami. Composed of Miami oolitic limestone with a thin overlay of sand this formation furnished early settlers high and dry building sites and suitable conditions for fruit groves. The marl soils in the "finger glades" that cut through the rock ridge attracted farming interests as well.

The creaking wheels of covered wagons, the construction of the Florida East Coast Railroad and the highway that paralleled it, the great hurricane of 1926 and the renaissance that followed, the first amphibious flight in 1927 by Pan American Airways from Key West to Havana that initiated an extensive system of communications and related industries, together with the continued influx of visitors are but a few of the episodes in the taming of this frontier.

From the original site at the mouth of the Miami River the largest metropolitan area in Florida has progressively spread out. The significance of Miami's geographic location is felt nationally and internationally. The dilemma created by Fidelismo (Castrismo) in Cuba and the fact that Miami became a haven for thousands of Cuban refugees recently centered attention upon our Latin American neighbors and their problems. The decision of Aerojet-General Corporation of California to take over 75,000 acres of land immediately west and northwest of Homestead for construction of a plant to manufacture solid fuels tends to equate the economy of Dade County with the space age (Miami Herald, 1962). The area will certainly experience much growth in the near future.

The pressure of urban encroachment on land resources in Dade County poses two queries. (1) What are the present-day aspects of agriculture? And, (2) What are the probable short- and long-run tendencies in the urban-agricultural sectors of the economy?

PRESENT-DAY ASPECTS OF AGRICULTURE

Mile after mile of ocean-front and bay-front hotels give the impression that tourism is the only concern of South Floridians today. Any such notion is quickly destroyed for those who take a 50-mile circuitous tour to the south of the city and find an entirely different landscape. Here lie valuable farmlands producing large quantities of out-of-season vegetables and tropical fruits. While meeting some competition from the Lower Rio Grande Valley of

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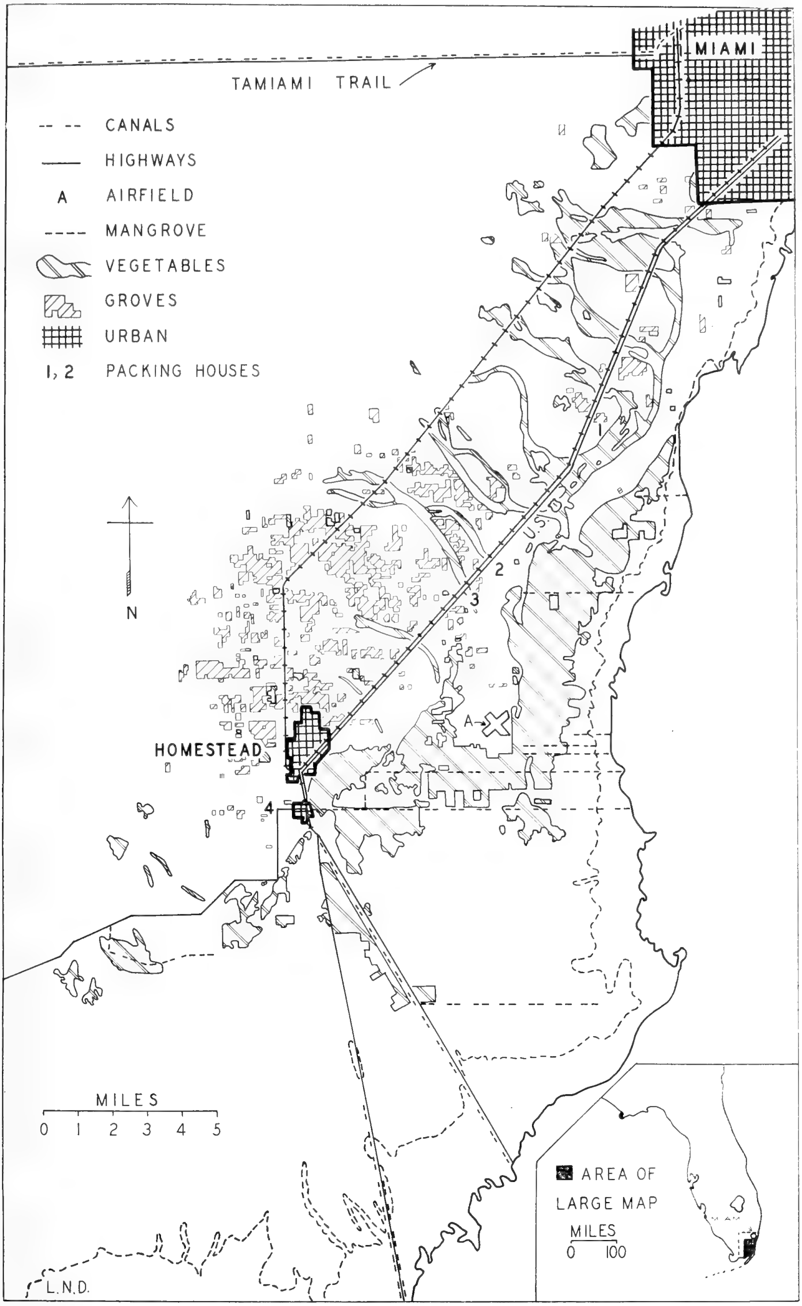
Figure 1. Agriculture, South Dade County, Florida, 1946.

Numbers: 1. Perrine, 2. Goulds, 3. Princeton, and 4. Florida City.

Source: United States Department of Agriculture, Soil Conservation Service, Florida Physical Land Conditions, Washington, D.C., 1946. Sheets for Everglades Drainage District, Numbers: 34, 35, 37, and 38, scale 1: 63,360.


MIAMI
TAMIAMI TRAIL
CANALS
HIGHWAYS
A AIRFIELD
MANGROVE
VEGETABLES
GROVES
URBAN
1, 2 PACKING HOUSES
N
U.S. 1
1
2
3
4
A
HOMESTEAD
MILES
0 1 2 3 4 5
AREA OF LARGE MAP
MILES
0 100
L.N.D.

Texas and the valleys in Southern California, the agricultural area of South Florida has the unique advantage of being the southernmost farmland in the nation.

By 1946, agricultural uses of land extended four to five miles on either side of U.S. Highway No. 1 from Miami to Florida City (United States Department of Agriculture, 1946). Vegetable growing was confined almost entirely to the gladelands on the east side of the highway, to the transverse glades reaching across the highway, and along the secondary roads to the south and southwest of Florida City. Citrus, avocado, and mango groves predominated on rocklands to the west of the highway from Peters and Goulds to Homestead and Florida City (Fig. 1).

Within the next decade farming was intensified and expanded, and certain shifts were made in production. In 1956 the area of vegetable growing on gladelands and finger glades and of fruit culture on rocklands remained essentially the same, though more acres were under cultivation, especially east and southeast of Florida City. Meanwhile, a new and much larger vegetable producing area extended over the rocklands. A tongue-like extension of this area spread southwest nearly to Everglades National Park (Fig. 2).

Another tendency, one that still continues, was the displacement of farmlands by land used for residential purposes immediately west and southwest of the urban limits of Miami, around Perrine and Goulds, to the north of the Homestead Air Base, in the vicinity of Brown Airport, and on the periphery of Homestead and Florida City.

The comparatively level terrain, "modified subtropical marine climate" (United States Department of Commerce, 1956), shallow marl and sandy soils, and high water table contributed to large-scale farm operations which could use mechanized equipment and migratory labor.

For the three leading truck crops (by value)—tomatoes, Irish potatoes, and pole beans—labor provided 38 per cent of total crop costs (average for a 5-year period, 1952-57); followed by fertilizers and sprays, land rent, seeds, repairs and maintenance, gas and oil, licenses, and interest on capital. During the growing period, labor was the single greatest cost factor for pole beans and tomatoes. During harvesting and marketing labor held first place

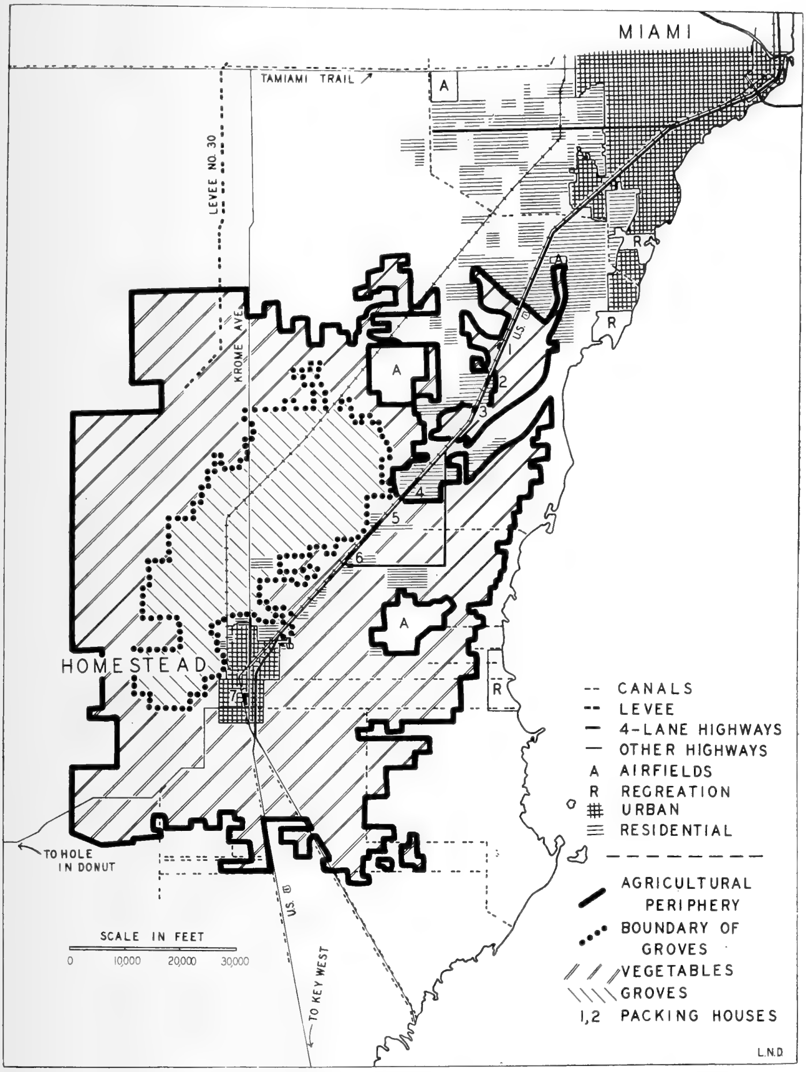


Figure 2. Agriculture, South Dade County, Florida, 1956.

Land use categories are based on dominant use of land. Numbers refer to location of large packing plants: 1. Rockdale, 2. Perrine, 3. Peters, 4. Goulds, 5. Princeton, 6. Naranja, and 7. Florida City.

Source: Aerial photographs for February 1956, scale 1:300, Engineers Office, Dade County; field reconnaissance 1957 through 1959, up-dated to end of 1960; and U.S. Department of Commerce, U.S. Coast and Geodetic Survey, 7.5 minute series (Topographic), Quadrangles: 55/37, 55/40, 56/38, 56/39, 56/40, 57/38, 57/39, 58/38, 58/39, and 58/40, scale 1:24,000.

in cost for all three crops, amounting to 65 per cent for Irish potatoes, 63 per cent for tomatoes, and 49 per cent for pole beans (Florida Crop and Livestock Reporting Service, 1958).

Large scale farm operations together with a short growth period for field crops (73 to 92 days for tomatoes, but only 65 days for beans) created a peak demand for labor during harvest. Since the local labor market was inadequate to meet the need for labor during the 1955-56 crop season,[1] some 10,000 migrants made up 75 per cent of the labor pool: 8,000 for work in the fields, plus another 2,000 to man the jobs in the packing houses (United States Department of Labor, 1956).

During the 1955-56 season, for example, 42 per cent of all farm migrants, recruited by the Florida State Employment Service, originated in Texas, Mississippi, Alabama, Georgia, South Carolina, and other parts of Florida. Another 20 per cent came from Puerto Rico, and 13 per cent from the Bahamas (Fig. 3). Most were Negroes, with Texas-Mexicans and Puerto Ricans making up the next largest, but growing category. Another 10 per cent were "Freewheelers." These came seeking their own jobs and subsistence, and creating most of the social problems (Personal communication, Bryan M. Page, 1957).

Along with availability of labor the climate is a major conditioning factor in successful farming operations in South Dade County.

The southern tip of Florida, with its low latitude and low elevations, projects into warm tropical waters on three sides, seas with temperatures further modified by shallowness and warm oceanic currents.

Summers are generally hot and humid due partly to the high angle of the sun's incidence, warm unstable air masses producing scattered shower and thunderstorm activity, easterly waves, tropical disturbances, and in some years, hurricanes. Winters, on the other hand, usually are mild and dry with only occasional rains

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[1] Crop season as defined in this study covers the interval from August 1, 1955 to July 31, 1956. When reference is made to a 5-year average, it includes the mean for each month starting with August 1953, more specifically, the mean for August 1953/1957 through July 1954/1958.

This definition does not conform with the national pattern of winter (January, February, and March), etc., rather, it is a geoeconomic delineation particular to this out-of-season fruit and vegetable producing region.

generated by frontal activity associated with the more southerly winter path of an extratropical middle latitude low pressure system.

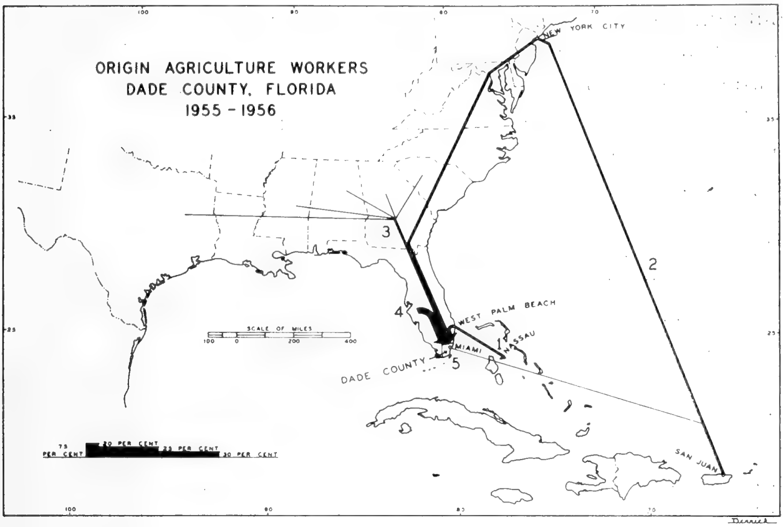

Figure 3. Origin Agricultural Workers, Dade County, Florida.

Average for November to May, 1955-56.

Numbers indicate source region of workers: 1. Bahamas, 2. Offshore (Puerto Rico), 3. Intra-State, 4. Interstate, and 5. Dade County (Local Workers).

Source: United States Department of Labor, Bureau of Employment Security, In-Service Farm Labor Reports for Dade County, Unpublished data.

The climate of South Florida is not one of extremes. A 56-year average for Miami indicated a mean temperature of 75.1°F, with a mean maximum of 80.7°F, and a mean minimum of 69.5°F. The highest recorded temperature was 95°F (July 1956) and the lowest 27°F (February 1917). The average annual rainfall for this same period was 54.44 inches. Prevailing wind direction is southeast, with winds from the southeast and east half of the time (United States Department of Commerce, 1956).

On rare occasions in winter, when pressure systems are properly oriented in relation to the north northwest-south southeast trending axis of the Florida peninsula, cold Canadian air flows over the entire length of the peninsula causing temperature inversions and low temperature readings.

Killing frosts have been recorded in South Florida only a few times in the last 75 years. Sustained cold spells are exceptional. As the center of the high pressure system shifts eastward over the southern states, a veering wind produces a flow of air the temperature of which is greatly moderated as it passes over 350 miles or more of warm water before reaching Southeast Florida.

Although rare, when killing frosts occurred, as they did in mid-January of 1956 (Fig. 4), they destroyed large acreages of tender vegetables, burned tropical fruit foliage in mature groves, and killed young trees. Farmers hastened to disc and replant their fields after the freeze in order to gain some profit. In the interim a voluntary out-migration of workers greatly depleted the labor force. Texas-Mexicans had to be recruited in April to handle the late harvest (Fig. 5).

Another cold spell of longer duration, February 9 to 22, 1958 dealt a further blow to farmers. Breadlines formed this time. Many growers, the community, and the U. S. Government contributed food and housing for thousands of stranded migrants who had no work.

Farmers have other problems unique to this region. Excessive, or prolonged rains during any part of the crop-season may spell disaster to field crops, especially on the eastern gladelands where there is inadequate natural, and/or artificial drainage. Conversely, drought and hurricanes tend to increase the chloride content of the top horizons of the marl and sandy soils and crops may be "salted out."

The eastern gladelands are less than four feet in elevation above sea level. They overlie permeable oolitic limestone. During dry periods when the discharge of fresh waters to the seas is greatly reduced, saline waters flow inland through the canals and ditches, and move laterally through the porous rock. When ground waters become contaminated with chlorides, evaporation results in the formation of thin surface crusts of highly salty soil which exceeds the relatively low tolerance of field crops to chlorides.

During the passage of hurricane Donna in the fall of 1960, flood waters from Biscayne Bay were washed far inland leaving heavy salt deposits throughout the area. Salt water stood two feet deep in many winter farm fields for nearly a week after the storm.

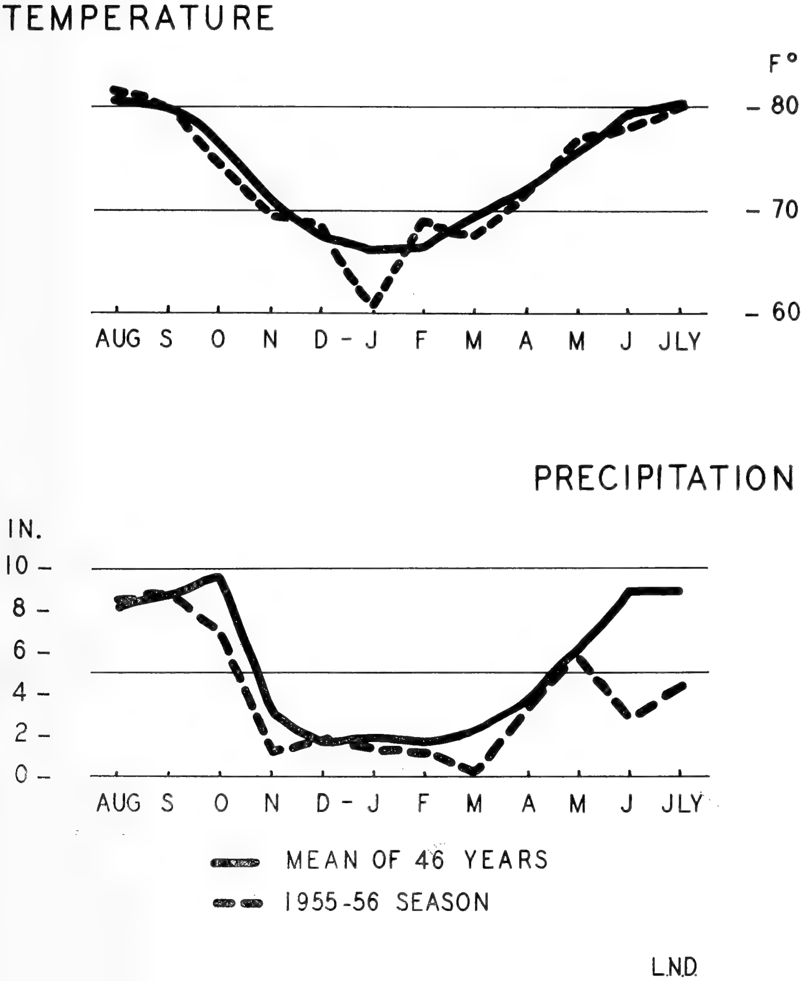

Figure 4. Climatic Data, Homestead Experimental Station, South Dade County, Florida.

Temperature and rainfall data for the crop season of 1955-56 are compared with the 46-year mean data for that station.

Source: United States Department of Commerce, Climatological Data, Florida, Annual Summary 1955, and Annual Summary 1956. Ashville, Kentucky: 1956 and 1957.

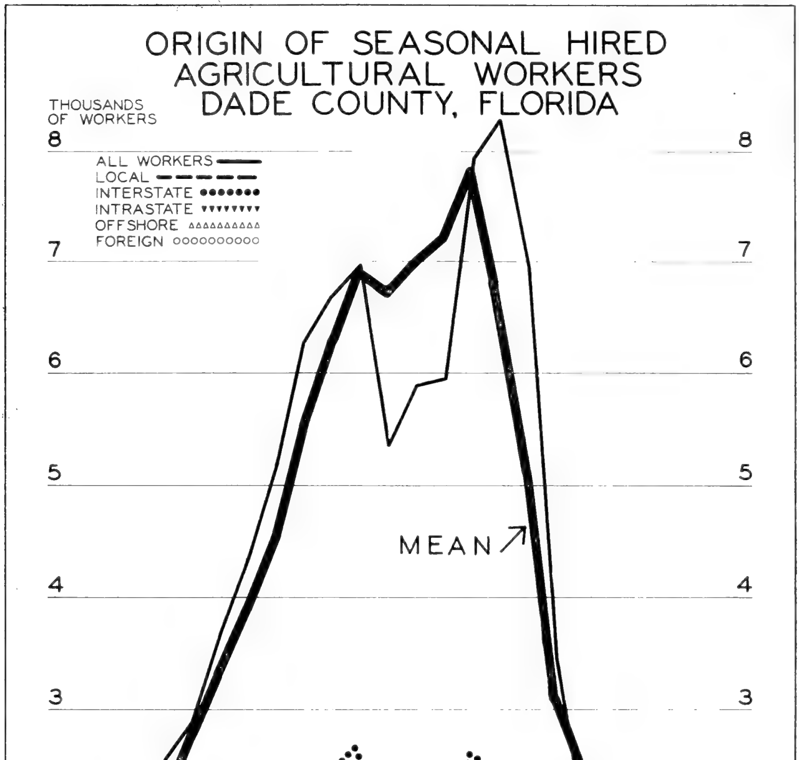

Figure 5. Origin of Seasonal Hired Agricultural Workers,
Dade County, Florida.

By-monthly for the Season 1955-56; and by-monthly 5-year mean for August 1, 1952-57 to July 31, 1953-58.

The disposal of culls from the packing houses is offensive from a sanitary point of view. It constitutes a misuse of low-density residential land that lies on the periphery of the urbanized area in South Dade County.

Though not clearly understood, the demand for produce is somewhat erratic. Crops harvested late in the season meet stiff competition from producing areas elsewhere in Florida, United States, and offshore.

Perhaps the gravest problem of all, because it is a multi-headed monster stalking about over the county ready to pounce upon its prey, the farmer, is urban encroachment. For several years farmers have been feeling the pressure to give up. This pressure is due in part to higher taxes, stiffer zoning regulations, more stringent health and sanitation standards, and minimum wage legislation, all of which have contributed to an increase in costs of production.

PROBABLE SHORT- AND LONG-RUN TENDENCIES IN THE URBAN-AGRICULTURAL SECTORS OF THE ECONOMY

Farming in Dade County became a $75 million business by 1955-56, eighty per cent of which was derived from vegetable and tropical fruit production. Several ornamental horticultural units, horse and chicken ranches, dairy farms, and a goose farm contributed to the remainder. A high degree of specialization dependent upon mechanization and migratory labor typified the commercial farming operations. This structure may continue for some time due to the interplay of those socioeconomic and environmental factors unique to southern Florida. These follow. (1) This is the southernmost of the vegetable and tropical fruit producing regions in the country. (2) Proximity to northern markets gives South Florida the advantage over its competitors in Texas and California. (3) The climate minimizes crop hazards. (4) Marl and rockland soils, though low in primary plant nutrients, are easily managable. (5) Large areas of comparatively level potential farmland await development. And (6) the large and growing market in southern Florida and the Nation is a market characterized by rising standard of nutrition that lays stress upon protective foods in the diet.

However, the three-dimensional land medium upon which agriculture depends for its existence has definite physical limits. In expanding economies, like that of southern Florida, shifts in land use are always in the direction of higher order land uses. Agriculture with its increasing costs of production declines and eventually succumbs to increasing land values.

For several decades Metropolitan Miami (synonymous with Dade County according to the 1960 census) has been attracting more and more people. Between 1940 and 1960 the population more than tripled and in 1961 passed the million mark.

The urban sprawl during 1950-55 took place mainly to the north and west of the city. The resulting built-up area is noticeably continuous on the north where it extends into Broward County. Starting in about 1955 the movement accelerated southward over the high pinelands around Perrine, Homestead, Florida City, and even into the Florida Keys. It also continued westward to the south of Tamiami Trail.

The projected population of Dade County by 1985 will be close to 2,500,000 people, or an increase of some 160 per cent over 1960. The next ten years will mark the most critical period of growing population pressure on limited resources, and, most certainly, of shifts in land use. The community must be revitalized and the economy expanded to provide 500,000 more homes and over a half-million more jobs (Metropolitan Dade County, 1961b).

The preliminary land use plan for Metropolitan Dade County provides for two urban nuclei: (1) Miami Metropolitan Core, with its Magic City Center, and (2) South Dade Urban Core now developing in the Cutler Ridge-Perrine Area. Fanning out from the Miami Core high, medium, low, and estate densities of land use are planned; and from the South Dade Core medium, low, and estate densities are planned (Metropolitan Dade County, 1961a).

Potential agricultural lands will be peripheral from a geoeconomic point of view. None will be fringing the Miami Urban Core, for estate density land use will extend westward as far as the undevelopable, deep, organic soils. Estate density land around the South Dade Center is projected to extend on the west as far as Krome Avenue; beyond, agricultural land usage may continue as far west as deep organic soils. Reclamation must predate any agricultural use of these low marsh and gladelands, for they lie within the five foot contour line.

Levee 31 Road, frequently referred to as the "Fish-hook Levee," is designed to encircle the southern part of the county from the present Levee 31. Construction plans specify that the levee shall be built to a height ranging from four to seven feet and to follow the one- or two-foot contour line. Inside this levee the water table will be controlled by an intricate system of canals, each with a sasalinity control dam at the salt barrier line,[2] a line that coincides with the levee. The area allotted to future farming on the west lies outside of Levee 31. However, on the south almost all of the future crop land lies within Levee 31 Road. With the exception of those areas taken up by groves and vegetables around Homestead and Florida City, it is expected that present farmlands may be displaced by urban land use of low and estate densities.

It must be kept in mind that of the total area in Dade County, 27.6 per cent is taken up by Everglades National Park, 15.6 per cent by Conservation Area No. 3, and 15.1 per cent by bay and ocean surfaces. Thus, a total of 58.3 per cent of the area is not available for economic development in the foreseeable future. Of the remaining 41.7 per cent of the total land area, that used for agricultural purposes in 1960 amounted to 13.7 per cent. This was the greatest single purpose use of space in the county. Agriculture occupied 4.4 square miles, or 2.2 per cent of the urban sector; and 89.8 square miles, or 11.5 per cent of the non-urban sector (Metropolitan Dade County, 1961a).

In the short-run, farming in Dade County will undoubtedly ascribe an erratic decline. For several years acreage planted increased, then lowered from the peak of 1957-58. Value derived dropped steadily after the 1954-55 season, showing only a slight recovery during 1958-59 (Table 1). Several large producers discontinued operations after three or four bad crop-seasons. The Bryant and Lownsbury Corporation, which farmed one-fifth of Dade's farmland, went into liquidating bankruptcy in 1959.

The largest remaining stands of pineland are in the southern part of the county. Urban encroachment upon agricultural land will continue for some time on those high and dry rocklands. The long-established policy of Arthur Vining Davis, who owns about one-tenth of the land area of Dade County, has been to lease sizable acreages of rocklands covered with pine-palmetto vegetation. Farmers "sacrified" (cleared) the land, chopped up the rocks and planted

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[2] The salt barrier line, established by Metropolitan Dade County in 1960, sets the inland limit beyond which no canal, channel, or other continuous excavation can be extended without a salt control structure.

tomatoes for two or more seasons, the acreage was then returned to the owner who proceeded with his housing developments. Cropped land merely constituted the interim stage in the land occupance sequence between unused land and "exurbia" (rural non-farm land) development.

TABLE I

AGRICULTURAL PRODUCTION, DADE COUNTY, FLORIDA*

Season	Total Agri.	Tropical Fruits & Veg.	Tomatoes	Total Agri.	Tropical Fruits & Veg.	Tomatoes
	T. Acres Planted			M. Dollars		
1954-55	57.7	39.8	22.0	75.7	59.2	44.6
1955-56	64.2	46.1	27.0	53.8	40.1	24.5
1956-57	73.4	55.2	32.3	49.8	33.9	23.5
1957-58	74.6	56.9	30.2	40.4	24.0	11.5
1958-59	60.0	42.8	21.4	45.0	30.3	17.4

* Dade County Agricultural Agent, 2690 NW 7th Avenue, Miami, Florida.

Urban forms are seeping onto contiguous gladelands in the vicinity of Westwood Lake, Bel Aire and Carol City Estates, and the Brown Airport. The land is filled with rock removed in making artificial lakes and canals to the prescribed height set by flood criteria. The economic breaking point between land in its natural state and land needing fill[3] is between three and four feet of fill (Metropolitan Dade County, 1960). The cost of filling land is high, averaging $1,200 to $2,000 per foot per acre (Metropolitan Dade County, 1961a).

For the past few years about four square miles of land used for farming gave way each year to urban usage. By 1985 the area covered by urban forms will have doubled with a greater intensity and more efficient use of land.

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[3] Flood criteria specify minimum elevations for land to be used for urban development. Considered are past records of rainfall and water table in relation to the height of the water table that would occur: (1) once in 10 years during a portion of a day, or (2) once in 5 years for a duration of one week, plus 18 inches (required amount of fill over an area where septic tanks are in use). The higher of the two elevations is selected.

Land fill requirements essential to prevent flooding depend on: (1) topography, (2) depth of organic soils, (3) water table, (4) flood criteria, and (5) location of approved bulkhead line.

As the national economy expands, the demand for foodstuffs—especially fresh fruits and vegetables—will continue to rise. The per capita consumption will probably be greatest in the subtropical regions of the country—the areas where growth in population has been most rapid during the last twenty years, and where the diet includes a significant caloric intake of fruits and vegetables.

Dwindling farmlands and increasing demand for their product will most certainly present a dilemma to Dade Countians. A partial solution might be to follow the pattern already noticeable in certain segments of the manufacturing industry, namely, of capitalizing upon a better production equation in other parts of the United States, or in offshore areas. A few farmers of South Dade County already have shown a tendency to gravitate to other parts of Florida, to certain of the islands in the Caribbean, and to places in the Central American countries.

The neat mile-long rows of vegetables and carefully tended groves will then be displaced by urban cultural features. Instead of the roar of the tractor and the smell of newly turned earth combined with diesel fumes, there will be the din of traffic and fumes from automobile exhausts. The serenity of the farm landscape will have been supplanted by the bustle of the metropolis. In the long-run farming will have passed from the scene in Dade County. Only two uses of land will remain: urban on the east and wilderness on the west separated by the park boundary. A super-city reclaimed and brought under cultivation within the levee, and a wilderness refuge, shielded by its boundaries—these two contrasting land use types may then exist harmoniously side by side.

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THE OCCURRENCE OF RAFTS FOR DISPERSAL OF LAND ANIMALS INTO THE WEST INDIES

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The origin of the fauna of the West Indies is either attributed to landbridge connections with the mainland (Barbour, 1914, 1916; Barbour and Noble, 1915; Scharff, 1922; Schuchert, 1935) or to waif dispersal over water by means of rafting or by windstorms (Darlington, 1938, 1957; Myers, 1938; Simpson, 1956; Williams and Koopman, 1952). Waif dispersal by wind and water, however, is the only means that can adequately explain the presence of certain faunal elements in the Antilles and the absence of others—conspicuous among the absentees are the carnivores and ungulates which certainly would have crossed any landbridge had one been available (Simpson, 1956). Some persons, merely because of the infrequency of suitable windstorms or raft materials, find it difficult to accept the possibility that an animal, or many animals, could be carried across an expanse of open sea and be deposited on an island to start a new population. It is my purpose to show that suitable rafts are sufficiently frequent in the Caribbean area to move considerable numbers of animals into the Antilles.

Perhaps one of the reasons that rafting is unacceptable as a means of dispersal is the conviction that substantial rafts (tree islands) are needed. These are indeed infrequent in occurrence. One such floating island with trees 30 feet high, sighted off the coast of North America in 1892, has been cited as evidence for rafting on at least four separate occasions (Powers, 1911; Matthew, 1939; Darlington, 1938, 1957). Other tree islands have been reported in the Molucca and Philippine islands (Lyell, 1834).

Far less substantial rafts have been reported to carry animals to sea. Clench (1925) reports a rattlesnake (*Crotalus adamanteus*) which was found on a raft of water hyacinth (*Eichhornia crassipes*) off the Florida coast. Guilding (1828; see also Purdy, 1839) reports a boa constrictor (*Constrictor constrictor*) which drifted ashore on St. Vincent Island in the Lesser Antilles.[1] It apparently was rafted

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[1] Guilding (1828) states that this boa came ashore, killed a few sheep, and then was itself killed. With its skeleton in front of him, he remarked that there might be reason to fear his future ramblings through the forests of St. Vincent "had this formidable reptile been a pregnant female, and escaped to

250 miles (the approximate distance from the Orinoco River) on the trunk of a cedar tree. Feilden (1889) records "the interesting fact of an Alligator being transported alive on the trunk of a tree from the continent of South America to Barbados in 1886." The "Alligator" was probably *Crocodylus intermedius* from the Orinoco River. Barbour (1914) reports a specimen of *Crocodylus intermedius* which came ashore in Grenada in 1910, with no apparent raft. Prescott (1959) reports a jack rabbit (*Lepus californicus*) off the California coast on a raft of giant kelp (*Macrocystis pyrifera*) which measured only forty feet by twenty-five feet. It is evident from the above cases that floating tree islands for rafting animals across ocean barriers are unnecessary. Rafts, in the form of logs and floating herbaceous plants, undoubtedly exist in the Caribbean area in sufficient numbers to account for the origin of the present fauna.

In order to determine the frequency with which rafts enter the Caribbean, observations were made over a period of a month and a half during the summer of 1960 at the Rio Tortuguero, Limon Province, Costa Rica. Because of a longshore current flowing south, any rafts leaving the Rio Tortuguero would drift towards Colombia, but the principles set forth here can be applied to the coastal Caribbean in general because of the presence of similar physical and biotic factors. The Rio Tortuguero is a sluggish, low-gradient river which in times of low water becomes choked with floating vegetation. Frequently large mats of these plants break loose and drift out to sea. Schmidt (1944) described similar conditions in the Paraguay and Parana rivers of South America. He states that during periods of flood, animals seek refuge on the mats, and it is during these periods of high water that the mats are most apt to be swept away downstream. These mats are therefore potential rafts for animals. Logs are also present on the Tortuguero, but infrequent.

From 13 July to 29 August 1960 daily records were kept on the types and sizes of rafts which formed on the river. Additional

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a safe retreat." Purdy (1839) does not cite the source of his information about the boa, but he states that the snake "was found to contain many young ones, nearly ready to escape; and which, but for the destruction of the old one, would have taken up their abode in the woods." If this snake is the same one Guilding cites (which I believe to be the case) then Purdy's statement that the snake was pregnant is in error. However, these may be two different snakes that reached St. Vincent on separate occasions. Lyell (1834) and Wallace (1881) cite Guilding's article; Guppy (1917) cites Purdy.

records were kept on the wind, rain, and surf conditions requisite for getting these rafts out of the river and into the open ocean. The results of these observations are summarized in table 1.

TABLE 1.

Daily observations on raft formation in the Rio Tortuguero, Costa Rica, during the summer of 1960.

Date	Rain [1]	Wind [2]		Surf [3]	Square feet of Vegetation/minute [4]	Rafting [5]
13 July		W	N		.5	
14	R	W	E	H	.5	
15		W	E	H	.5	
16		W		H	1—25	
17			E		25—50	
18	R	W		H	.5	
19		E	E	H	.5	
20		E	E	H	.5	
21		E	E	H	.5	
22	R	E	E	H	.5	
23		W	E	H	.5	
24	R	W	E	H	.5	
25		W	E	H	.5	rafting
26	R	W	E	H	100—500	
27		W	E	H	100—500	
28				H	.5	
29	R	W	E	H	.5	
30		W	E	H	.5	rafting
31		W	E	H	.5	
1 Aug.		W	E	H	.5	
2		W	E	H	.5	
3	R	W	E	H	25—50	
4	R	W	E	H	.5	
5	R	W	E	H	.5	
6	R	W	E	H	25—50	
7		W	E	H	.5	
8	R	W	E	H	.5	
9	R	W	E	H	1—25	
10	R	W	E	H	500—1000	
11	R	W	E	H	100—500	rafting
12		W	N	H	1—25	rafting
13		W	W		500—1000	rafting
14		W	E		.5	rafting
15		W	E		.5	rafting
16		W	E		.5	rafting

TABLE 1—Continued

Date	Rain [1]	Wind [2]		Surf [3]	Square feet of Vegetation/minute [4]	Rafting [5]
17		W	E		.5	
18		W	E	H	.5	
19		W	E	H	.5	
20		E	E	H	1—25	
21	R	W	E	H	.5	
22		W	E	H	1—25	
23		W	W	H	1—25	
24		W	W	H	.5	
25		W	W	H	.5	
26	R	W	W	H	.5	
27	R	W	W	H	.5	
28	R	W	W	H	1—25	
29 Aug.	R	W	W	H	1—25	

[1] Days of rain are shown—the amount was not measured.

[2] Wind direction was recorded twice a day—first column at 07:00, second column at 19:00. West winds blow offshore.

[3] Heavy surf with whitecaps and breaking waves.

[4] Square feet of rafting vegetation passing a given point on the river each minute—size of individual rafts is not shown.

[5] Days when rafts successfully reached the open sea and drifted out of sight of land are shown. Observations were made at least three times a day—at 07:00, 13:00, and 19:00.

It will be noted from the table that each period of rafting is preceded by one or more days of rain. Any appreciable amount of rain will raise the level of the low gradient Rio Tortuguero several inches to a foot. This high water lifts the floating vegetation free of the bottom and allows the current to tear away large central portions. In such a way the rafts are formed. Low water between rainy spells permits the plants to grow out from the banks and form new mats of vegetation that will be torn away with the next high water. Every day of rain was not followed by a day of rafting (see table 1) because the vegetation mats were not always large enough to be torn loose by high water.

The rafts on the Rio Tortuguero are of five types: *Hydrocotyle* mats; water hyacinth mats (*Eichhornia*); water hyacinth-grass mats (*Eichhornia* and *Panicum);* logs; and trees. The *Hydrocotyle* rafts are small (less than 10 square feet) in size and extremely flimsy.

None traversed the surf to the open sea. The water hyacinth rafts are larger in size (up to 5,000 square feet) and considerably more sturdy. Many of these rafts floated out through the surf to the sea. The water hyacinth-grass rafts were the largest (up to 10,000 square feet) and sturdiest of the rafts. I attempted to tear several of these rafts apart by hand and had extreme difficulty in doing so. The hyacinth rafts are held together by their root system and intertwined leaves. In the water hyacinth-grass rafts, the tough stems of the grass grow in and around the intertwined hyacinths, and firmly lash the raft together. Log and tree rafts were not encountered during the study, although the local people state that numerous logs and trees drift down the river on occasion.

Once the rafts have reached the mouth of the river, they are at the mercy of the waves and eddies of current which usually tear them apart and cast them up on the beach. If, however, the surf is low (as it was on the last four days of rafting—see table 1), or there is an off-shore wind (west wind) to blow the rafts through the surf (as there was every morning when rafting occurred), then the rafts drifted out to sea and disappeared over the horizon. To a person standing on the beach (eye-level approximately 10 feet above sea level) and looking out to sea, the rafts (12-24 inches in height) disappear from sight about four nautical miles from shore (U.S. Coast and Geodetic Survey, 1958). Concerning the fate of the rafts beyond this point I can only guess. At least two local people (former seamen shipping between Colón, Panama, and San Andrés Island) report seeing such rafts fifty miles off shore.

Two or three days in sea water is sufficient to kill the water hyacinth (Penfound and Earle, 1948), but the water hyacinth-grass rafts would certainly hold together for a longer period of time. During the eight days of observed rafting an estimated 1,500,000 square feet of hyacinth and hyacinth-grass rafts (usually of more than 100 square feet each) entered the ocean from the Rio Tortuguero. The total observation period was 48 days. If the whole year is considered as similar to the seven weeks of observation, and if the total number of rivers entering the Caribbean from Central and South America is considered, the square feet of rafting material entering the Caribbean each year must be impressive.

That some of the rafts do reach the Antilles might be attested to by the presence of several species of water hyacinth in these islands, in addition to the common *Eichhornia crassipes* (see Small, 1933 (under the generic name *Piaropus*); Marie-Victorin and Leon, 1942).

These rafts could not transport large land vertebrates whose weight would tend to break the rafts apart. Certainly the available rafts could transport many small vertebrates and invertebrates into the Caribbean islands.

Barbour and Noble (1915:424) state that if rafting occurred "we could lie-to in the mid-Caribbean and watch the rafts go by. . . . " While this may not be possible, it is evident that studies on rafting can be conducted at any of the major low-gradient rivers along the Caribbean coast of Central and South America. During flood periods it would be possible to study raft formation, raft faunas, and, by following the larger rafts by boat or airplane, even discover how far they travel, and what the fates of their faunas are.

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THE FLORIDA FISHES OF THE GENUS *CENTROPOMUS*, COMMONLY KNOWN AS SNOOK[1]

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Introduction

Until 1949, the popular game fishes commonly called snook in Florida had been referred to a single species, *Centropomus undecimalis.* At that time, material available to me showed that four distinct species of the genus *Centropomus* occur in the state (Rivas, 1949: 13). These species were only listed in that publication and no means for their identification were offered. Later, Carr and Goin (1955: 30, 84, 85) keyed and described three of the species, including a figure of *C. undecimalis.* Marshall (1958:22) published a key to the four species but no descriptions, diagnoses or figures. Robins (1958: 19, 20), and Briggs (1958: 278), again listed the four species. Volpe (1959) discussed the biology of the common snook (*C. undecimalis*) but did not mention the other three species.

It is my purpose here to provide a key, diagnoses, figures and other taxonomic data, as a means for identification. In addition, data on the biology and distribution of the species are given.

This study is based largely on the collections of the University of Miami Ichthyological Museum (UMIM). A total of 78 specimens were examined from various localities in Florida. In addition, many fresh-caught specimens, captured by anglers, were examined in the field.

Lateral scales are counted along the longitudinal row immediately above the lateral line, from the post-temporal (supraclavicle) to the caudal base. In the anal fin, the last two closely approximated elements are counted as a single ray divided to its base. All pectoral rays are counted. Gill rakers are counted along the lower limb of the first arch, including gill raker at angle but not the rudiments. Other characters are self-explanatory. Unless otherwise indicated, lengths (expressed in millimeters) refer to the standard length.

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[1] Contribution No. 42 from the Ichthyological Laboratory and Museum, Department of Zoology, University of Miami.

Genus CENTROPOMUS Lacépède

Centropomus Lacépède, 1802: 248 (original description). Type species, *Sciaena undecimalis* Bloch, 1792, by subsequent designation (Cuvier and Valenciennes, 1828: 75).

This compact genus, sole representative of the family Centropomidae (*sensu stricto*), is restricted to tropical and subtropical North, Middle and South America. Most or all of the species of *Centropomus* are euryhaline and show preference for the estuarine mangrove habitat. In fresh water, they are usually found in the lower course of streams and seldom stray far from estuaries when occurring in salt water. In the Atlantic drainage, the genus ranges from South Carolina to Brazil including the West Indies, and in the Pacific, from the Gulf of California to northern Peru.

About 28 nominal species have been described in the genus *Centropomus* some of which have already been synonymized. Future revision may show that less than half of the proposed species are actually valid. The species occurring in Florida, however, although very similar in appearance, are very distinct. They are sympatric and may occur together in the same locality. Recently, Mr. Bruce Roggenstein, Junior Assistant in Ichthyology, collected the four species in the Coral Gables Canal.

The common snook, *Centropomus undecimalis*, is by far the most abundant and widest ranging in Florida. The other three species are much less common, especially *C. ensiferus* which appears to be restricted to extreme south Florida. Mr. Phil Francis of Clewiston has kept fishing records of the frequency of occurrence of the species of snook in the Caloosahatchee River. At the time his information was received (*in litt.*), he had taken 768 *C. undecimalis,* seven *C. parallelus* and one *C. pectinatus.*

The following key, based on the museum material examined from Florida, provides a preliminary means of identification for young from 100 mm. in length and adults. To obtain positive identification, the diagnoses and comments under each species should also be consulted as well as the figures. The diagnoses comprise all the characters used in the key and are based on the same material. Juveniles and young between about 20 and 100 mm. in length can be identified by characters discussed under the respective species.

1a.—Lateral scales 53 to 60. Second anal spine reaching well beyond vertical from caudal base. Pectoral fin reaching to or slightly beyond vertical from tip of pelvic.

1. *Centropomus ensiferus*

1b.—Lateral scales 62 to 90. Second anal spine not reaching beyond vertical from caudal base. Pectoral fin not reaching to vertical from tip of pelvic.

2a.—Lateral scales 62 to 70. Gill rakers 15 to 18. Anal rays 7. Pectoral rays 14. Maxillary not reaching to vertical from center of eye.

2. *Centropomus pectinatus*

2b.—Lateral scales 70 to 90. Gill rakers 7 to 13. Anal rays 6, very rarely 7. Pectoral rays 15 or 16. Maxillary reaching to or beyond vertical from center of eye.

3a.—Lateral scales 80 to 90. Gill rakers 10 to 13. Pelvic fin reaching to or beyond anus. Distance between anus and origin of anal fin, 1.2 to 1.6 in distance between anus and insertion of pelvic.

3. *Centropomus parallelus*

3b.—Lateral scales 70 to 77. Gill rakers 7 to 9. Pelvic fin not reaching to anus. Distance between anus and origin of anal fin, 1.9 to 2.5 in distance between anus and insertion of pelvic.

4. *Centropomus undecimalis*

1. *Centropomus ensiferus* Poey
Sword-spined snook

Figure 1 B

Centropomus ensiferus Poey, 1860: 122 (original description; Cuba), pl. 12, fig. 1. Jordan and Evermann, 1896: 1125 (description, distribution, synonymy). Rivas, 1949: 13 (listed, common names, distribution; Florida). Marshall, 1958: 22 (characters in key; Florida). Robins, 1958: 20 (listed, common names, distribution; Florida). Briggs, 1958: 278 (listed, distribution, habitat; Florida).

Lateral scales 53 to 60. Gill rakers 13 to 16. Anal rays 6. Pectoral rays 15 or 16. Second anal spine reaching well beyond vertical from caudal base. Pectoral fin reaching to or slightly beyond vertical from tip of pelvic. Pelvic fin reaching to or beyond anus. Distance between anus and origin of anal fin, 1.8 or 1.9 in distance between anus and insertion of pelvic. Maxillary not reaching beyond vertical from center of eye.

Specimens of *Centropomus ensiferus* less than 96 mm. in length are not available but smaller individuals could be distinguished from those of the other three species by the lower number of lateral scales. Judging from the juveniles of the other three species, the much longer second anal spine would identify *C. ensiferus* as small as about 20 mm. in length.

This is by far the smallest and rarest of the species of snook occurring in Florida. Full grown adults probably do not attain a total length of more than twelve inches. The specimens examined by the writer from Florida and elsewhere, were all less than ten inches in total length.

In Florida, *Centropomus ensiferus* is so far known only from the fresh water canals of the Greater Miami area. The species also occurs in the West Indies and in the Atlantic drainage of Central and South America from British Honduras to Brazil.

Four specimens, 96 to 146 mm. in length, were examined from the following localities in Florida. One, 146 mm., fresh water canal, Miami (UMIM 4443). One, 99 mm., fresh water canal, Coral Gables (UMIM 4449). Two, 96 and 98 mm., fresh water canal, Coral Gables (UMIM 3339).

2. *Centropomus pectinatus* Poey
Tarpon snook

Figure 1 C

Centropomus pectinatus Poey, 1860: 121 (original description; Cuba), pl. 13, fig. 6. Jordan and Evermann, 1896: 1122 (description, distribution). Rivas, 1949: 13 (listed, common names, distribution; Florida). Carr and Goin, 1955: 30 (characters in key), 84 (description, distribution, habitat; Florida). Marshall, 1958: 22 (characters in key; Florida). Robins, 1958: 20 (listed, common names, distribution; Florida). Briggs, 1958: 278 (listed, common name, distribution, habitat; Florida).

Lateral scales 62 to 70. Gill rakers 15 to 18. Anal rays 7. Pectoral rays 14. Second anal spine not reaching beyond vertical from caudal base. Pectoral fin not reaching to vertical from tip of pelvic. Pelvic fin reaching well beyond anus. Distance between anus and origin of anal fin, 1.1 to 1.6 in distance between anus and insertion of pelvic. Maxillary not reaching to vertical from center of eye.

The name "tarpon snook", proposed by Robins (1958: 20), refers to the upturned anterior part of the head, reminiscent of the tarpon (*Megalops atlantica*). In the other species of snook, the anterior part of the head is much less upturned.

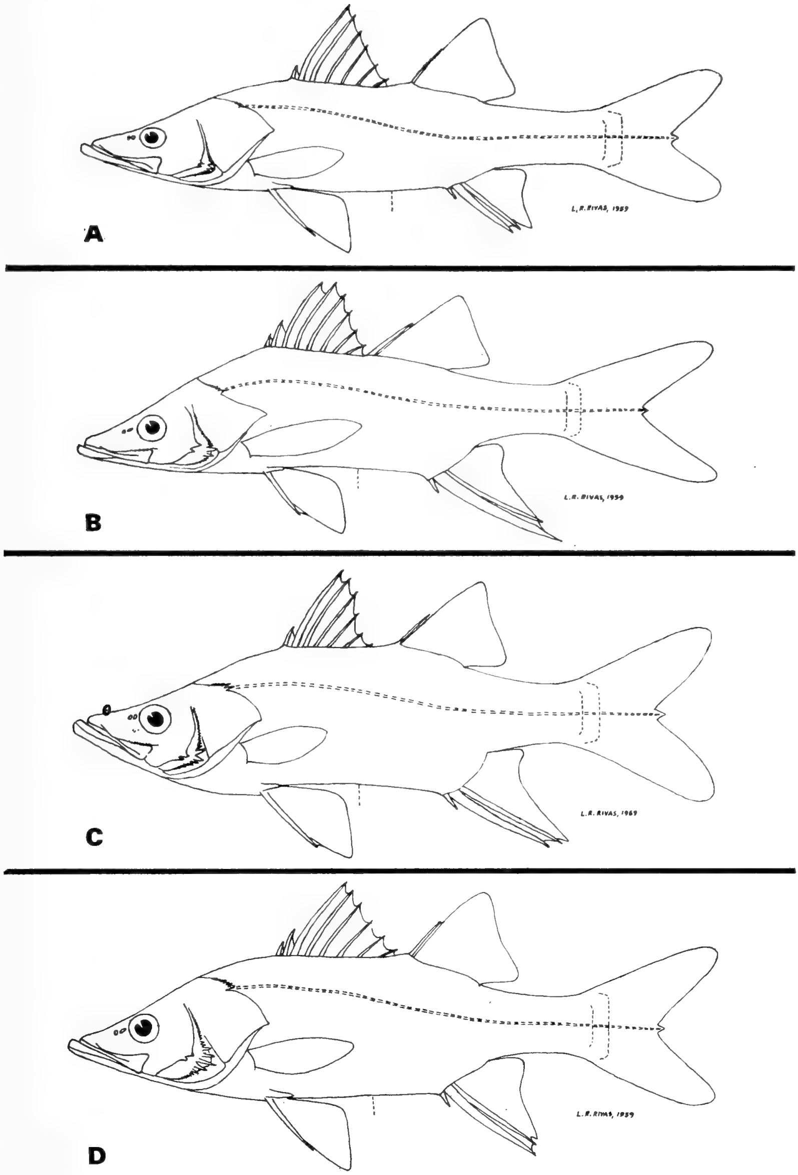

Figure 1. Four species of *Centropomus* occurring in Florida. A. *C. undecimalis,* from a specimen 343 mm. in length, Biscayne Bay at North Miami (UMIM 4446). B. *C. ensiferus,* from a specimen 145 mm. in length, fresh water canal, Miami (UMIM 4443). C. *C. pectinatus,* from a specimen 306 mm. in length, Card Sound Canal, Homestead (UMIM 4673). D. *C. parallelus,* from a specimen 307 mm. in length, Biscayne Bay at North Miami (UMIM 4678). Drawn by the author.

This species is sharply distinguished from the others occurring in Florida by the much more compressed body. This may be readily ascertained by comparing specimens of about the same size. Also, in *Centropomus pectinatus*, the ventral outline of the body and the anal base form an angle more strongly salient than in the other three Florida species.

Young and juveniles of *Centropomus pectinatus* less than about 100 mm. in length, as well as adults, can be distinguished from those of the other three species by the number of anal and pectoral rays, and by the number of lateral scales. The three smallest juveniles available, 30 to 32 mm. in length, have about 64 lateral scales, 7 anal rays, 14 pectoral rays and 16 or 17 gill rakers. The number of gill rakers distinguishes juveniles of *C. pectinatus* from those of *C. parallelus* and *C. undecimalis* but probably not from those of *C. ensiferus*. Juveniles of *C. pectinatus* can probably be distinguished from those of *C. ensiferus* by the much shorter second anal spine. In the three juveniles of *C. pectinatus* referred to above, the second anal spine does not reach beyond a vertical from the caudal base. This spine, as the fish grows, becomes progressively shorter in relation to body length in all the species of *Centropomus.*

The third anal element is completely ossified and appears as as a fully formed spine at the length of 30 mm. in *Centropomus pectinatus.* Judging from the juveniles of *C. parallelus,* however, the third anal spine is probably fully developed at a length of about 20 mm. or less in *C. pectinatus.*

In the juveniles of *Centropomus pectinatus* discussed above, the maxillary does not reach to a vertical from the anterior margin of the pupil. In juveniles of *C. parallelus* and *C. undecimalis* of comparable length, the maxillary reaches well beyond a vertical from the anterior margin of the pupil.

The maximum size attained by *Centropomus pectinatus* appears to be much greater than in *C. ensiferus* and less than in *C. parallelus* and *C. undecimalis.* The largest specimen of *C. pectinatus* known to the author measured fifteen and three quarters inches in total length (UMIM 4673) and no larger individuals have been reported in the literature. The fish was collected in Card Sound Canal near Homestead. Full grown adults probably do not attain a total length of much more than twenty inches.

In Florida, *Centropomus pectinatus* is so far known from the Caloosahatchee River southward to Card Sound. Along the east coast drainage, it is known to occur from the latter area to the extreme norther portion of Biscayne Bay. The species also occurs in the West Indies and in the Atlantic drainage of Central and South America southward to Brazil.

Fifteen specimens, 30 to 315 mm. in length, have been examined from the following localities in Florida. Six, 208 to 315 mm., Card Sound Canal, Homestead (UMIM 4673). One, 248 mm., fresh water canal, Coral Gables (UMIM 4675). One, 245 mm., fresh water canal, Coral Gables (UMIM 4676). Three, 30 to 32 mm., fresh water canal, Coral Gables (UMIM 2445). Three, 146 to 170 mm., fresh water canal, Coral Gables (UMIM 3338). One, 271 mm., Biscayne Bay, North Miami (UMIM 4677).

3. *Centropomus parallelus* Poey

Figure 1 D
Fat snook

Centropomus parallelus Poey, 1860: 120 (original description; Cienfuegos, Cuba), pl. 13, figs. 2-3. Jordan and Evermann, 1896: 1122 (description, distribution). Rivas, 1949: 13 (listed, common names, distribution; Florida). Carr and Goin, 1955: 30 (characters in key), 85 (description, distribution, habitat; Florida). Marshall, 1958: 22 (characters in key; Florida). Robins, 1958: 20 (listed, common names, distribution; Florida). Briggs, 1958: 278 (listed, common name, distribution, habitat; Florida).

Lateral scales 80 to 90. Gill rakers 10 to 13. Anal rays 6. Pectoral rays 15 or 16. Second anal spine not reaching beyond vertical from caudal base. Pectoral fin not reaching to vertical from tip of pelvic. Pelvic fin reaching to or beyond anus. Distance between anus and origin of anal fin, 1.2 to 1.6 in distance between anus and insertion of pelvic. Maxillary reaching to or beyond vertical from center of eye.

Robins (1958: 19) comments that the name “fat snook”, originally proposed for this species by the present writer (Rivas, 1949: 13), has not taken hold. At the same time, Robins proposed the name “little snook” for the species. According to the writer’s experience, the name “fat snook” is currently in use and the name “little snook” appears to be misleading. As already discussed, the preceding species, *Centropomus ensiferus* and *C. pectinatus*, are smaller than *C. parallelus* especially *C. ensiferus*.

Five juveniles from Jamaica, 23 to 35 mm. in length (UMIM 1827) and one from Cuba, 41 mm. in length (UMIM 4735), indicate that *Centropomus parallelus* of those sizes can be distinguished from equally small *C. pectinatus* and *C. undecimalis*, by the number of lateral scales (about 80) and the number of gill rakers (12 or 13). The number of lateral scales would distinguish juveniles of *C. parallelus* from those of *C. ensiferus* but not the number of gill rakers. The length of the second anal spine would also serve to distinguish juveniles of *C. parallelus* from those of *C. ensiferus*. In the juveniles of *C. parallelus* referred to above, the second anal spine does not reach beyond a vertical from the caudal base. In *C. ensiferus* of similar size, the second anal spine would probably reach well beyond that vertical, as already discussed under *C. pectinatus*. In *C. parallelus*, the third anal element is completely ossified and appears as a fully developed spine at a length of 23 to 25 mm., according to the juveniles discussed above.

The position of the anus with respect to the origin of the anal fin and the insertion of the pelvic (see diagnoses), does not seem to vary with age in the species of *Centropomus*. This character distinguishes juveniles, young adults of *C. parallelus* from those of *C. undecimalis* and probably also *C. ensiferus* but not from those of *C. pectinatus*.

In the juveniles of *Centropomus parallelus* referred to above, the maxillary reaches beyond a vertical from the anterior margin of the pupil but not to a vertical from the center.

This is the second largest species of snook occurring in Florida. It occasionally attains a total length of about eighteen inches but larger individuals are apparently very rare. The largest known specimen of *Centropomus parallelus* was recorded by Meek and Hildebrand (1925: 424) from Panama. It measured 580 mm. (22⅞ inches) in length. The largest specimen known from Florida is 376 mm. (14⅞ inches) in length (UMIM 2588).

The distribution of *Centropomus parallelus*, in Florida, comprises the southern part of the state, from the Lake Okeechobee drainage southward including the keys. The species also occurs in the West Indies and in the Atlantic drainage of Mexico, Central, and South America, from Veracruz to Bahia.

Thirty specimens, 120 to 375 mm. in length, were examined from the following localities in Florida. One, 245 mm., Lake Okeechobee at Clewiston (UMIM 4679). Ten, 157 to 341 mm., Biscayne Bay at North Miami (UMIM 4678). Eight, 121 to 165 mm., fresh water canal, Coral Gables (UMIM 4680). One, 141 mm., Goulds

Canal, Perrine (UMIM 3149). Nine, 201 to 275 mm., Card Sound Canal, Homestead (UMIM 4444). One, 376 mm., Marathon (UMIM 2588).

4. *Centropomus undecimalis* (Bloch)
Common snook

Figure 1 A

Sciaena undecimalis Bloch, 1792: 60 (original description; Jamaica), pl. 303.
Centropomus undecimalis, Jordan and Evermann, 1896: 1118 (common names, description, distribution, synonymy). Rivas, 1949: 13 (listed, common names, distribution; Florida). Carr and Goin, 1955: 30 (characters in key), 84 (description, distribution, habitat; Florida). Marshall, 1958: 10 (fishery), 21 (biology), 23 (distribution), 24 (life history), 34 (ecology). Robins, 1958: 20 (listed, common names, distribution; Florida). Briggs, 1958: 278 (listed, common name, distribution, habitat; Florida). Volpe, 1959: 8 (migration), 21 (age and growth), 34 (spawning and fecundity).

Lateral scales 70 to 77. Gill rakers 7 to 9. Anal rays 6. Pectoral rays 15 or 16. Second anal spine not reaching to vertical from caudal base. Pectoral fin not reaching to vertical from tip of pelvic. Pelvic fin not reaching to anus. Distance between anus and origin of anal fin, 1.9 to 2.5 in distance between anus and insertion of pelvic. Maxillary reaching to or beyond vertical from center of eye.

The number of lateral scales (about 70 to 73) and gill rakers (9 or 10) distinguish juvenile *Centropomus undecimalis* from those of the other species as indicated by 14 specimens 30 to 64 mm. in length from Cuba (UMIM 4440). In these juveniles, the second anal spine does not reach to a vertical from the caudal base, and the third anal spine is not formed until a length of 35 to 40 mm. is attained. On the basis of this character, juveniles between about 23 and 40 mm. without a developed third anal spine probably are *C. undecimalis.* As already indicated, the third anal spine develops at a length of about 23 to 25 mm. in *C. parallelus* and probably at the same or smaller lengths in *C. pectinatus* and *C. ensiferus.* The second and third anal spines, in *C. undecimalis,* are much shorter than in the other three species as may be readily observed when specimens of similar size are compared. These spines show very marked negative allometric growth and their length, in relation to that of the body, is therefore of little value as a diagnostic character.

In the juveniles of *Centropomus undecimalis* referred to above, the maxillary reaches to or beyond a vertical from the center of the pupil. In the larger adults, the maxillary may even reach to or beyond a vertical from the posterior margin of the orbit.

In juveniles and young of *Centropomus undecimalis* about 80 mm. in length or less, the pelvic fin may reach to or slightly beyond the anus. In juveniles and young of *C. parallelus, C. pectinatus* and probably also *C. ensiferus,* the pelvic fin, as in their adults, reaches well beyond the anus (except in larger adults of *C. parallelus*). In *C. undecimalis* larger than about 100 mm. in length, the pelvic fin does not reach to the anus.

The position of the anus, with respect to the origin of the anal fin and the insertion of the pelvic (see diagnoses), distinguishes juveniles, young and adults of *Centropomus undecimalis* from those of the other three Florida species. As already indicated under *C. parallelus,* this character does not seem to vary with age.

A considerable amount of work has been conducted on several aspects of the biology of *Centropomus undecimalis* in Florida. According to Marshall (1958), the spawning season of *C. undecimalis* is protracted in southwestern Florida and extends from June to November. He also found that only a few individuals are adult at 350 mm. in fork length but that about fifty percent are mature at 400 mm., and nearly all at 500 mm. Small, immature individuals, apparently less than a year old, usually occur in the marginal areas of coastal lagoons and estuaries such as shallow streams, ditches, shorelines and backbays. Adults may occur well inland, in waters generally regarded as fresh, or in salt water relatively far from estuaries. The species is known to occur along the Florida Keys as far west as the Dry Tortugas.

Marshall's studies (*l.c.*) also indicate that the common snook is very sensitive to temperature change. Extreme lows of water temperature may cause the fish to be sluggish or kill them. The minimum safe level appears to be about 15.5° C (about 60° F).

The common snook, as the other species of *Centropomus,* is carnivorous. According to Marshall (*l.c.*) it feeds primarily on fishes but crustaceans are also an important food item.

Studies on the migration, age and growth of *Centropomus undecimalis* in Florida, were conducted by Volpe (1959). According to him, migration is not extensive and appears to involve only short coastwise and/or offshore and inshore movements. Volpe also indicates that *C. undecimalis* may reach the age of at least seven years and that almost all specimens are mature by their third year of life. At this age, the fish are about 500 mm. in fork length and weigh about two and a half pounds (Marshall, 1958: 27).

This is the largest and by far the most common species of snook occurring in Florida. Specimens over twenty inches in total length are not uncommon and according to the writer's own observations much larger specimens are frequently taken. The largest known specimen of *Centropomus undecimalis,* recorded from Panama by the International Game Fish Association (1961), measured four feet seven inches in total length and weighed fifty pounds and eight ounces. In the same publication, the largest specimen known from Florida (Marco) is listed as having weighed forty-nine pounds and eight ounces.

According to Marshall (1958: 23), *Centropomus undecimalis* occurs on the west coast of Florida northward to the vicinity of Hernando County. On the east coast, it occurs northward to Duval County. The species also occurs in the Lake Okeechobee drainage. Outside of Florida, *C. undecimalis* has been recorded as far north as Georgia and South Carolina (Lunz, 1953: 240), and from southwestern Texas southward along the Atlantic drainage to Rio de Janeiro, Brazil (Marshall, *l.c.*). It also occurs throughout the West Indies.

Twenty-nine specimens, 83 to 707 mm. in length, have been examined from the following localities in Florida. One, 417 mm., Inland Waterway, Riviera Beach (UMIM 2268). Three, 322 to 342 mm., Biscayne Bay at North Miami (UMIM 4446). Nineteen, 130 to 221 mm., Miami (UMIM 751). Three, 83 to 110 mm., Bear Cut, Miami (UMIM 4441). Two, 103 to 119 mm., Marco Road canal (UMIM 3340). One, 707 mm., Lake Maggiore, St. Petersburg (UMIM 4681).

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TWO LARGE OPHIODERMATID BRITTLESTARS NEW TO FLORIDA[1]

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Ophioderma, Family Ophiodermatidae, is a tropical genus whose species are, with several questionable exceptions, absent from the Indo-West Pacific region. Ziesenhenne (1955) listed twenty-one species of which twelve are found in the western Atlantic. The following species have been recorded from shallow (ten meters or less) Florida waters: *Ophioderma brevispinum* (Say), *O. brevicaudum* Lütken, *O. appressum* (Say), *O. cinereum* Müller and Troschel, and *O. rubicundum* Lütken. The last two species, particularly *O. rubicundum,* are most common in coral reef environments, whereas *O. brevispinum* is exceedingly common in beds of turtle grass (*Thalassia testudinum*). *O. appressum* may be found in a variety of habitats including clumps of the alga *Halimeda* and under the rubble of coral reefs. Although Verrill (1899) reported *O. brevicaudum* from the Florida Keys, I have never taken it from Florida waters.

The upper arm plates of *Ophioderma cinereum* are broken into numerous irregular segments (Fig. 1), a characteristic which is also found in the two species new to Florida (*O. guttatum* Lütken and *O. squamosissimum* Lütken). As these species are the only ones in the western Atlantic with this feature its possible significance is discussed below.

Ophioderma guttatum Lütken, 1859

Material Examined: 1 spec. disc diameter 33 mm., Soldier Key, Biscayne Bay Florida, 17 July, 1950, G. L. Voss, Coll. UMML 41.59.

1 spec. disc diameter 37 mm., Bear Cut, Key Biscayne, Florida, depth, 4 feet, 12 July, 1959. L. P. Thomas, Coll. UMML 41.142.

1 spec. disc diameter 45 mm. Margate Fish Shoal, S. of Elliot's Key, Miami, Florida, depth, 10 feet, 20 June, 1961. Marine Laboratory staff, Coll. UMML 41.143.

1 spec. disc diameter 32 mm. ½ mile S.S.W. of Alligator Reef Light,

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Monroe County, Florida, depth 15-20 feet, 30 April, 1961. W. A. Starck II, Coll. UMML 41.153.

Ophioderma guttatum Lütken was described (1859) from a single specimen collected at St. Thomas in the Virgin Islands. Only two other records of this large brittlestar exist. H. L. Clark (1915) reported two specimens from Port Antonio and Montego Bay, Jamaica, and mentioned (1918) its presence at Tobago, B.W.I. Within the past several years four specimens of this species have been collected in and near Biscayne Bay. All have been taken under rubble associated with hermatypic corals. A more common species, *O. cinereum*, may be found in the same environment.

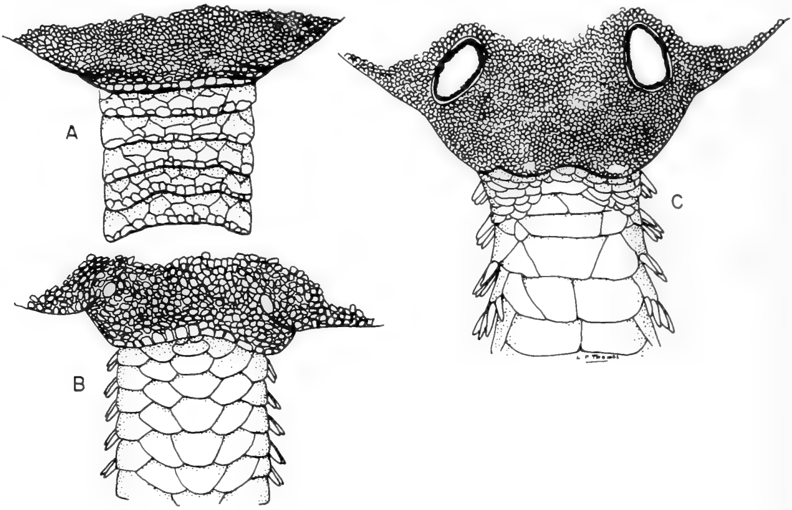

Figure 1. A. *Ophioderma guttatum*, B. *O. squamosissimum*, C. *O. cinereum*. Basal portion of an arm with adjoining section of the disc.

O. guttatum is one of the larger West Indian brittlestars. Although Lütken's description was based on a specimen with only a 12 mm. disc diameter, Clark (1933) gave a disc diameter for full grown specimens of nearly 30 mm. The disc diameters of the specimens in The Marine Laboratory collection measure 32, 33, 37 and 45 mm. The arm length of the largest one is 183 mm.

Because of its large size and similar brownish color, *O. guttatum* may be confused with *O. cinereum*. Both also have the upper arm plates broken into irregular smaller plates. *O. cinereum*, however, has banded arms, round disc granules, and naked radial shields. *O. guttatum* has unbanded arms, finely peppered with dark spots and flattened disc granules which are irregular in shape and cover the radial shields.

Ophioderma squamosissimum Lütken, 1859

Material Examined: 1 spec. disc diameter 38 mm, ¼ mile SSE of Alligator Light, Florida Keys, depth 15 feet, 26 Aug. 1961. W. A. Starck II, Coll. UMML 41.144.

1 spec. disc diameter 42 mm, Margate Fish Shoal, S. of Elliot's Key, Miami, Florida, depth 10 feet, 20 June, 1961. Marine Laboratory Staff, Coll. UMML 41.145.

5 spec. disc diameters 17-22 mm, Buccoo Bay, Tobago, B.W.I., MCZ. 4170.

1 spec. North Bimini, Bahamas, Richard Foster, Coll. MCZ 6652.

A second species new to Florida waters, *Ophioderma squamosissimum* Lütken, 1859, has been collected in less than five meters of water at two separate south Florida locations. The original description was based on a single specimen from an unknown West Indian locality. Fifty-nine years later H. L. Clark (1918) described and figured this species from five specimens which he collected in Buccoo Bay at Tobago, British West Indies. "These were all found (but only by long and intensive searching) on the least exposed parts of Buccoo Reef" (Clark, 1918). Richard Foster of the Museum of Comparative Zoology at Harvard collected a seventh specimen (MCZ 6652) at North Bimini, Bahamas. Dr. Clark was interested in the apparent wide distribution of this little known species but was unable to publish upon it before his death in 1947.

O. squamosissimum is another giant among ophiodermatids. Formerly the largest specimen was the type which has a disc diameter of 28 mm and arms 158 mm long. The two Florida specimens have disc diameters of 42 and 38 mm and arms 155 and 200 mm long, respectively. Both were regenerating arms which explains the one with the largest disc having the smallest arms.

There is little question of confusing this *Ophioderma,* which Clark (1933) considered the most brilliantly colored animal on West Indian Reefs, with its congeners. The color is a bright vermilion which unfortunately fades rapidly upon the death and preservation of the specimen. Clark (1918) found the discs of his specimens lightly marked with a yellowish shade. Similarly the under arm surfaces of the Florida specimens were yellowish. The writer has seen all extant specimens, except the type, and in no case is there any trace of banding or spotting. The very small radial shields are naked and the disc granules are extremely flattened and irregular in outline so that they form a mosaic. The arm plates are broken into smaller plates just as they are in *O. cinereum* and *O. guttatum*. Instead of being irregular they form a very regular series of scales with a central dorsal row and two or three lateral rows on each side.

Possibly, *O. guttatum* and *O. squamosissimum* are closely related for both possess flattened irregular disc granules which, to the writer's knowledge, do not occur in other members of the genus. Clark (1918) suggested that the two should probably be placed in a separate genus. The phylogenetic significance of the presently used taxonomic characters in ophiuroids is unknown. A great deal more work remains to be done with the problem of brittlestar speciation before morphologic similarities can be equated with phylogenetic relationships. If indeed similarities in disc granules show phylogenetic relationship, *O. cinereum*, which has round disc granules, would appear to be more closely allied to the remaining group of ophiodermas. It is particularly similar to *Ophioderma teres* of the Pacific coast of Mexico and Central America. This species has irregularly broken upper arm plates, similar oral plates, and may be spotted with light yellow, just as the young of *O. cinereum*. Whether or not a close phylogenetic relationship exists between these species is unknown.

I wish to thank Walter A. Starck, II and Clyde F. E. Roper of The Marine Laboratory for their assistance in obtaining observations and specimens. The specimens at the Museum of Comparative Zoology at Harvard were examined while I was working under National Science Foundation Grant (G-5183). I am grateful to Dr. Elisabeth Deichmann for her many kindnesses during my stay there.

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AN OPHIURIAN SHOAL ON THE MISSISSIPPI COAST[1]

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On July 15, 1959, R. A. Woodmansee and I conducted a field trip on the Gulf Coast Research Laboratory vessel *Hermes* to the east end of Ship Island, Mississippi. This island is one of the barrier islands that lies a few miles to the south of the mainland, and which forms part of the seaward boundary of Mississippi Sound. Ship Island is composed of coarse sand in contrast to the mud bottom of most of the Sound and the sandy mud to seaward in the Gulf of Mexico. The island is oriented roughly ENE and WSW, and the eastern end is one of the closest localities to the Laboratory where a truly marine fauna can be found.

Observations were begun in shallow depths around the tip of the island. The water, usually murky with sediment, was unusually clear, and made diving with a face mask practical. As I worked my way around to the Gulf side of the island, I observed slender flexible objects, usually paired, projecting from the sand. Digging revealed these to be the arms of a brittle star that was living with its body buried about three inches in the sand. Most, apparently, had two arms projecting, but the number ranged from one to three. A little to the westward of where they were first found, their numbers increased, and soon there appeared to be a forest of small arms extending an inch or two above the sand. The densest part of this "ophiurian shoal" was in a depth of three to four feet, and was more than a hundred feet out from the beach.

Specimens collected were later identified as *Ophiophragmus wurdemani* Lyman (family Amphiuridae). However, as the systematics of this genus is rather involved, several specimens were sent for examination to Lowell P. Thomas at The Marine Laboratory, University of Miami. His opinion, in a communication dated January 24, 1961, was that "the specimens of *Ophiophragmus* which you recently sent me (1959) are very close to *O. wurdemani,* but differ slightly in several respects and could represent an undescribed species. Until we know more about speciation in this genus an identification cannot be made with certainty."

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[1] Contribution No. 376 from the Marine Laboratory, University of Miami.

The environment in which these brittle stars were taken is fairly typical of the northern gulf coastal waters. The water is rather turbid, and contains a considerable amount of organic matter (Priddy, *et al,* 1956). The salinity is reduced, and is usually about 30°/00 where the Gulf and Mississippi Sound meet; however, this may be considerably reduced by heavy precipitation, and a surface salinity of 11.5°/00 has been reported from the northern side of Ship Island (Moore, 1961). Thomas (1961) has reported that *O. wurdemani* is found in a similar environment along the west coast of Florida.

The habit of protruding one or more arms from the sand is undoubtedly a method of feeding. The great concentration of *O. wurdemani* at Ship Island was able to take advantage of the tidal currents flowing past the tip of the island. The water is laden with a rich load of organic material, yet salinities apparently remain within the range of tolerance for this organism during all but the most adverse conditions. Little is known about the biology of *O. wurdemani,* but burrowing habits of the family Amphiuridae have been described by Des Artes (1910). What little information there is appears to be almost entirely systematic or geographical, and no one has mentioned its habit of protruding its arms from the sand.

A comparable phenomenom has been reported by Mitsukuri and Hara (1897) for a shoal in the shallow waters of Kagoshima Bay, Japan. They found large numbers of brittle stars in very shallow water in an environment similar to the Mississippi shoal. The brittle stars in this case were described some years later by Matsumoto (1915) as *Amphiura vadicola* (family Amphiuridae).

Two such similar occurrences in closely related animals on opposite sides of the earth is of interest. In both cases, the animals took advantages of local conditions, and protection from predators and a bountiful food supply made it possible for great numbers to survive and prosper. Moore (1956) has reported that large numbers of the echinoderm, *Mellita quinquiesperforata* Leske, a sand dollar, exist in the shallow coastal waters of the northern Gulf. However, there is apparently no record of large concentration of amphiurids in the shallow waters of the United States. This may be because suitable habitats are limited, and that these localities are in areas where turbid waters are the rule and discourage underwater observation.

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RESEARCH NOTES

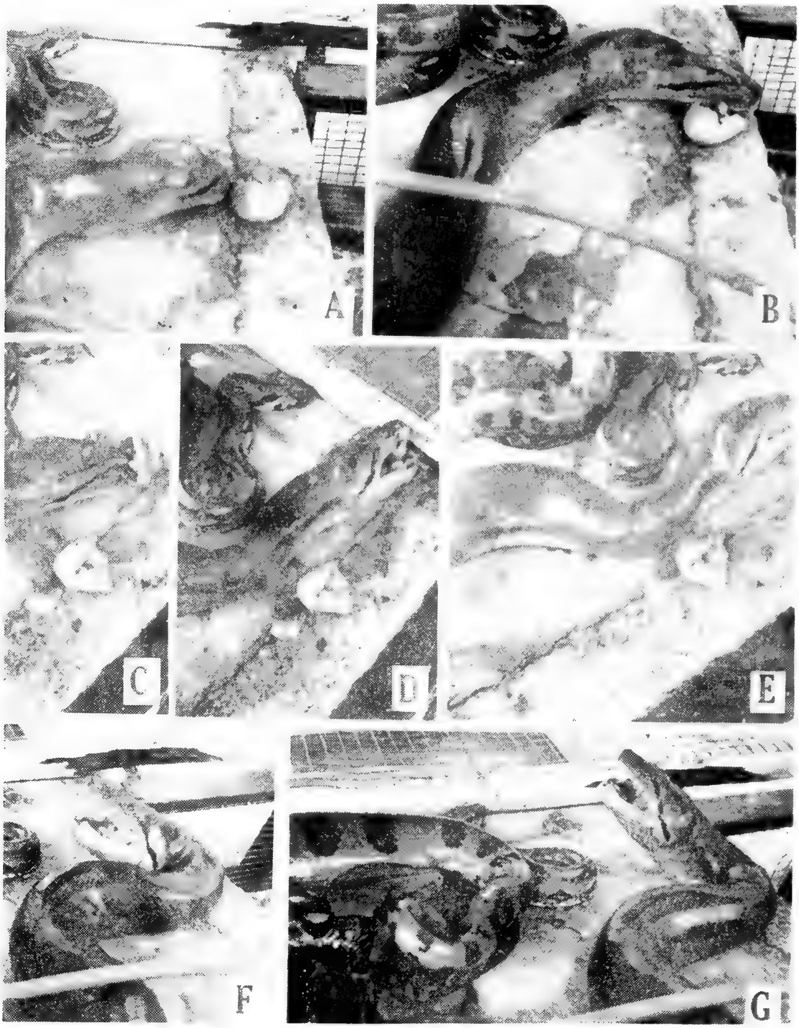
PARTURIENT ANACONDA, *EUNECTES GIGAS* LATREILLE, EATING OWN ABORTIVE EGGS AND FOETAL MEMBRANES.—A 15-foot anaconda, exhibiting the characters of *Eunectes gigas* Latreille as redefined by Dunn and Conant (1936, Proc. Acad. Nat. Sci. Phila., 88: 503-506) was collected in British Guiana in October, 1958, and kept on display at Ross Allen's Reptile Institute, Inc. It gave birth to young on the night of January 8-9, 1959. By 8:25 A.M. on the morning of the 9th, the snake had produced 4 living young and 19 large abortive eggs. After parturition had ceased, the reptile began to eat the abortive eggs, one by one. By noon only 4 abortive eggs remained. Photographs were made to document the episode.

The method whereby the snake ate the abortive eggs was quite unlike the normal feeding behavior. The snake would press its nose to the concrete substratum, slowly following a trail of foetal membranes and birth fluids (Fig. 1, a-b). When the nose touched an abortive egg, the snake's tongue would flicker out a few times in exploratory fashion. Then the reptile would slowly open its mouth, and gently try to engulf the entire egg. This being difficult on concrete (c), the anaconda would slowly push the egg until it was secured against some backstop. Then with considerable delicacy the snake would take the egg into its mouth (d). Next it would tilt the head upward, also elevating the head and neck (e). In this position the snake would slowly masticate the egg, and swallow the fragments (f-g). During the swallowing, the snake's tail was coiled and uncoiled a number of times, but the body remained motionless. After ingestion of the egg, the reptile would lower the head to the substratum, lie motionless for 5 or 6 minutes, then search for another egg.

In one case the anaconda, nosing an egg, pushed it over the rim of a basin in the cage. The snake became motionless the moment its nose lost contact with the egg, and made no search therefor. In another case, following a trail toward an egg, the snake encountered a small puddle of birth fluids and foetal membranes. This it tried to consume, by small, biting movements.

The anaconda's method of eating the birth debris was reminiscent of a lizard's feeding in that (1) the head was first bent down, the tip of the nose touching the item to be ingested; (2) the item was taken into the mouth by a simple bite; (3) the head was then elevated; and (4) the item was masticated. In contrast, the normal feeding behavior of an anaconda is more typically snake-like. The prey is seized usually with a slashing, sideways bite, followed almost instantly by coils of body. While deglutition proceeds, the snake's tail is waved and thrashed about. (Such tail-waving is characteristic of many normally feeding snakes and lizards, especially if several individuals are penned together.)

The normal method whereby a snake engulfs its prey involves no mastication but a sort of "walking" motion of the jaws, made possible by their extreme flexibility; the snake "literally draws itself over the prey . . . " (Schmidt, 1950, Evolution, 4: 79). The normal method of ingestion is the "most fundamental snake character . . . Once the evolutionary trend toward lightness and flexibility of the jaw apparatus had set in there could not be any development of the jaws or teeth for comminution of the food." (*idem*).



This particular anaconda had never accepted food in captivity. As an experiment, a small shad was rubbed in the birth debris and placed near the snake's head. The anaconda took it as though it had been another abortive egg. With the fish in its jaws, the snake raised its head and began mastication. This procedure, effective on the fragile abortive eggs, was useless with the tougher fish, which was finally dropped. A rabbit, rubbed in the birth fluids, was also taken, lifted, chewed ineffectually for a time, and abandoned. The normal feeding behavior would permit an anaconda this size to swallow prey much bigger than the shad or the rabbit; a specimen of *Eunectes gigas,* about the size of this one, once passed the remains of a large dog (Neill and Allen, 1956, Herpetologica, 12(3): 173-174). Evidently, the scent of the birth debris evoked from the snake a reaction quite different from the usual pattern of feeding behavior. Another 15-foot anaconda, penned with the parturient female, also became stimulated by the abortive eggs, which it nosed and investigated; but it was disturbed by people in the cage, and soon desisted. South American boas, *Boa c. constrictor* Linnaeus, likewise in the cage, were oblivious to the proceedings.

Many mammals are well known to devour their own afterbirth; the habit is also widespread among live-bearing lizards (Oliver, 1955, The Natural History of North American Amphibians and Reptiles: 259). It is interesting to find the same behavior pattern in a primitive snake. The function of this behavior is problematical, at least in reptiles. It is possible that the anaconda obtains some physiologically or metabolically useful substance by eating its own birth debris; however, such actions have a more obvious survival value. As we have many times noted, a parturient anaconda produces a large quantity of birth fluids, foetal membranes, and abortive eggs, all of which have a strong and characteristic odor. This odor might soon advertise to keen-nosed carnivores the nearby presence of relatively helpless young snakes and their exhausted female parent. By devouring the debris immediately after birth, the adult reduces the telltale odor to a minimum.

The family Boidae, which includes the anaconda, appeared very early in the history of snakes (Bellairs and Underwood, 1951, Biol. Rev. Cambridge Phil. Soc., 26(2): 195). Modern boids exhibit numerous primitive features of the viscera, vascular system, and skeleton (*ibid.*: 231; Romer, 1956, Osteology of the Reptiles: 571-572). The occurrence in a boid of a primitive, unspecialized, lizard-like method of ingestion is therefore noteworthy, even though it is not a part of the usual feeding behavior. Other snakes employ masticating motions, something like those of lizards, when biting in defense or attack, or when drinking, but apparently not when ingesting solid objects.—WILFRED T. NEILL and ROSS ALLEN, Research Division, Ross Allen's Reptile Institute, Inc., Silver Springs, Florida.

Research Note Quart. J. Florida Acad. Sci.

PLICARIA FULVA SCHNEIDER (ASCOMYCETES) IN FLORIDA SOILS. In a recent article I (1959, Quart. J. Florida Acad. Sci. 22: 147-154) reported the recovery of species of *Phymatotrichum* Bon. (*Fungi Imperfecti*) from soils in chrysanthemum plantings. Further work has shown that all Florida isolates were the conidial stage of *Plicaria fulva* as represented by a culture kindly supplied by Dr. Schneider.

A generic name was not assigned to the conidial stage of *P. fulva* when it was described by Schneider (1954, Zentr. Bakteriol. Parasitenk. Abt. II, 108: 147-153). Wolf, (1955, J. Elisha Mitchell Sci. Soc. 71: 213-217) described *Mycotypha dichotoma* F. A. Wolf (Phycomycetes) from soil in which contaminated pine seed were planted. Wolf later (1957, Mycologia 49: 280-282) reported that *M. dichotoma* was identical with the conidial stage of *P. fulva.* He further stated that *M. dichotoma* was not a Phycomycete but belonged to an unnamed form genus. The taxonomic status of *P. fulva* is presently being investigated by G. L. Hennebert, Canada Department of Agriculture, Ottawa.—Curtis R. Jackson, Coastal Plain Experiment Station, Tifton, Georgia.

NEW LOCALITY RECORDS FOR THE SAND SKINK (*NEOSEPS REYNOLDSI*) IN CENTRAL FLORIDA, WITH COMMENTS ON THE HABITAT. In an earlier paper, I (1959, Copeia; 2: 110-119) restricted the range of the sand skink, *Neoseps reynoldsi* Stejneger, to Lake, Polk, and Highlands counties in central Florida, and indicated my belief that it occurs only in rosemary scrub. Seven collecting localities were cited.

Field work during 1959, 1960, and 1961 by Robert H. Mount and I revealed nine new localities within Lake, Polk, and Highlands counties at which *Neoseps* is common. In view of the rapid rate at which rosemary scrub and sandhill habitats are being destroyed—three of the four Winter Haven localities cited in my earlier paper have been developed into "improved pasture" and residential areas within the last four years—it seems desirable to list these additional collecting sites.

Contrary to my earlier observations, *Neoseps* is a common inhabitant of longleaf pine-turkey oak habitat, or sandhills, as Laessle (1958—Ecol. Monog.; 28: 361-387) has termed this distinctive association. Collecting technique in the scrub consists of raking in the surface sands beneath debris of various sorts: palmetto fronds, branches, logs, and especially fallen Spanish moss. This technique is practical in the scrub, where such debris provides most of the cover available for the lizards and their prey. A "funneling" of the lizards thus results, which permits the collector to focus his activities in spots likely to prove productive. In sandhills, however, more surface cover is present, chiefly in the form of wiregrass and fallen turkey oak leaves, and the "funneling" apparently does not occur, to the collector's disadvantage. Until development of an efficient collecting technique for sandhills which permitted systematic collecting in an area, an erroneous impression of the sandhill herpetofauna was to be expected.

During his study of the red-tailed skink, *Eumeces egregius,* Robert H. Mount (Ph.D. thesis, University of Florida) discovered that *Neoseps* is abundant in the mounds which the pocket gopher, *Geomys pinetis,* thrusts above the surface of the ground during its fossorial meanderings. Knowledge of this microhabitat permits the collector to focus his collecting in sandhills, and has resulted in the discovery of eight new localities in which *Neoseps* occurs in sandhill habitat.

Neoseps reynoldsi has been collected from the following localities in central Florida (new localities designated by *):

Lake County: Fruitland Park (sandhills); Eustis airport (scrub); *½ mile east of the intersection of Florida highways 448 and 561 (mixed scrub and sandhills); *¾ miles east of Clermont along the north side of Florida highway 50 (sandhills).

Polk County: *5 miles south of the Lake County line, along the east side of U.S. highway 27 (sandhills); *¼ mile south of the intersection with Florida highway 547, along the east side of U.S. highway 27 (sandhills); *½ mile south of the intersection of Florida highway 640, along the west side of U.S. highway 27 (scrub); *4¾ miles south of the intersection of U.S. highways 27 and 98 (north), along the east side of 27 (sandhills); Blue Lake scrub, 4 miles northwest of Winter Haven (data on U.S. National Museum specimens refer to this scrub area as "Auburndale"); Lake Thomas-Lake Sears scrub, approximately 3 miles southwest of Winter Haven (now a residential area); Eagle Lake rifle range scrub, approximately 5 miles southwest of Winter Haven (now "improved pasture"); *Babson Park (sandhills).

Highlands County: Archbold Biological Station, approximately 3 miles south of Lake Placid (scrub); *3 miles south of the intersection of U.S. highways 27 and 98 (south), along the east side of 27 (sandhills); *10.2 miles south of Frostproof (Polk County—speedometer reading from center of town), along the east side of U.S. highway 27 (sandhills).

These localities all lie within the range as I previously restricted it. Additional information has been supplied on the supposed locality record for *Neoseps* in Dade County (Duellman and Schwartz, 1958: 291; Telford, 1959) by Wilfred T. Neill, who inspected the reported collection site. He characterizes the area as tropical hammock, which in my opinion is additional cause to invalidate the Dade County record, since it is doubtful that a fossorial animal such as *Neoseps,* adapted to living in loose sand in the xeric habitats of scrub and sandhills, could tolerate the humid, well-packed soil of tropical hammock. The present distribution of *Neoseps* suggests that soil moisture acts as an effective barrier to dispersal.

I wish to thank Robert H. Mount, Alabama College, Montevallo, for information on the *Neoseps* which he collected, Wilfred T. Neill, Research Division, Ross Allen's Reptile Institute, Silver Springs, for information on the supposed Dade County collecting site, and M. J. Fouquette, Jr., Southwestern Louisiana University, Lafayette, and Kenneth S. Norris, University of California, Los Angeles, for their suggestions concerning this paper. Sam R. Telford, Jr., Dept. of Zoology, Univ. of Cal., Los Angeles.

TELFORD, SAM R., JR. (U. California, Los Angeles). New locality records for the sand skink (*Neoseps reynoldsi*) in central Florida, with comments on the habitat. Quart. Jour. Florida Acad. Sci. 25(1): . 1962. Recent field work indicates that *Neoseps reynoldsi* inhabits the sandhills habitat in Florida, as well as the previously established scrub habitat. It may be collected by raking through the mounds of sand thrust up by the pocket gopher, *Geomys pinetis.* Nine new localities in central and south-central Florida are listed from which this fossorial skink has been collected.—S. R. Telford, Jr.

NEWS AND NOTES

Edited by
J. E. Hutchman
Florida Southern College

Miami: Lewis D. Ober, Chairman, Division of Natural Science & Mathematics, Dade County Junior College, advised us they opened their doors for the first time on September 11, 1960. The three independent departments—Biological, Physical Sciences, and Mathematics—were brought together into the Division of Natural Sciences and Mathematics. Their General Education Program consists of a four-semester series of courses based on the Natural Sciences and Mathematics. In addition, they offer twelve introductory courses in the area of science and fourteen in mathematics.

The present staff of this division consists of twenty-three full-time teachers, two part-time teachers, one full-time secretary, and eight student assistants. The college is presently housed in temporary quarters on the campus of Miami Central High School. Intensive planning is underway for very modern facilities and buildings on a new site.

Winter Park: Dr. Jerome Regnier replaced Dr. Roy Wilson on the Department of Geology staff at Rollins College. Dr. Regnier comes to Florida with an unusual background of educational and business experience including a degree from the University of Nancy, service with the French Army and the French Atomic Energy Commission, a Fulbright scholarship, and a Ph.D. degree from Columbia.

Miss Lucca Winifred Lovell joined the Department of Mathematics. She has her B.S. from the John B. Stetson University and the M.A. degree in Mathematics from the University of Florida. In between academic pursuits, Miss Lovell enjoyed a variety of experiences including five years in Venice, Italy, and Kabul, Afghanistan.

St. Petersburg: We are indebted to President John W. Rembert for information on Gibbs Junior College. The construction of additional science laboratories will be one of the features of a $306,000 building program originally scheduled to get underway in January on the GJC campus. This will raise the value of new buildings on the campus to more than $1 million.

The college, with a student body enrollment in excess of 700, already has chemistry, biology, and physics laboratory facilities, but the bulging enrollment is causing GJC officials to expand to accommodate more than 1,000 students who are expected in the near future. Plans also call for a drafting laboratory.

Miss Florence Francis, Science Department Head at Gibbs Junior College for three years, is on leave of absence to resume her studies toward the doctor's degree at Catholic University. L. L. Edwards, Mathematics Department Head, was one of thirty college and junior college instructors who attended an NSF two-week conference on calculus at the Washington and Jefferson College in Washington, Pennsylvania. Paul Mohr, also a member of the Mathematics Department, spent the summer at Texas Southern University doing independent study in Modern, Linear, and Abstract Algebra under the auspices of the National Science Foundation on an NSF program.

Pensacola: From Chairman E. G. Owens, Division of Exact Science, we have this information about Pensacola Junior College: Ronald E. Head is on leave at the University of the Pacific, Stockton, California. They recently have announced the birth of a daughter, Laurie Jan. G. E. Sandifer will attend the University of Mississippi for additional graduate work during the summer session. Dr. Virginia Foster has recently been added to the Biology Department.

Washington: Another constellation has been added to the galaxy in Washington that may affect the distribution of our money back to us. Dr. George B. Kistiakowsky, Professor of Chemistry at Harvard, was announced by President Bronk as Chairman of an Academy Committee on Government Relations. At present, the Government receives advice at every level, in many separate fields of science and technology, and from a variety of sources. The Committee on Government Relations, whose membership includes senior scientists representing every branch of the natural sciences, will serve to give over-all advice and to suggest steps by which the balance among competing needs can be soundly established.

An Invitation: If you are interested in scientific advancement, you are invited to become a member of the Florida Academy of Sciences. Regular membership dues are $5 annually; student rate is $2. Send your name, address, and present connection with a check for proper amount to Dr. John S. Ross, Treasurer, Department of Physics, Rollins College, Winter Park, Florida. In addition to regular and student memberships, there are several types including Industrial, $100, and Patron, $1,000. You may choose your sectional preference from the list of sciences: Biological, Medical, Physical, Social, Teachers of Science, or a new section, Conservation. That's all you have to do now. Dr. Ross will see to the rest of the formalities. Since the Quarterly Journal goes mainly to individual members, this invitation is wasted unless you pass it on to eligible members of your school.

In view of the inactive status of the former Collegiate Academy, this $2 membership open to students should be very popular.

Miami: A message from the President of FAS, Alfred P. Mills:

"We have come a long way in our twenty-six years. However, we must regularly review our current goals and practices and analyze our shortcomings. Since Sputnik awakened the public to the need for more high quality scientists, in order for our country to maintain a relative strength sufficient to preserve our free way of life, there have been many changes in the science picture as a whole. Not only have the funds for basic research grants been increased, but considerable funds have been made available through the National Science Foundation for upgrading teaching at both the college and high school level, and for encouraging highly qualified students to go into science.

"Florida was not caught napping. The Science Fair movement got underway in 1954 and now has a program which is the envy of any state in the Union. The Florida Foundation for Future Scientists (FFFS) was organized two years later to coordinate and help develop financial support for junior science activities at the state level. It was primarily responsible for guiding and encouraging the organization of most of the regional science fairs and for initiating Florida's participation in the Westinghouse Science Talent Search.

"Five years ago the Academy in re-evaluating its goals decided that it should have an important function in the area of the recruitment and teaching of future scientists. As a first step considerable effort was put into the reorganization of the Junior Academy. The exhibits, which actually overlapped the Science Fair, were dropped, and emphasis was placed on the presentation of research papers. With the help of a $19,326 NSF grant this past year, the Junior Academy has now increased in size to fifty chapters and over a thousand members, with well-balanced state-wide participation. The quality and quantity of the research papers entered into the competition has increased considerably, so that winning an award for a paper can now be considered quite an honor.

"Two years ago a "Science Teaching" Section was established in the Academy. Although it can certainly be regarded as successful, we don't have nearly the junior college and high school teacher participation that we would like to have. Much work has to be put into this area to accomplish optimum results.

"It is anticipated that we will receive an NSF grant for the operation of a Visiting Scientists program this next year. If we do receive this, many of you will be asked to participate—this very valuable program will only fully succeed with your wholehearted cooperation.

"Another very important area in which a State Academy of Science should be vitally interested is that of Conservation. Although we hear a lot about conservation and although most of our citizens are all for it, we still encounter the continuing setbacks when strong financial or political interests are involved, or when the true merits of the case become clouded. We have just set up a new Conservation Section in the Academy. It is my hope that it will become a dynamic force in protecting and preserving Florida's natural resources during these hectic years of rapid population and industrial growth.

"There are many other areas in which we, as an organization, can contribute. If you have ideas you'd like us to consider, please send them along. An Academy such as ours can only prove really worthwhile through the efforts of many of its individual members."

Tallahassee: Florida State University has recently received a total of $640,728 in the form of grants from the Federal Government and W. K. Kellogg Foundation.

In the field of science, Dr. William C. Rhodes, of the Chemistry Department, received a grant of $63,375 from the United States Public Health Service. This grant will help to finance a three-year study of genetic DNA, the substance which plays a key role in both heredity and the vital functions of the cell. Dr. Rhodes' research will be both theoretical and experimental in nature.

Three science education grants were also given to the University. Grants totaling $58,000 from the National Science Foundation will be used to conduct summer institutes for 30 high school teachers of mathematics and 20 high school science teachers.

A $125,000 grant from NSF will be used to up-date science teaching at Broward County junior high schools. The program, to be conducted at FSU, will be during the summer of 1962 and the 1962-63 school year. An additional $60,000 was granted for a similar program to be conducted the following school year.

Dr. Lawrence Simkins of the Psychology Department has received a one-year grant of $3,863 from the United States Public Health Service for a study of linguistic behavior. He will be assisted in the research by graduate student Pat Livingston.

Gainesville: Florida State University and the University of Florida have received a grant of $330,490 from the Kellogg Foundation. The joint program is aimed at providing the needed junior college administrators for ten states of the Southeast.

Tampa: Chairman C. C. Clark is congratulated for his part in making the annual meeting of the Academy at the University of South Florida successful. The amount of new construction in progress is impressive. Perhaps due to President Allen's interest in astronomy, the speaker for the General Academy Lecture Thursday evening was Dr. Harlow Shapley from Harvard University. His address, the Galaxies, was most entertaining and informative. Another interesting feature of the program was the luncheon speaker, Dr. Ira N. Gabrielson, President, Wild Life Management Institute, Washington, D. C.

Those members interested in the inactivated Collegiate Section gained some ground in the decision to accept collegiate applications for membership in the Senior Academy and to schedule properly sponsored collegiate papers on the senior academy program.

St. Petersburg: Dr. George Reid from Presbyterian is scheduled as Chairman of the relatively new Conservation Section. Doctors Luella N. Dambaugh and Dr. Reid served last year with Dr. O. E. Frye, Jr., Assistant Director, Game & Fresh Water Fish Commission. The annual report prepared by the outgoing chairman Dr. Frye cites an impressive program and accomplishments. The conservation committee is attempting to secure the protection and utilization of our water supplies as well as guard against pollution. This latter phase includes changes in our coastal waters adversely affecting the health and growing conditions of oysters and clams. It has been estimated by competent agencies that the largest business dollar-wise in Florida in ten years can be clam and oyster farming. To accomplish this, not only pollution in the usual sense of the word must be avoided, but also silting from improper dredging and other shoreline changes. The 1961 legislature reorganized the State Board of Conservation and strengthened antipollution laws in line with this thinking.

Miami: On September 1, 1961, Embry-Riddle Aeronautical Institute began operations as an independent institution chartered under the laws of the State of Florida. It is the only technical institute in the State of Florida to offer courses in an accredited Engineering Technology Program. There are only three institutes other than ERAI in the United States where aeronautical engineering technology courses are accredited by the Engineers' Council for Professional Development. Although ERAI is new in its present role, their predecessor—the Embry-Riddle International School of Aviation—had a total of 67,925 graduates since 1939 when the Embry-Riddle Company was reorganized into a school of aviation. The Board of Trustees contains many prominent names. They envision the school as a future Aeronautical and Aerospace Engineering College but with distinct possibility of affiliation with a university in the State of Florida.

Cocoa: Dr. Mary Cathryne Park of Brevard Junior College is keeping up her activity and interest in the Academy. She sent in the names and membership data on six recent additions to their staff—E. L. Boyles, math; Robert N. Pooley, science/math; Marm M. Harris, Chairman, Math/Science Division; LeRoy Estergard, math/science; Charles C. Matthews, chemistry; and George M. Holley, math. Who will make it ten? That is, ten new applications!

Miami Shores: Barry College is promised a grant of $19,875 over a three-year period from the U. S. Department of Health, Education & Welfare for equipment and laboratory assistance. Sister Agnes Louise, O. P., Head of the Department of Biology, and Sister Alma Marie, O. P., Instructor in Biology, will deal with "Enzymatic and Genetic Studies of Lysozyme-Resistant Mutants." The work at Barry will attempt to determine if the difference in the bacteria is a genetic one or is due to a change in the surface properties of lysozyme-sensitive cells.

West Palm Beach: The Math and Science Club of Roosevelt Junior College was organized in October, 1961. The club has planned a program for the school year 1961-62 in which it sponsors outstanding speakers on science and mathematical subjects. The projects planned for the academic year 1961-62 include visits to Pratt Whitney Corporation, Cape Canaveral, R. C. A. Corporation, and The International Weather Bureau at the West Palm Beach Airport. The first activity of the club was a pre-Christmas breakfast given on December 14, 1961, in the Physics Room. Mr. C. G. Gentry, one of the teachers of mathematics at Palm Beach Junior College, Lake Worth, Florida, gave a very interesting and inspiring address.

Miss Ruby L. Bullock, the mathematics teacher, and Mr. S. H. Cooke, the instructor in science, were participants on a panel discussion on "Reading" in the respective areas on January 15, 1962, at the Roosevelt Elementary School. Dean Paul W. Butler presided over the discussion.

The Math and Science Club is open to all students interested in mathematics and science. Mr. Thomas Towns was elected President of the "Math and Science Club" for the school year 1961-62. Miss Ruby L. Bullock and Mr. S. H. Cooke are co-sponsors of the club.

St. Petersburg: We failed to get news from St. Petersburg Junior College because we slipped up on answering their letter inquiring what kind of news is wanted. We want all news that originates on your campus or is closely associated with your campus if it is of interest to FAS members on another campus. These items should be mailed to us in Lakeland immediately, as indicated on the heading for this section. Periodically just before the deadline for publication we will sit up all night sorting them out to avoid duplication.

Babson Park: Webber College news sheet contains some unique features—for example, a "brainstorming session" at an early assembly on the subject, "How Many Ways Can We Think of to Practice Courtesy on Our Campus?" Students at Webber College have already participated in fifteen off-campus trips to visit business enterprises, trade fairs, etc., to compare actual performance with textbook teaching. A $76,000 multipurpose building is nearing completion. It will be used for athletic events and for assemblies. The event considered the highlight of the year was the Third Annual Adventures in Creativity Convocation, directed by President Paul C. Staake, stressing two parallel subjects, "Man's Search for Personal Freedom through Literature" and "Man's Search for Personal Freedom through Art." The Convocation was open to the entire college community.

Jacksonville: It has been definite for some time Jacksonville University will go on trimester system next year. JU was accredited by the Southern Association of Colleges in December, and in January was elected a member of the Association of American Colleges. The history-government major has been changed to separate majors. A final item from JU campus: Dr. Ralph M. Dreger of the Psychology Department has written a book, "Fundamentals of Personality" to be published by Lippincott.

Lakeland: FSC was fortunate in getting Dr. Leigh C. Anderson, Chairman of the Chemistry Department, University of Michigan, as Visiting Scientist speaker. In addition to a heavy program on campus, Dr. Anderson spoke to several large off-campus groups including an appearance on the educational channel of TV.

Washington: The National Academy of Sciences' Space Science Board issued a report on "The Atmosphere of Mars and Venus." Single copies are available from NAS for $5. The conclusion favors the possibility of life on Mars but probably unlike anything on Earth. For Venus there is much conflicting evidence—generally indicating conditions not suitable for habitation.

Lakeland: Florida Southern College's Biology Department is the recipient of an undergraduate research grant awarded by the National Science Foundation. The program will be in effect from June, 1962, till June, 1963. Applications and information concerning the research program may be secured from Dr. Margaret Gilbert, Biology Department Head. Recently Dr. Gilbert directed nature study for a one-week session at Leesburg Methodist Youth Camp.

Washington: The National Academy of Sciences will award its John J. Carty Medal to Dr. Charles H. Townes in recognition of his pioneering work in the development of microwave amplification by stimulated emission of radiation. They have already demonstrated their extraordinary usefulness in radio astronomy. The maser was used to receive echoes of a radar signal reflected from the planet Venus in a recent experiment.

Lakeland: Dr. Juliana Jordan was a featured speaker at a Convocation

March 22 at Webber College. Dr. Jordan is Chairman of the German Department of Florida Southern College.

Gainesville: From the State Director of the Florida Junior Academy, Mrs. Louise V. Ash, an enthusiastic letter provided the following wealth of information concerning the recent state meeting at the University of South Florida. All but one area of the state was represented with 326 students and 70 sponsors. In the Senior Literary Section first place went to Ronald Plastor, Andrew Jackson High, Jacksonville, for his paper on "Atoms"; second place to Judy Pofahl, Gainesville High, on "Early Polynesia"; third place to Linda Haynes, Pensacola High, on "From These Ancestors".

In the Senior Laboratory Section first place went to Bob Howard, Gainesville High, on "Reduction of Certain Inorganic Ions"—; second to Arlene Price, Miami Norland High, on "Indophenol Method for Qualitative Identification of Phenol"; third to Dan Smith, Hialeah High, on "Variations of Temperature & Salinity of the Florida Current". Honorable mention went to Allan Gammon, Gainesville, and to Ruth Scally, Coral Gables.

In the Junior High Literary Section first place went to Bruce Chappell, Buchholz J. H., Gainesville; second to Mark Davis, Nautilus J. H., Coral Gables; third to Myles Tralins, also of Nautilus J. H.

Trophies were presented to each winner, and plaques were given to the schools of the first place winners. Dr. John Baxter was the popular banquet speaker on the subject, "Count Down for Your Future." Miss Charlotte Buckland, Landon High, was honored for her service to the Junior Academy since she was commissioned by the Florida Academy in 1939 to start the Florida Junior Academy of Science. Mrs. Louise V. Ash, Sponsor, Gainesville High, was re-elected State Director. She expressed her appreciation of the excellent cooperation of the sponsors and her expectation of a bigger and better year in 1962-63.

The officers elected for next year, according to Mrs. Ash, are—President, Winter Haven High School; Vice-President, Edgewater High School (Orlando); Secretary, Gainesville High School; and Treasurer, Landon High School (Jacksonville). The convention this year was under a National Science Foundation grant.

Lakeland: The oldest sophomore in the United States, Robert K. Orr, delivered a paper on Factualism and Juvenile Delinquency at the Florida Academy of Sciences annual meeting in Tampa in March. Mr. Orr was born in a log cabin in Tuscola County, Michigan, in 1879. He organized the Workmen's Compensation Fund for Michigan in 1912. He organized the Wolverine Insurance Company in 1917 and served as its General Manager for several years. He was associated with Dr. Theo. Klingmann, formerly of Columbia University, and with Dr. Louis Berman, formerly of the University of Michigan.

The dedication of his paper reads, "Dedicated to the memory of Dr. Louis Berman from whom I learned to think in terms of facts." Factualism is a method of scientific investigation which is based upon facts which are derived from observation. The facts as to causes of juvenile delinquency can be grouped under the three headings—physical disorders, nutritional deficiencies, and environmental conditions. All cases of delinquency can be traced to one or more of these three basic causes. The cure for delinquency is in discovering and correcting the causes of the abnormality rather than by punishment.

Tampa: The stellar speaker Dr. Harlow Shapley more than lived up to the part in his talk to a fair-sized audience on the Thursday night program of the FAS annual meeting. No manuscript, no notes, but a lot of pictures of Galaxies and star-fields presented around the main theme—the newly discovered knowledge of our peripheral location in the Milky Way Galaxy. Smoothly alloyed secondary themes included: (1) Cosmic evolution including the growth of all elements from hydrogen; (2) the population of the sidereal (material) universe is more than 1×10^{10} galaxies, more than 1×10^{20} stars, and billions of life-bearing planets; and (3) the need of revising our philosophies and religious creeds in the light of our new views of the material world.

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Contributions to the JOURNAL may be in any of the fields of Sciences, by any member of the Academy. Contributions from non-members may be accepted by the Editor when the scope of the paper or the nature of the contents warrants acceptance in their opinion. Acceptance of papers will be determined by the amount and character of new information and the form in which it is presented. Articles must not duplicate, in any substantial way, material that is published elsewhere. Manuscripts are examined by members of the Editorial Board or other competent critics.

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THE QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

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SOME MORPHOLOGICAL AND ECOLOGICAL DIFFERENCES IN TWO CLOSELY RELATED SPECIES OF SCALLOPS, *AEQUIPECTEN IRRADIANS* LAMARCK AND *AEQUIPECTEN GIBBUS* DALL FROM THE GULF OF MEXICO[1]

A. N. SASTRY[2]
Florida State University

INTRODUCTION

The bay scallop, *Aequipecten irradians* Lamarck and the calico scallop, *A. gibbus* Dall are the two most common species of scallops on the Western Gulf Coast of Florida. In the literature there is no unanimous acceptance of these scallops as separate species. Dall (1899), Perry (1940) and Villas and Villas (1954) have considered the bay scallop as a subspecies of *A. gibbus*. The confusion appears to have originated from the original description by Linnaeus of widely distributed members of American scallops as *Ostrea gibba* (Refer Dodge, 1952 for details). Bullis and Ingle (1958) reporting the discovery of new scallop beds offshore in the Gulf of Mexico, stated that there is some question regarding the taxonomy of *Aequipecten gibbus* because of certain variations in the shell characters. Dodge (1952) and Abbott (1954) treated these two scallops as separate species.

The bay scallop, *Aequipecten irradians,* has a geographical range from Nova Scotia to the upper half of the east and west coasts of Florida and to Colombia with three subspecies, *A. i. irradians* Lamarck, *A. i. concentricus* Say and *A. i. amplicostataus* Dall. The

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subspecies are discontinuously distributed with distinct geographical ranges (Dodge, 1952; Abbott, 1954; and Sastry, 1961). The subspecies of both the east and west coasts of Florida is *A. i. concentricus.* Throughout the range of the species the typical habitat is in enclosed bays and estuaries on grass flats in shallow waters.

Aequipecten gibbus is primarily an offshore form and ranges from south of Cape Hatteras, North Carolina, to the upper half of the east and west coasts of Florida and to the West Indies, (Dodge, 1952 and Abbott, 1954). As a result, the distribution of *A. gibbus* and *A. irradians* (subspecies *concentricus*) overlap from south of Cape Hatteras to the upper half of the coasts of Florida. *A. gibbus* is reported from depths of 60-90 feet (Hulings, 1961) and 25-50 fathoms (Bullis and Ingle, 1958), and inhabits a bottom primarily composed of sand and shells.

Even though *A. i. concentricus* and *A. gibbus* are in the same geographical range, their ecological habitats differ. The purpose of the present report is to show some differences in the morphological characters as well as the overlap of certain ones. Dodge (1952) stated that these species present nomenclatural difficulties because of the highly variable nature of morphological characters of each species. It is hoped, from the account presented below, to stimulate interest in the analysis of the physiological properties of the two species to make clear specific distinction. This should be of interest to many Gulf Coast biologists in view of the fishery potential in that area.

Materials and Methods

The bay scallops, *Aequipecten irradians concentricus,* were collected from the Western Gulf Coast near Alligator Harbor, Franklin County, Florida. *Aequipecten gibbus* were obtained from collections made by the U. S. Fish and Wildlife Service during cruises in the Gulf of Mexico.

Measurements of shell dimensions were made with aid of a vernier calipers. Hinge length, length (anterior-posterior dimension of the shell) and height (hinge line to ventral margin of the valves) were measured for a hundred shells of each species. The shells ranged from small to adult sizes. Rib counts were made on the upper (left) valve of the scallops.

OBSERVATIONS

Some morphological differences in the shells of both species are listed in Table 1. These morphological differences cumulatively allow one to distinguish the species, but any one character may not be an adequate diagnostic feature to separate the two, because of the overlap.

TABLE I

DIFFERENCES IN SOME SHELL CHARACTERS OF *A. IRRADIANS CONCENTRICUS* AND *A. GIBBUS.*

Character	*A. i. concentricus*	*A. gibbus*
Size of adult shell	larger, about 60-70 mm	smaller, about 45-50 mm
Depth of valves	upper valve flatter than the lower valve	both valves deep, gibbous in appearance
Shape of shell	semicircular in outline	more circular in outline
Proportion of hinge length to length and height of the shell	range 1.0-1.7	1.4-2.0
Ears	prominent	not characteristically demarked
Byssal groove	well formed	not well formed, a slight indentation on the anterior margin below the ears
Teeth on byssal groove	about 3-5, prominent	fewer, usually two, not prominent, delicate structures
Color of valves	upper valve dull brown, lower valve white	upper valve brightly colored, reddish mottlings on a cream colored background, few reddish mottlings on the lower valve
Number of ribs and appearance	18-24, 21 most common, more elevated, roundish to squarish in cross section	18-23, 19 most common, flat, squarish in cross section

A biometrical analysis of shell dimensions was made and the proportions of hinge length to length and height of shell in each species are shown in Table II. Scatter diagrams (figures 1 and 2)

TABLE II

PROPORTIONS OF HINGE LENGTH TO LENGTH AND HEIGHT OF *A. IRRADIANS CONCENTRICUS* AND *A. GIBBUS* IN HUNDRED SHELLS OF EACH SPECIES.

Proportion	*A. i. concentricus*		*A. gibbus*	
	length / hinge length	*height* / hinge length	*length* / hinge length	*height* / hinge length
1.0-1.1	2	1		
1.1-1.2	23	20		
1.2-1.3	23	31		
1.3-1.4	23	28		
1.4-1.5	17	15	12	3
1.5-1.6	10	4	31	35
1.6-1.7	1	1	32	37
1.7-1.8	1	0	18	19
1.9-2.0			1	1
2.0-2.1			0	2

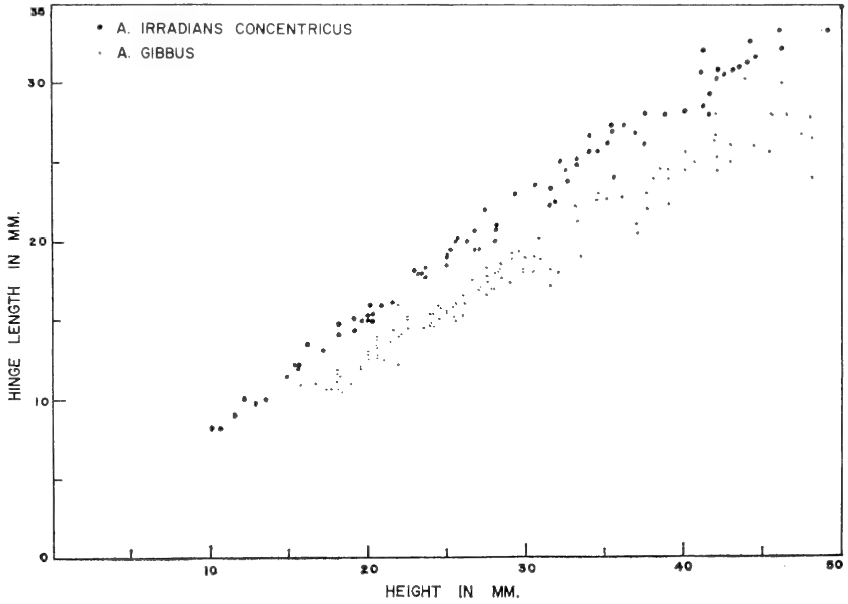

Fig. 1

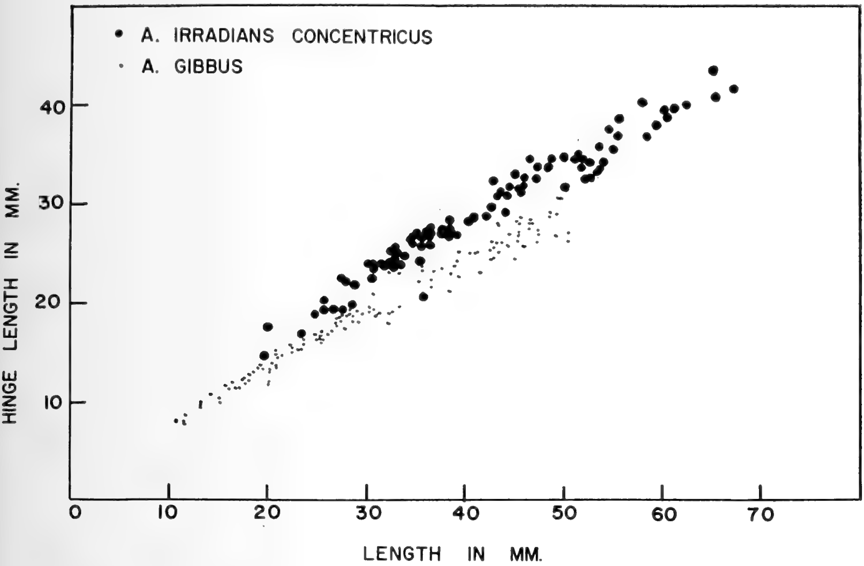
● A. IRRADIANS CONCENTRICUS
· A. GIBBUS
HINGE LENGTH IN MM.
40
30
20
10
0
10
20
30
40
50
60
70
LENGTH IN MM.

Fig. 2

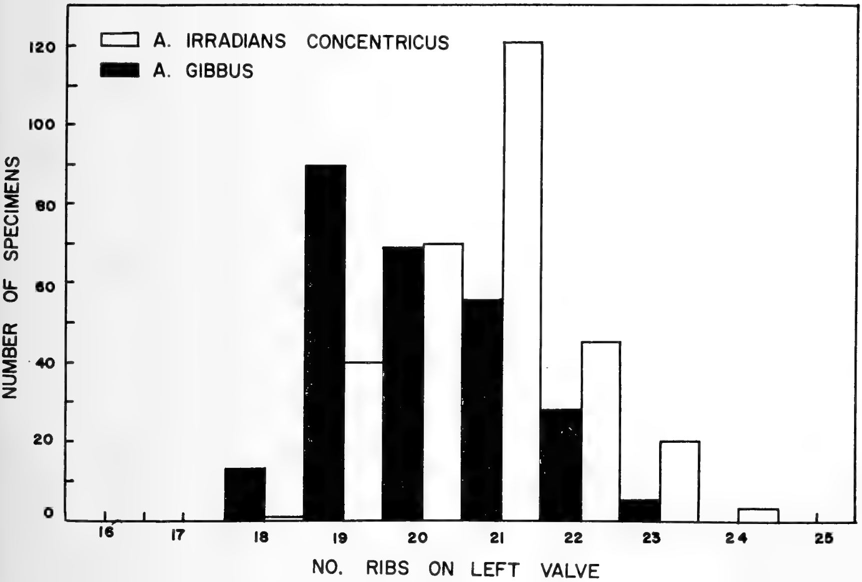
A. IRRADIANS CONCENTRICUS
A. GIBBUS
NUMBER OF SPECIMENS
120
100
80
60
40
20
0
16
17
18
19
20
21
22
23
24
25
NO. RIBS ON LEFT VALVE

Fig. 3

clearly indicate the differences in the hinge length to length and height of the two species in the small shells of *A. irradians* and the adult shells of *A. gibbus*. The frequency distribution of the number of ribs (figure 3) is highly variable. The most frequent number of ribs was 19 and 21 in *A. gibbus* and *A. concentricus* respectively.

Despite the fact that *A. i. concentricus* and *A. gibbus* occur in the same geographical range it has been stated above that the ecological habitat is different for the two; *A. i. concentricus* is a shallow water form and *A. gibbus* is a deep water form. Sastry (1961) found that *A. i. concentricus* near Alligator Harbor, Florida reaches sexual maturity towards the end of July with the peak of spawning during August and September. Bullis and Ingle (1958) reported that the gonads were highly developed in *A. gibbus* during the spring months and it completed spawning by late summer (August and September).

DISCUSSION AND SUMMARY

The overlapping morphological characters in the species *A. i. concentricus* and *A. gibbus* from the Gulf of Mexico make difficult a clear identification of the species. The differences in habitat as well as the differences in time of spawning of the two species would render hybridization unlikely although it cannot be excluded. *A. i. concentricus* is divided into three subspecies because of the variability of the morphological characters and each subspecies is highly variable. *A. gibbus* is highly variable also. Although it is demonstrated that there is much overlap in the morphological characters, a thorough study should be made of the morphological features of the two species from more extensive material and the possibility of intergrades investigated thoroughly. An aid in identifying intergrades would be the rearing of the hybrids in the laboratory, if possible, for a comparison of the morphology.

ACKNOWLEDGMENTS

The author wishes to thank Dr. R. Winston Menzel for his interest and encouragement during this work. Thanks are also due to Mr. Harvey Bullis of the U. S. Fish and Wildlife Service, Pascagoula, Mississippi, for providing the samples of *A. gibbus* used in this study.

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PROTOZOAN INQUILINES FROM REPTILES. I. *MONOCERCOMONAS NEOSEPSORUM* N. SP. FROM THE SAND SKINK, *NEOSEPS REYNOLDSI* STEJNEGER.

Eugene C. Bovee and Sam R. Telford, Jr.[1]
University of Florida

The sand skink, *Neoseps reynoldsi* Stejneger, is a small lizard of the family *Scincidae.* It is endemic to central Florida, and has been found only there in sandy mounds of rosemary scrub[2] and sandhills in Lake, Polk and Highlands counties (Telford, 1959). It is morphologically adapted to existence in loose sand, and has limbs reduced in size and number of digits, a pointed flattened snout, with countersunk lower jaw. Its diet is highly specialized, consisting mainly of termites which inhabit the scrub and sandhills.

Its protozoan inquilines include a hypermastigid flagellate of the genus *Monocercomonas* (= *Eutrichomastix*), but one clearly distinct from the *Monocercomonas colubrorum* Hammerschmidt (1844) of vagile and aquatic reptiles; and also distinct from, though somewhat similar to, *Monocercomonas axostylis* Kirby (1931) described from the termite *Nasutitermes kirbyi.*

Materials and Methods

Cloacal feces and gut content were taken from eleven specimens of *Neoseps reynoldsi.* Some material was placed in covered dishes in 25 ml. of Trager's solution (Trager, 1934), to accelerate the growth of trophic protozoa. It was examined at intervals after 24 hrs. Fresh fecal material was diluted with Trager's solution or reptilian Ringer's solution and examined.

Slides were prepared with 4% formalin, AFA, Noland's or Bouin's fixatives, and air dried. Some were observed unstained by phase contrast and interferometric microscopy. Others were stained with Giemsa's hematoxylin or Gomori's hematoxylin as

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[1] Present address: University of California, Los Angeles, Zoology Department.

[2] The classification of habitats referred to here is that of A. M. Laessle (1958).

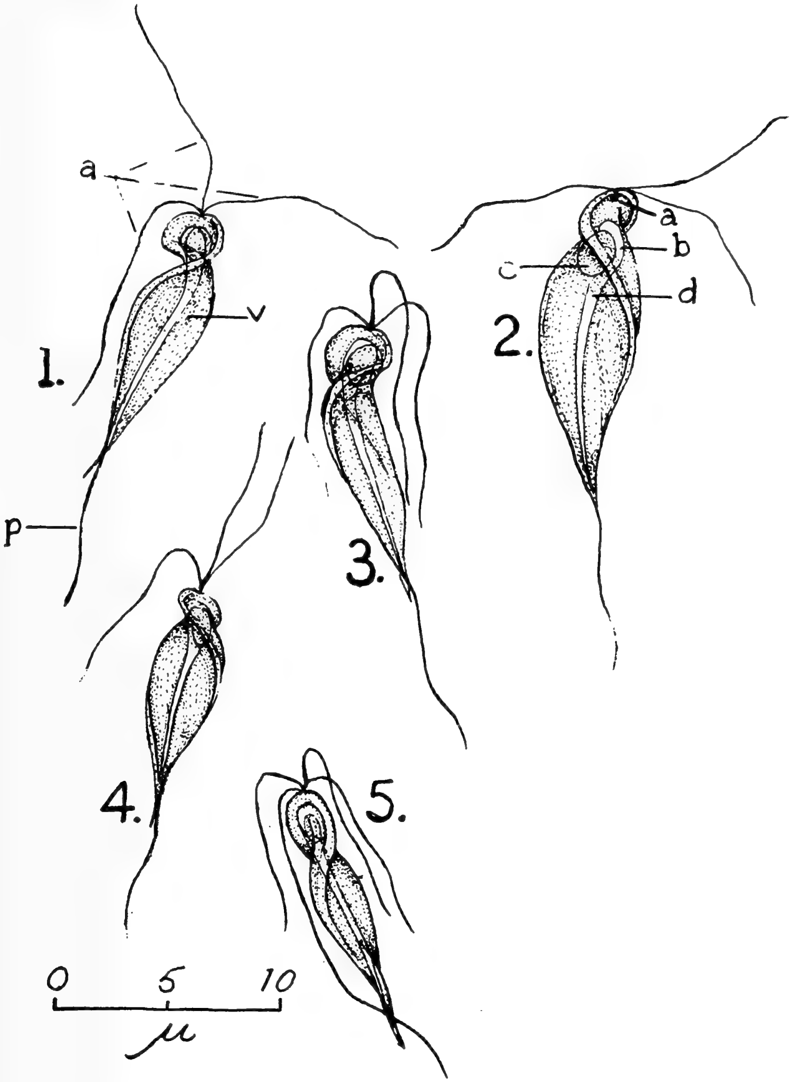

Fig. 1. *a*. The three anterior swimming flagella. *v*. vacuole-like central body present in some individuals. p. posterior trailing flagellum.

Fig. 2. *a*. Kinetosomal complex (mastigont) of the flagella. *b*. The capitulum of the axostyle. *c*. The nucleus. *d*. The shaft of the axostyle.

Figs. 3-5. Other specimens of *Monocercomonas neosepsorum* n. sp.

modified by Melander and Wingstrand (1953), or were stained with chloroform-extracted methyl green, or congo red.

Microscopic examinations were done also with bright-field microscopy, as well as phase contrast and interferometric systems, at 100x to 1000x magnifications. All measurements were made with calibrated ocular micrometers, or ocular grids; and are for live specimens, unless otherwise indicated.

Results and Observations

Monocercomonas neosepsorum n. sp. was found in fresh fecal material of two specimens of *Neoseps reynoldsi* captured in the rosemary scrub near Winter Haven, Florida; and also in a several-day-old culture from a specimen taken in the sandhills of southern Lake County, Florida.

Morphology of the Protozoan: Size and Shape: The body is laterally flattened and distinctly twisted, with an axostyle appearing to project beyond the rear end of the body. The torsion of the body is marked anteriorly in the region of the nucleus and axostylar capitulum, the rotation of the anterior end being 190° to 210° clockwise as viewed anteriorly with respect to the center of the body. The posterior half is also twisted, 90° or more with respect to the mid-region, so that the body is twisted nearly two complete turns about the axostyle within the body length. The organism is a flattened twisted spindle, blunt at the anterior end and pointed at the rear. The greatest width of the body is 2.5 to 3 μ (widest in the longest, largest individuals) just anterior to the position of the nucleus. It is approximately 1.5 μ thick. The overall length, including the tip of the axostyle, is 7 to 12.5 μ, the majority of individuals being 9 to 10 μ long.

The Flagella: There are four of these, arising from a complex of kinetosomes (mastigont) anterior to the capitulum of the axostyle. Three of the flagella beat freely at the anterior end. The fourth is a trailing flagellum, usually lying against one edge of the flattened body and extending behind the tip of the axostyle during locomotion. The trailing flagellum is not firmly attached to the body, however; and it may, and sometimes does, beat freely and independently, particularly as the organism changes direction when swimming.

The exact lengths of the flagella could not be clearly determined, even with phase microscopy. The tips of all are so slender that they cannot be resolved with a light microscope. In the live protozoan the 3 anterior flagella are about ¾ as long as the body (*i.e.* 7 to 8.5 μ long), being somewhat the longer in the larger individuals. They measure about 0.35 μ diameter at the bases, and taper gradually to the tips, which cannot be clearly resolved, and are less than 0.2 μ diameter. In stained specimens these flagella appear thicker, 0.5 μ at the bases, and shorter, about ⅔ the body length. In stained specimens also, these flagella appear to be acronematic. The trailing flagellum is somewhat thicker, about 0.4 μ at the base in the live organism, 0.6 μ when fixed and stained. It is at least 15 to 17 μ long on the live animal; but appears only 12-14 μ long on the fixed and stained specimens. It is also apparently acronematic, when stained.

Parabasal Apparatus: The parabasal body is difficult to see. It sometimes appears to be a slender rod 4.5 x 1.5 μ, other times a round structure 0.7 μ diameter, adjacent to, and apparently attached to the kinetosomal complex. The ball-like contracted form may be an artifact due to fixing and staining. The parabasal apparatus was not seen in the living organism.

We could find no sign of the presence of a cresta, or pelta, or costa, nor of an undulating membrane.

The Axostyle: The capitulum of the axostyle is about 0.85 μ wide by 1.5 μ long, ovate and flattened. The shaft of the axostyle is narrower, about 0.4 μ just behind the capitulum, tapering to a slender tip less than 0.3 μ diameter at its terminus. It is 6 to 12 μ long. The slender tip does not actually project through the cell membrane, but sometimes appears to do so, and plainly is adherent to it where the tip seemingly projects.

The Nucleus: This is adjacent to the axostylar capitulum, is broadly ovate, slightly broader than thick (0.4 x 0.55 μ) and is 1.25-1.45 μ long. When stained with acid-methyl green it is of a homogeneous shade. In the nucleus of certain specimens stained with Gomori's or Giemsa's hematoxylins a small dense nucleolus could sometimes be seen peripherally, usually near the anterior end of the nucleus. It is about 0.2 μ in diameter, barely visible.

Other Inclusions: There were no distinct vacuoles in the living organism. In stained specimens the cytoplasm sometimes appeared areolar. Usually, however, the cytoplasm appeared slightly granular when stained, with the larger granules in approximate rows along either side of the axostyle, and with some of the larger granules (0.3 to 0.4 μ diameter) in the region surrounding the capitulum and the nucleus. Some of the larger granules appeared spherical, others irregular and perhaps crystalline.

Discussion

The genus *Monocercomonas* Grassi (1879) is presumably synonymous with *Eutrichomastix* Kofoid and Swezy (1915) and with *Trichomastix* Blochmann (Kudo, 1954). Its placement in higher taxa is disputed. Grassé (1953) places it in the subfamily Monocercomonadidae, family Trichomonadidae, order Trichomonadida. Reichenow (1952) recognizes the same genus, family and subfamily, but not the ordinal rank, placing the family in the order Polymastigina. Kudo (1954) recognizes *Eutrichomastix* in lieu of *Monocercomonas,* family Polymastigidae, order Polymastigina. Hall (1953) recognizes both the orders Trichomonadida and Polymastigida, disagreeing with Kudo by employing the generic name *Monocercomonas,* in a family Monocercomonadidae, order Trichomonadida. Kirby (1931) uses *Eutrichomastix,* family Trichomonadidae; and Honigberg (1947) employes *Monocercomonas,* placing it in a trichomonad family. Calkins recognizes all three genera, and places each separately in group one (including *Monocercomonas*), and group two (including *Eutrichomastix*) of a tribe, Monozoa, in the order Polymastigida.

Whatever the placement, the members of the genus more closely resemble the trichomonads in most morphological respects, and are plainly closely related to them, if not perhaps strictly belonging to the same family taxon. They differ mainly from "true" trichomonads in the absence of an undulating membrane with its attendant costa or cresta. A pelta is presumably present in some species of *Monocercomonas* (Grassé, 1953).

Monocercomonas neosepsorum n. sp. differs from other members of the genus, being smaller in size, except for those species found in termites (Kirby 1931; Bernstein, 1928) and beetles (Travis and Becker, 1931; Travis, 1932), and with greater torsion of the body. *Monocercomonas colubrorum,* the only other species reported from reptiles, is less twisted and much larger. The host of *Monocercomonas neosepsorum,* the sand skink, *Neoseps reynoldsi,* is distinctive, also, restricted to an endemic xeric habitat in Florida.

Since the host feeds on termites, and perhaps other small insects in its restricted habitat, termites were examined for the presence of *Monocercomonas* spp. in their intestinal tracts. None from the habitats of the lizards harbored any. Hence it is not likely that the organism was surviving in the lizard after digestion of a presumed isopteran host by the lizard. Furthermore, as the protozoan is coprophilic, growing well in fecal suspension in Trager's solution, it could invade by ingestion of the feces.

Diagnosis: Monocercomonas neosepsorum n. sp., inquilinic in the intestinal tract of the Florida sand skink, *Neoseps reynoldsi*. Length 7-15 μ; greatest breadth, 3-4.5 μ. Shape flattened, clockwise-twisted spindle around a central axostyle. Four flagella, 3 anterior, 7-8.5 μ long, 0.35 μ diameter at bases, tapering to less than 0.2 μ at tips; one trailing flagellum, adjacent, not attached to body, 15-17 μ long, 0.4 μ thick at base, tapering to less than 0.2 μ at tip. Kinetosomes of flagella form a mastigont. Parabasal body rod-shaped to round, 0.2 x 0.5 μ, or 0.7 μ diameter. Axostyle single, central, with ovate capitulum, 0.85 x 1.5 μ, with nucleus adjacent to capitulum; shaft of axostyle straight, tapering to a point, 0.4 μ diameter at capitulum, 6-12 μ long. Nucleus broadly ovate, 0.4 x 0.55 x 1.3 μ diametric dimensions, vesicular, without endosome, but with small peripheral nucleolus 0.2 μ diameter. Cytoplasm with small granules, no distinct vacuoles. No pelta, costa, nor undulating membrane. From rosemary scrub and sandhills of Lake and Polk Counties, Florida.

SUMMARY

1. A new species of trichomonad flagellated protozoan, *Monocercomonas neosepsorum* n. sp., inquilinic in the intestinal tract of the Florida sand skink, *Neoseps reynoldsi* Stejneger is described and depicted.

2. This new species differs from other members of the genus in being smaller and having greater torsion of the body than *Monocercomonas colubrorum,* the species commonly found in reptiles, and smaller than other species, except for certain ones found in termites, the latter also having less torsion of the body than the new species.

3. *Neoseps reynoldsi* is an endemic lizard, restricted in habitat and diet, and therefore likely to harbor a specialized and restricted group of protozoan inquilines.

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PROTOZOAN INQUILINES FROM REPTILES. II. *MONOCERCOMONAS TANTILLORUM* N. SP. FROM THE FLORIDA CROWNED SNAKE, *TANTILLA CORONATA* BAIRD AND GIRARD.

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The Florida variety of the crowned snake, *Tantilla coronata* Baird and Girard, is restricted to scrub, sandhills and mesic hammock (Laessle, 1958) as a fossorial species, feeding presumably on small invertebrates (Telford, 1961).

An examination of eight specimens of this snake for protozoan inquilines yielded negative results except in one specimen which had in its fresh feces about two dozen tetramastigote zooflagellates, small and active, of the genus *Monocercomonas.* These flagellates differed in size and certain details of morphology from either of the other two species inquilinic in saurians, *Monocercomonas colubrorum* Hammerschmidt (1844) and *M. neosepsorum* Bovee and Telford (1962), and it differed also from the small *Monocercomonas* spp. in arthropod invertebrates (Bernstein, 1928; Kirby, 1931; MacKinnon, 1912; Travis and Becker, 1931).

Materials and Methods

Cloacal and gut contents from eight specimens of the crowned snake, *Tantilla coronata,* were obtained, cultured, prepared and studied by methods previously discussed (Bovee and Telford, 1962). The fresh feces from one snake captured in Polk County, Florida, contained a number of monocercomonad flagellates which swam actively in Trager's (1934) solution. These were studied in detail.

Observations and Results

Morphology of the Protozoan: Size and Shape: The body is spindle-shaped, 10-12 μ, averaging 11 μ long to the tip of the axostyle, and averaging 5.75 μ wide at the widest part of the body, midway of its length. (Fig. 1) The body at that point is nearly

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oval in cross section (Fig. 3), and it is twisted about one and one-third turns around the axostyle within the length of the body. This torsion is shown principally by the presence of a shallow spiral groove which marks the twist of the body.

The Flagella: These four organelles arise from a complex of kinetosomes (a mastigont) at the anterior end, three of them beating freely. The fourth is a recurrent flagellum usually lying against the body, trailing behind the posterior tip of the axostyle. It is not firmly adherent to the body surface, and sometimes may beat freely, but ordinarily does not.

The flagella are very slender, the tips being too fine to resolve clearly, so that the exact lengths could not be determined. The three anterior flagella are approximately the same length as the body, about 10-12 μ; and they are about 0.4 μ diameter at their bases, tapering to unresolvable slenderness at their tips. The trailing flagellum is heavier, about 0.6 μ at its base, and also tapering to an unresolvable tip. It is at least one and two-thirds times as long as the body, about 19-21 μ long. (Figs. 1, 2).

Parabasal Apparatus: The parabasal body (kinetoplast) is a small ovate structure about 0.5 μ long, attached to the kinetosomal complex, and usually rests against the nucleus. It can be discerned only in the fixed organism. No cresta, costa, pelta, nor undulating membrane is present.

Axostyle: The capitulum of the axostyle is a very slightly broadened structure, rounded at the anterior end. It does not partially embrace the nucleus as does the capitulum of *M. colubrorum* (Grassé, 1953). The capitulum is about 0.8 μ broad, and about 2.5 μ long. At the rear end of the capitulum the axostyle shaft is about 0.6 μ diameter, tapering to a pointed tip at the rear end. The entire axostyle is 9.5-11.5 μ long. (Fig. 1).

The Nucleus: This internal organelle is of broad oval shape, nearly spherical, 2.8 μ x 3.2 μ in dimensions. It is clear and vesicular in the living specimens, and is homogeneously stained both by acid methyl-green and nuclear hematoxylin (Melander and Wingstrang, 1943). It is located adjacent to the capitulum of the axostyle near the anterior end of the body (Fig. 1).

Other Inclusions: Fifteen to 20 crystalline and refractile granules 0.3-1.2 μ in size are clustered near the axostyle and nucleus, particularly in the anterior one-third of the body length. Some of the larger granules seem attached to the inner surface of the cell membrane just to the rear of the nucleus. Numerous other very tiny granules, too small to be clearly resolved, are also present, distributed generally throughout the cytoplasm.

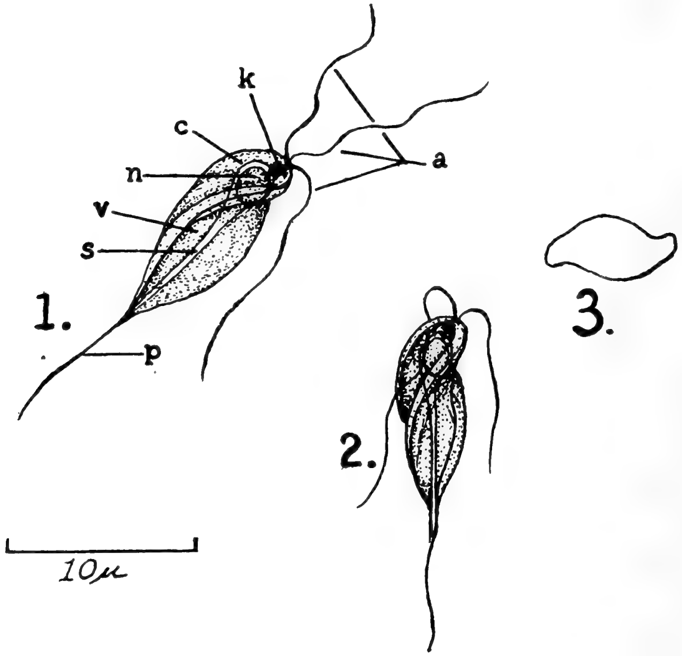

Fig. 1. *a.* Anterior swimming flagella. *p.* Posterior trailing flagellum. *k.* Kinetosomal complex. *n.* Nucleus. *c.* Capitulum of axostyle. *s.* Shaft of axostyle. *v.* Vacuole-like structure present in some individuals.

Fig. 2. Another specimen of *Monocercomonas tantillorum* n. sp.

Fig. 3. Cross-section through the body at *v.*, Fig. 1.

Discussion

The systematic placement of the genus *Monocercomonas,* and its synonymies, have already been discussed (Bovee and Telford, 1962). *Monocercomonas tantillorum* n. sp. differs from other species by its host, and its relatively thick body, the other species being much more flattened. It has less torsion of the body than does *M. colubrorum* and *M. neosepsorum;* it is smaller than *M. colubrorum;* and while about the same length as *M. neosepsorum,* it is thicker and broader than that species.

Diagnosis: Monocercomonas tantillorum n. sp., inquilinic in the intestinal tract of the Florida variety of the crowned snake, *Tantilla coronata* Baird and Girard. Length 10-12 μ; greatest breadth, 5-6 μ. Shape, a twisted spindle, body ovate in cross-section, torsion about one and one-third turns about the axostyle, clockwise. Four flagella, 3 anterior, 10-12 μ long, 0.4 μ diameter at bases tapering to less than 0.2 μ at tips; one trailing flagellum, adjacent, not attached to, the body, 10-21 μ long, 0.6 μ diameter at the base, tapering to less than 0.2 μ at tip. Kinetosomes of flagella form a mastigont. Parabasal body small, oval, 0.5 μ long, attached to mastigont. Axostyle single, central, with ovate capitulum 0.8 μ x 2.5 μ, shaft straight, 0.6 μ diameter, 9.5-11.5 μ long, tapering to pointed posterior tip. Nucleus broadly ovate, 2.8 x 3.2 μ diameters, adjacent to axostylar capitulum, vesicular, without endosome. Cytoplasm with small granules, no vacuoles; several refractile granules 0.3-1.2 μ, adjacent to cell membrane near nucleus. No cresta, costa, pelta nor undulating membrane. From snake in Polk County, Florida.

SUMMARY

1. *Monocercomonas tantillorum* n. sp. a trichomonad flagellated protozoan inquilinic in the Florida crowned snake, *Tantilla coronata* Baird and Girard, is described and depicted.

2. It differs from other species of *Monocercomonas* in being smaller than most, and proportionately thicker, with less torsion of the body than other species.

3. Its host is an endemic species in Florida, restricted in habitat and diet, and presumably likely to have developed its own specialized inquilines.

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SPERMIATION IN *RANA P. PIPIENS* IN RESPONSE TO HETEROPLASTIC PITUITARY MATERIALS

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Introduction

The earliest studies employing pituitary materials as a gonadal stimulant were conducted on mammals (Ascheim, 1926; Smith, 1926; Zondek, 1926). An excellent summary of vertebrate ovulatory responses induced by homoplastic and heteroplastic pituitary materials is provided by Creaser and Gorbman (1939). Amphibian spermiation was first evoked by a hormonal stimulus when Galli-Mainini (1947) reported the male toad, *Bufo arenarum*, responding to human chorionic gonadotropin. Since that date world-wide usage of the male anuran pregnancy test has involved numerous representative species from the families Discoglossidae, Pipidae, Ranidae, Microhylidae, Bufonidae, and Hylidae.

In view of the success of the male anuran pregnancy test it is surprising that the effect of pituitary gonadotropins upon spermiation has been little studied. In 1954 Houssay summarized some limited work on induced spermiation, reporting that spermiation is produced in *Bufo arenarum* by the pituitary glands of *Bufo arenarum, Leptodactylus ocellatus, Rana pipiens, Xenopus laevis, Bufo paracnemis, Bufo marinus,* and *Bufo d'Orbigny.* Reciprocally, Houssay found the anterior lobe of pituitary glands from *Bufo arenarum* to produce spermiation in *Leptodactylus ocellatus* and *Bufo marinus.* Crude extracts from pituitary glands of ox, sheep, swine, dog, guinea pig, cat, and fishes did not produce spermiation in *Bufo arenarum.* Limited positive results were reported using high doses of pituitary extracts from rat, rabbits, and man. Pure follicle-stimulating hormone and luteinizing hormone from sheep pituitary also gave positive results. Burgos and Ladman (1955) reported sperm release by *Rana pipiens* after the administration of purified swine follicle-stimulating hormone, sheep luteinizing hormone, and human chorionic gonadotropin. Witschi and Chang (1958), summarizing all available data on spermiation and ovulation reactions, put spermiation on the same basis with ovulation, though stating the former to be a more sensitive reaction.

The present study seemed justified since a very spotty and incomplete representation from the vertebrate series had been studied in relation to the induced spermiation reaction. The purpose of the present investigation was therefore, to observe the effect of representative vertebrate pituitary materials upon spermiation in the male northern leopard frog, *Rana p. pipiens.*

Materials and Methods

A detailed species list of all pituitary donors employed in this study is given in Table I. The giant tree frogs (*Hyla septentrionalis*), Key anoles (*Anolis stejnegeri*), and sharks (*Sphyrna tiburo, Carcharhinus platyodon*) were collected from the Key West area. The tropical marine toad (*Bufo marinus*) was taken from a recently introduced population now breeding in the Miami area. Except for the mudpuppies (*Necturus maculosus*), Louisiana specimens ordered from the Carolina Biological Supply Company, the remaining species were collected in Volusia County, Florida or obtained locally (chickens, white mice). Lederle Laboratories generously supplied frozen swine whole pituitaries. The recipient species, *Rana p. pipiens,* were ordered in one-dozen lots from the Carolina Biological Supply Company.

Pituitary glands were removed from each donor as soon as it was sacrificed. In the majority of cases the pituitary was removed as follows: the head was severed from the body at the base of the occipital bone and the lower jaw was then removed. From the remaining cranium, the membranes covering the dorsal roof of the mouth were removed. This exposed the ventral bones of the cranium, in particular the basioccipital, basisphenoid, and presphenoid complexes. The ventral floor of the brain case was then removed by inserting scissors or Liston bone-cutting forceps into the foramen magnum, lateral to the brainstem, and snipping anteriorly. The pituitary was usually easily distinguished, lying immediately posterior to the optic chiasma, on the infundibular region of the hypothalamus. The gland was removed with fine-pointed watchmaker's forceps and placed into 2 ml. of amphibian ringer's solution. If the pituitary was not to be used immediately, it was frozen until time for injection. It has been shown that no adverse effects are encountered using pituitary materials that have been frozen for periods up to one year (Hansen, 1955).

Whole glands from donors were thoroughly macerated with a small mortar and pestle to facilitate the injection. The fresh or frozen gland macerate was mixed thoroughly in 2 ml. of amphibian ringer solution and then injected subcutaneously with a 25 gauge needle. To prevent leakage, the needle was inserted into the dorsal lymph sac and then directed to either side into the two lateral lymph sacs. Any leakage from the lateral lymph sacs would, therefore, move through the connective tissue back into the dorsal lymph sac. No leakage was ever noted at the point of insertion on the dorsum.

Urine was obtained from the recipient frogs from two to four hours after injection. Cloacal fluid was taken by aspiration, by inserting a small, blunt-tipped pipette into the external cloacal orifice. A few drops of the urine were placed on a microscope slide and examined under low magnification for the presence of spermatozoa. The presence of sperm indicated a positive test, its absence, a negative test.

Because of the possibility of natural spermiation, each frog used in the study was checked for the presence of sperm in the cloacal fluid just prior to injection. In no case was any sperm ever found. Natural emission of sperm in anura seems to be rare as no cloacal sperm were found even when animals were collected from a breeding population (Hansen, 1960). Although individual refractoriness by a test animal can never be ruled out completely, multiple injections in the majority of cases probably negates this possibility to a large extent. Further controls used throughout the study were as follows: injection of amphibian ringer's solution, human male urine, human pregnancy urine, and solutions of macerated frog brainstem. Negative results were obtained in all cases except for the pregnancy urine which induced spermiation.

A number of the test animals were re-used after negative and positive tests, although a recovery period of not less than five days was allowed in both cases. This period seemed adequate in the light of Burgos and Ladman's report (1955) where spermiating *Rana pipiens* were re-used after 48 hours, with no observed cumulative effect.

RESULTS

This study demonstrated the effect of representative vertebrate pituitary homogenates, specifically the gonadotropic hormones, upon the spermiation reaction in the male northern leopard frog, *Rana p. pipiens*. These results are listed in Table I.

TABLE I

EFFECT OF PITUITARY INJECTIONS UPON SPERMIATION IN RANA P. PIPIENS

Pituitary Donor	No. Pituitary Glands Injected	Size(s) of Donor(s)	Spermiation Result
CHONDRICHTHYS		Total length (head-tail, cm.)	
Sphyrna tiburo	1 male	137	neg.
Carcharhinus platydon	1 male	132	neg.
OSTEICHTHYS		Standard length (head-caudal fin base, cm.)	
Lepisosteus osseus	2	49,52	pos.
Esox niger	2	54,69	neg.
Micropterus salmoides floridanus	5	35,38,40,43,47	neg.
AMPHIBIA		(Head-tail, mm.)	
Necturus maculosus	1 female	265	neg.
	2 ”	260,262	neg.
	3 ”	249,258,261	pos.
		(Snout-vent, mm.)	
Scaphiopus h. holbrooki	1 male	62	neg.
	2 ”	58,59	neg.
	3 ”	55,57,60	pos.
	1 female	65	neg.
	2 ”	53,57	pos.

TABLE I—Continued

EFFECT OF PITUITARY INJECTIONS UPON SPERMIATION IN RANA P. PIPIENS

Pituitary Donor	No. Pituitary Glands Injected	Size(s) of Donor(s)	Spermiation Result
Rana p. pipiens	1 male	63	pos.
	1 female	88	pos.
Rana p. sphenocephala	1 male	71	pos.
	1 female	79	pos.
Rana catesbeiana	1 male	129	pos.
	1 female	132	pos.
	.5 "	156	pos.
	.25 "	156	pos.
Rana grylio	1 male	145	pos.
	.5 female	151	pos.
	.25 "	151	pos.
Bufo marinus	1 male	137	pos.
Bufo t. terrestris	1 male	68	neg.
	2 "	48,55	pos.
	1 female	80	pos.
Hyla septentrionalis	3 male	51,54,58	pos.
	2 female	65,69	pos.
Hyla squirrela	3 female	27,30,31	pos.

TABLE I—Continued

EFFECT OF PITUITARY INJECTIONS UPON SPERMIATION IN RANA P. PIPIENS

Pituitary Donor	No. Pituitary Glands Injected	Size(s) of Donor(s)	Spermiation Result
REPTILIA		(Carapace length, mm.)	
Sternotherus odoratus	1 male	74	neg.
	1 female	88	pos.
Deirochelys reticularia	1 female	112	neg.
Pseudemys floridana	1 male	218	neg.
peninsularis	1 ”	239	neg.
	1 female	308	pos.
Gopherus polyphemus	1 male	147	neg.
	1 ”	270	neg.
	1 female	210	neg.
	1 ”	240	pos.
Tryonx f. ferox	1 female	225	pos.
		(Snout-vent, mm.)	
Anolis c. carolinensis	1 male	50	neg.
Anolis stejnegeri	2 male	47,55	neg.
Cnemidophorus sexlienatus	11 individuals (7 males, 4 females)	68,69,69,70,71,72 73; 55,65,68,70	pos.
		(Total length, cm.)	
Coluber constrictor priapus	1 female	107	neg.
Coluber f. flagellum	1 female	137	neg.
Drymarchon corais couperi	1 male	139	neg.
Elaphe obsoleta quadrivittata	1 male	152	neg.

TABLE I—Continued

EFFECT OF PITUITARY INJECTIONS UPON SPERMIATION IN RANA P. PIPIENS

Pituitary Donor	No. Pituitary Glands Injected	Size(s) of Donor(s)	Spermiation Result
AVES			
Gallus gallus	2 female	8 wks.	pos.
	4 ”	1 year	pos.
	6 ”	8 wks.	pos.
Cyanocitta cristata	2 sex undetermined	adult	pos.
MAMMALIA			
Myotis austroriparius	1 male	adult	neg.
Felis domesticus	1 female	adult	neg.
	.5 ”	”	neg.
	.25 ”	”	neg.
Sus scrofa	2 sex undetermined	adult	pos.
	1 ” ”	”	neg.
	.3 ” ”	”	neg.
	.1 ” ”	”	neg.
	.05 ” ”	”	neg.
Sciurus c. carolinensis	3 male	adult	neg.
Mus musculus	1 female	adult	neg.
	3 ”	”	neg.
	6 ”	”	neg.

Pituitary homogenates from two elasmobranchs, the bonnethead shark (*Sphyrna tiburo*) and Gulf shark (*Carcharhinus platydon*) failed to evoke spermiation in the experimental animals. Pituitary macerates from the long-nose gar (*Lepisosteus osseus*) caused sperm release, whereas, two teleost species (Chain pickerel, *Esox niger;* Florida largemouth bass, *Micropterus salmoides floridanus*) failed to do so.

From the Amphibia, representative species from four anuran families responding positively included: the eastern spadefoot, *Scaphiopus h. holbrooki*; northern leopard frog, *Rana p. pipiens;* southern leopard frog, *Rana pipiens sphenocephala;* southern bullfrog, *Rana grylio;* American bullfrog, *Rana catesbeiana;* southern toad, *Bufo t. terrestris;* marine toad, *Bufo marinus;* squirrel tree frog, *Hyla squirrela;* and giant tree frog, *Hyla septentrionalis.* From the Urodela, the mudpuppy (*Necturus maculosus*) also effected a positive response.

Spermiation responses due to pituitary materials from the Reptilia proved somewhat variable. Chelonian donors evoking a positive response included large-sized representatives from four families; the southern soft-shelled turtle (*Tryonx f. ferox*), mud turtle (*Sternotherus odoratus,* peninsular turtle (*Pseudemys floridanus peninsularis*) and gopher tortoise (*Gopherus polyphemus*). A negative response was obtained from the chicken turtle (*Deirochelys reticularia*). Single pituitary homogenates from four snakes (indigo, *Drymarchon corais couperi;* coachwhip, *Coluber f. flagellum;* Florida black snake, *Coluber constrictor priapus;* rat snake, *Elaphe obsoleta quadrivittata*) and two lizards (Carolina anole, *Anolis c. carolinensis;* Key anole, *Anolis stejnegeri*) failed to stimulate spermiation. A pituitary homogenate containing eleven pituitaries from the six-lined racer (*Cnemidophorus sexlineatus*) did evoke a positive response.

Multiple pituitary homogenates from two avian species (chicken, *Gallus gallus;* bluejay, *Cyanocitta cristata*) caused *Rana p. pipiens* to spermiate.

Representatives from four mammalian orders were tested and no positive results were realized from the smaller mammals, including the Florida brown bat (*Myotis austroriparius*), laboratory mice (*Mus musculus*), southern grey squirrel (*Sciurus c. carolinen-*

sis) and domestic cat (*Felis domesticus*). The only positive result came from hog (*Sus scrofa*) pituitary in which two whole glands were necessary to induce the reaction.

DISCUSSION

Creaser and Gorbman (1939) ably demonstrated in their induced ovulation studies that a qualitative species specificity exists within vertebrate gonadotropic hormones. The results of the present work bear out this generality in that some vertebrate pituitary materials readily evoke anuran spermiation while others do not. The variation in the present results can almost certainly be attributed to phyletic differentiation in the pituitary gonadotropins as well as to hormonal amount and titer.

It seems almost certain that some of the negative reactions may be attributed to the small amounts of pituitary material available from the smaller species as the snakes, lizards, bat, and mice. This reasoning seems verified in a number of instances (*Bufo, Scaphiopus, Necturus, Cnemidophorus*) where small amounts of pituitary failed to induce sperm release, while larger amounts did evoke a positive response.

It seems reasonable to assume that the anuran endocrine system would have differentiated to a higher degree than specialized members of lower vertebrate groups, as the teleosts. The fact that pituitary material from the Chondrichthys and Osteichthys, with the exception of the long-nose gar (*Lepisosteus osseus*), failed to induce spermiation, lends validity to the hypothesis of species specificity.

Perhaps the most interesting problem arising in this study was the positive response obtained by pituitary from the long-nose gar. This case was the sole exception to total negative responses by pituitary materials from all vertebrates phylogenetically below the Amphibia. Creaser and Gorbman report:

> "Wills, Riley, and Stubbs have demonstrated a positive ovulation inducing capacity of *Lepisosteus* (gar pike) pituitaries in the toad *Bufo americanus* and in one specimen of *Rana pipiens*. The later datum deserves checking and should prove of considerable significance if verified, since Lepisosteus is phylogenetically more closely related to the amphibian forms than any of the fishes studid so far."

The present finding, therefore, adds validity to this earlier work and indicates an endocrine relationship between the anura and the ancestoral holostean group.

The positive reaction obtained with the mudpuppy, *Necturus maculosus,* is the first record of caudate amphibian pituitary acting positively upon the gonads of an anuran species. This is not in agreement with the induced ovulation study upon anuran species (Creaser and Gorbman, 1939). Induced spermiation reactions by reptile, bird, and mammal pituitary preparations are in general agreement with Creaser and Gorbman (1939) and Hansen (1959) in their ovulation studies.

It seems noteworthy that somewhat larger amounts of pituitary material from donor species outside the Ranidae are needed to cause sperm release. The need for two entire hog pituitary glands to induce spermiation is in keeping with Creaser and Gorbman's findings. These workers stated, "Those amphibia in which a response is produced by mammalian preparations require very large doses". Because of variations in pituitary size and gonadotropic titers, it is apparent that an accurately quantified work in this general area is seriously needed. The primary difficulty presently is that no standard method for determining accurate hormone titer has as yet been forthcoming.

In several cases (*Bufo, Gopherus, Pseudemys*), it was noted that a single female pituitary would cause a positive reaction while a single male pituitary from the same species would not. In *Scaphiopus* where a multiple pituitary homogenate was used, two male glands failed to evoke a response, whereas two female glands did so; three male glands did bring about the reaction. This quantitative evidence corroborates the findings of Rugh (1937) and Hansen (1959), that the female pituitary has a higher hormone titer than that of the male of the same species.

SUMMARY

1. Pituitary-induced spermiation tests were conducted from October, 1961 through May, 1962 on 66 northern leopard frogs, *Rana p. pipiens.*

2. Fresh pituitary preparations from 111 individuals representing 34 vertebrate donor species were used in the study.

3. Spermiation was induced by pituitary materials from representatives of the Osteichthys, Amphibia, Reptilia, Aves, and Mammalia, while negative reactions resulted from the Chondrichthys.

4. The female pituitary gland was found to have a higher potency than the male gland in evoking spermiation.

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STINGING DUE TO *LINUCHE UNGUICULATA* (SCHWARTZ) IN FLORIDA WATERS [1]

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Although Hutton (1952) was cognizant of many reports that *Linuche unguiculata* (Schwartz)[2] could produce stinging sensations to bathers who come in contact with it and was aware that many people believed this medusa caused seabathers' eruption, he was unable to produce either a dermatitis or a stinging sensation on any of numerous human subjects. The several hundred medusae used by Hutton had been collected, placed in aquaria, and kept alive for several weeks prior to testing. He also reported observing thousands of these medusae in the shallow waters of Miami Beach on April 7, 1950, where many people were in the water with not one case of eruption reported.

On July 5, 1954, I observed swarms of "thimble jellyfish" below the New Pass Bridge and at Lido Beach near Sarasota, Florida. Although these were abundant and came in contact with many people in the water, no reactions were noted. A few caught by hand and rubbed on my forearm failed to produce stinging or other irritation. Twelve, measured at the sub-umbrellar surface, ranged in size from 9 to 15 mm in greatest diameter with the average about 11 mm and thousands present were within the limits of this range.

As I observed them daily for two weeks, these medusae remained numerous as they grew larger, apparently causing no irritation among the bathers. On July 21, however, upon arriving at Lido Beach in the late afternoon, I heard several comments from bathers that the "thimbles" were stinging and two individuals who had cupped them out of the water in their hands, exhibited red welts between their fingers which were burning and itching. Upon entering the water where wave action was more violent than usual, I noted that at least some of the medusae were able to prick as

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[1] Contribution from the Cape Haze Marine Laboratory, the Archbold Biological Station and the Department of Zoology and Entomology, University of Connecticut. Aided in part by Grant E-740 from the National Institutes of Health.

[2] Referred to by Hutton as *L. unguiculata* Escholtz.

they were washed against my legs and abdomen, leaving nickel-sized patches of red papules, 5 to 10 or more at each contact site. A number were picked up by hand and rubbed on my forearm. These produced an immediate stinging and resultant dermal itching which lasted for more than 5 days, after which a light purple scarring remained for several more days. An eleven year old girl lifted a handful of dead ones from the shore debris and suffered burning and swelling with later purple scarring but no papular dermatitis, suggesting that poison was not injected by nematocysts but that contact with dead ones was dangerous.

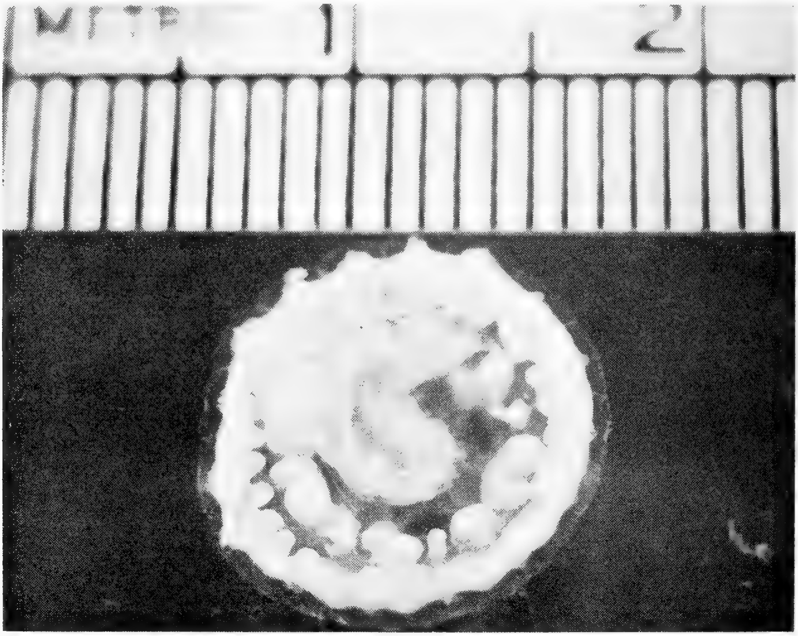

Fig. 1. Subumbrellar surface of *Linuche unguiculata,* 11 mm in greatest diameter. This size did not produce stinging or other irritation.

Dr. Eugenie Clark has provided me with a report of her experiences with these in causing dermatitis, as follows:

"On July 15, 1955 a group of us from the Cape Haze Marine Laboratory anchored our boat about 600 yards offshore from the Range Light at Boca Grande to collect fishes and algae from a large area of rocky bottom covered with algae, sponges, tunicates, and bryozoa. We used "skin diving" methods, diving in bathing suits in water between 10 to 14 feet deep.

"We began our diving activities about 10:00 a.m. and noticed that the water contained numerous jellyfish, *Linuche* sp. (ca. 4 to 20 cubic meter). I caught a few in my hand and rubbed them between by fingers and then on my forearm but could feel no stinging or other irritation from this.

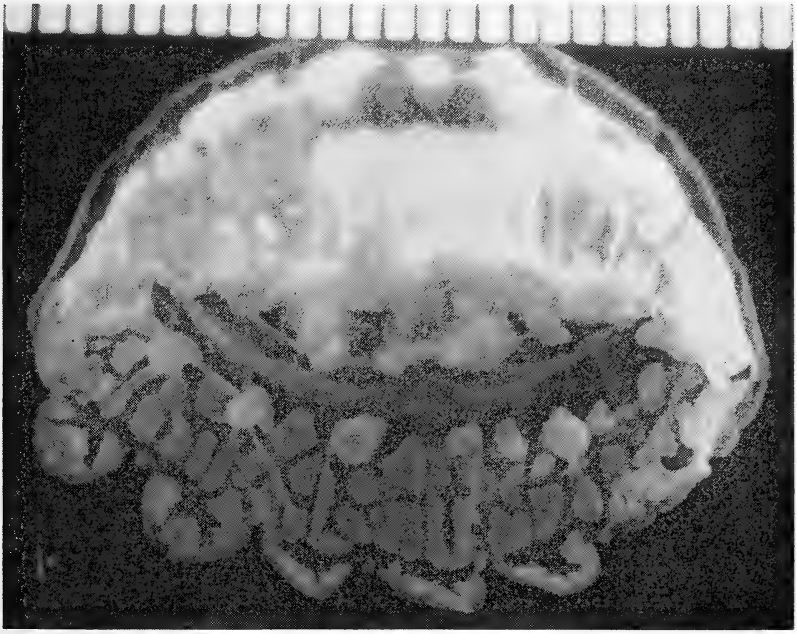

Fig. 2. Lateral view of *Linuche unguiculata,* 23 mm in greatest diameter. This size did produce stinging naturally and when applied experimentally to the human skin.

"Four of us (two thirteen year old boys, Bruce Marshall and Carey Winfrey, Mr. Phil Youngman, a graduate student at Connecticut University and myself) dived in this area for about 2½ hours. We were not particularly bothered by the jellyfish although each of us must have come in contact with hundreds of individuals during this time. I thought I occasionally felt a pricking sensation when a jellyfish came in contact with my skin, especially on my face, but this was so slight I thought it might be just my imagination. By evening areas of skin on my hands, face, throat, and waistline just under and above the belt of my bathing shorts, became swollen with red welts that burned and itched. This irritation became worse by the following day especially around my mouth and back of my hands at the bases of the fingers. The swelling began to subside the following day and was mostly gone in one week, except for small areas on the back of my hands and corners of my mouth which continued to be slightly swollen and itchy for over two weeks, then became horny and developed small scabs. My hands retained this condition for over a month, perhaps aggravated by frequent handling of specimens preserved in formalin.

"Messrs. Marshall and Winfrey had similar skin irritations but Mr. Youngman reported no reaction at all from his jellyfish contacts.

"The local people claim that certain individuals are immune to the sting of this "thimble jellyfish". Mr. Beryl Chadwick, who has had twenty-seven years of commercial fishing experience in this region, reports that he has frequently seen blooms of these jellyfish in the Gulf during the latter part of the summer but never at other times."

Measurements of these specimens provided by Dr. Clark, ranged from 11-29 mm, with the average about 22 mm, similar in size to those occurring on July 21, 1954, at Lido Beach. Those averaging 1 cm in greatest diameter were not offensive; those above 2 cm in diameter were a nuisance and in at least three cases the lesions produced were serious enough to warrant medical attention.

Dr. Mary Sears of the Woods Hole Oceanographic Institution has kindly identified the medusae as *Linuche unguiculata* (Schwartz) and has provided the following information:

"This seems to be a species which varies considerably and at one time your specimens might have been referred to *aquila* thought to be a Pacific species. However, Bigelow (1928, p. 510) states that Vanhöffen (1913) 'by his discovery of the supposedly Pacific variety as well as the supposedly Atlantic, among *Linuche* from the Tortugas, Florida, proved that the two are not separated geographically. This, Thiel (1927) substantiates by again finding Atlantic specimens (from Haiti) showing the arrangement of subumbral sacs which Mayer (1910) had thought typical of the Pacific *aquila*. This, according to Thiel, indicates the co-existence in the Atlantic of two distinct forms of *Linuche* of the *unguiculata* group, either varieties (*aquila* and *unguiculata*) of one species, or possibly distinct species. But the great variability in the number and in the radial location of the subumbral sacs of the *Arcturus* series and of other specimens in the Museum of Comparative Zoology described below, tends to support Vanhöffen's (1913) explanation of the difference between *unguiculata* and *aquila* as due, simply to individual variation. They are therefore united here, following him, under the older of the names.'

"Bigelow still held to this view in a paper written 10 years later. Stiasny (1931) also accepted this view."

That these specimens from the Gulf are capable of stinging is suggestive that those with which Hutton worked might be either intra-specifically different, smaller specimens perhaps incapable of producing irritation, or affected in some way by the long laboratory confinement.

The average length of life of the majority of free-swimming medusae is possibly two months. Some have long planktonic lives but it would seem that for *Linuche* it is relatively short.

Linuche is apparently a neritic surface living form. Hydrographic conditions may have been the important factor in its great temporary abundance in 1954 at Sarasota and 1955 at Boca Grande. Russell (1953) has discussed the value of medusae as indicators of the movement of water masses in the sea, previouly shown by Kramp (1927). However, the 1954 abundance at Sarasota followed a red-tide year and numerous observations revealed entirely different populations of many organisms at Lido Beach from those occurring during the summers of 1952-1960 exclusive of 1954. The fish population was drastically reduced and a notably high crab population prevailed. So it is felt that the previous presence of red-tide could have been a factor. Numerous visits made to Lido Beach and to other Gulf Coast beaches during July and August from 1952 through 1960 have not revealed evidence that *Linuche* was present, certainly not in the swarming numbers observed in July of 1954 or 1955. However, because a species is recorded as occurring in a certain area, does not mean that it must necessarily be abundant there, or even present at all in some years.

ACKNOWLEDGMENTS

Appreciation is expressed to Dr. Eugenie Clark for providing data and specimens; to Dr. Mary Sears for her identifications and taxonomic information, and to Mr. Charles Colledge for helpful technical assistance.

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SEASONAL SUCCESSION OF CERTAIN INVERTEBRATES IN A NORTHWESTERN FLORIDA LAKE

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SYNOPSIS

Seasonal succession of bottom macro-invertebrates was studied from October 1960 to October 1961 in an attempt to discover the facts of succession in a northwestern Florida lake. Several observed factors influenced invertebrate succession but temperature seemed to be the major cause. As the water temperature fluctuated so did the number of organisms; however, the variety of invertebrates remained relatively constant throughout the year.

INTRODUCTION

The affect of seasonal changes on invertebrate organisms in Florida's streams and lakes is a phase of aquatic ecology in which too little investigation has been concentrated. Major contributions to knowledge in this field are by Harkness and Pierce (1941), Sellards (1914), and Pierce (1947) who have described the physical, chemical, and biological conditions that prevail in the waters of peninsular Florida.

Because invertebrate seasonal succession in northwestern Florida waters may differ from that in waters of peninsular Florida it seemed worthwhile to investigate succession in this section of the state. A preliminary study of the standing crop of Lake Cassidy was conducted in June 1960 and from October 1960 to October 1961, a continuous monthly investigation was made. The purpose of this monthly investigation was to determine seasonal succession of bottom invertebrates. This was accomplished by studying selected environmental factors involved in seasonal succession and attempting to discover their relative values.

DESCRIPTION OF THE LAKE

Lake Cassidy is a 220 acre lake which has been relatively undisturbed since a fish population study in September, 1957 (Byrd and Wilson). The lake is in western Holmes County on the Walton-Holmes county line, 8 miles northeast of DeFuniak Springs, Florida. The lake basin is of Alum Bluff group origin, deposited during the Miocene times, as described by Vernon (1942).

The littoral zone is comprised of a dense entanglement of vegetation including; pickerelweed (*Pontederia cordata*); water lily (*Nymphaea sp.*); water milfoil (*Myriophyllum heterophyllum*) and several species of algae. Bordering the lake is a woodland climax of Pinus-Quercus association (Fig. 1). The dominant species present are; yellow pine, (*Pinus echinata*); red oak (*Quercus falcata*); white oak (*Quercus alba*); and laurel oak (*Quercus laurifolia*). Extending into the littoral zone is a stand of bald cypress (*Taxodium sp.*).

Fig. 1. A photograph of Lake Cassidy showing the heavy vegetative growth bordering the lake.

The lake bottom consists of silt overlying sand and has an irregular contour. The deepest areas are in the southeastern section where the maximum depth is approximately 32 feet. (Fig. 2).

Limnologists have postulated several methods for the classification of lakes. I have chosen Whipple's (1927) physical classification to further describe this lake. Lake Cassidy is a tropical lake

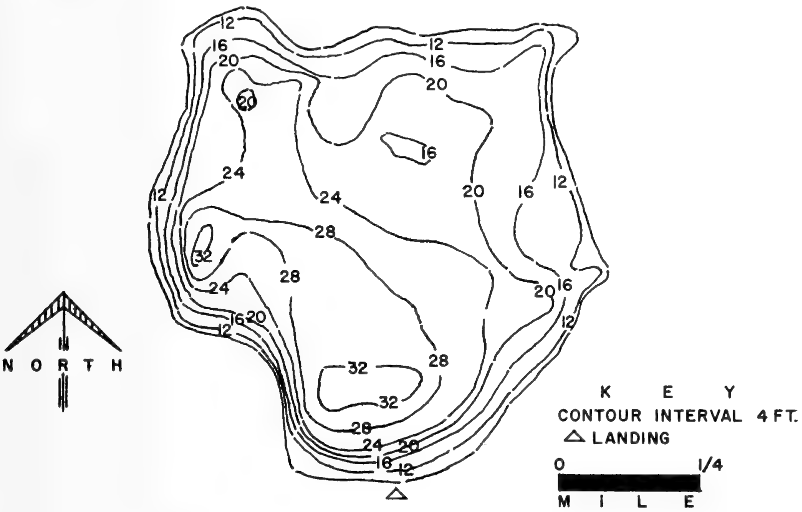

Fig. 2. A map indicating the contour of the lake. (Florida Game and Fresh Water Fish Comm. 1960)

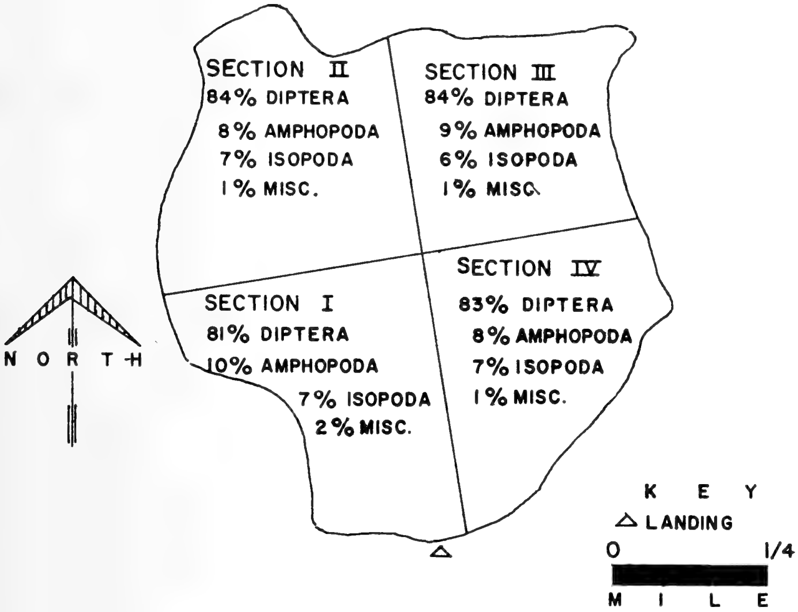

Fig. 3. A comparison of fauna collected in four sections of Lake Cassidy during the standing crop study. (Percent by numbers)

of the third order or by definition, a lake in which the temperature of the bottom water is very similar to that of the surface water.

METHODS AND MATERIALS

The preliminary survey of the biology and chemistry of Lake Cassidy was completed in June, 1960. The lake was divided into 4, approximately equal sections and invertebrate organisms were collected from each section. In comparing the invertebrates from these 4 sections, no significant difference in variety or number was found. (Fig. 3).

Chemical analyses, done during this phase of the study, showed minor variations at field stations sampled. This chemical similarity indicated each station did not warrant individual consideration. Instead, chemical data collected at various depths, from a single station would be of greater value in the seasonal succession study to follow.

Since Sections I, II, III and IV were biologically and chemically similar, only Section I was selected for study during the seasonal investigation.

Section I is approximately 55 acres, or one-quarter of the lake. The maximum, normal depth is 32 feet, the bottom consists of a layer of silt overlying sand.

Biological bottom samples were collected at each of 10 field stations in this section. These stations were arranged to effectively sample the sublittoral and littoral zones; they range in depth from 6 to 32 feet. (Fig. 4).

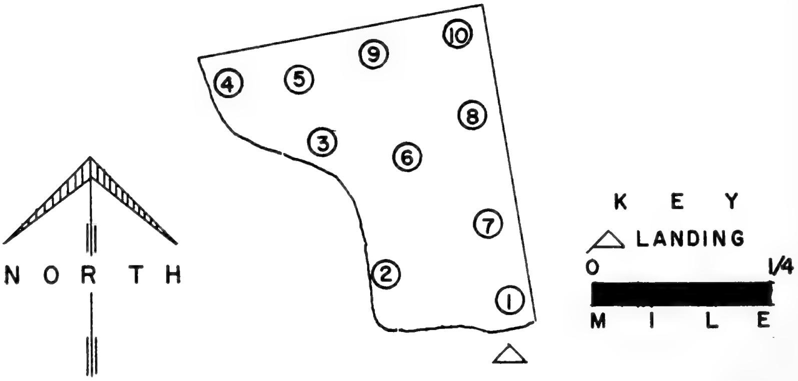

Fig. 4. Section I of Lake Cassidy, showing the location of field sampling stations.

The bottom organisms were collected with a standard 6 x 6 inch Ekman dredge, (Welch, 1948). Animals were preserved and later returned to the laboratory for quantitative and qualitative analyses.

Organisms were separated and classified according to Pennak (1953) and to modified keys for the identification of Diptera larvae (Beck, 1960); Ephemeroptera (Berner, 1950); Trichoptera (Ross, 1944); and Odonata (Byers, 1930). In addition specific identification of certain Ephemeroptera and Odonata was made by Dr. L. Berner and Dr. M. J. Westfall, Jr., respectively.

To aid in quantitative analyses the total number of organisms from each Ekman dredge sample are expressed as number of organisms per square meter.

Water samples to be used in the determination of chemical data were collected at 6 foot intervals from station 10. The pH, dissolved oxygen and temperature were determined in the field. Other analyses including determination of acidity, alkalinity, nitrogen (ammonia), carbon dioxide, total dissolved solids, hardness, color and turbidity were made in the laboratory. All analytical procedures followed the eleventh edition of Standard Methods for the Examination of Water and Waste Water. (1960).

Faunal Habitat and Distribution

Invertebrate organisms collected in the open water or sublittoral zone of section I were abundant in number but few in variety; the opposite was true of the littoral zone. These faunal differences are correlated with littoral vegetation (Reid 1950) and are shown in Table I.

Fauna of the littoral zone was dominated by Diptera larvae, but several other species of insects, crustaceans and aquatic worms were also collected.

Invertebrate variety decreased as bottom sampling approached the sublittoral zone. Dominant species of the sublittoral bottom were the phantom midge larvae, (*Chaoborus punctipennis*) the bloodworm (*Chironomus dux*) and two other midge larvae (*Procladius culiciformis,* and *Clinotanypus sp.*). The only other larvae collected in this area were *Pentaneura carnae; Pentaneura sp. D; Cryptochironomus fuluus* and *Culicoides spp.* The few times they were collected indicated their limited numbers in deep water.

TABLE 1

THE INVERTEBRATE ORGANISMS OF LAKE CASSIDY COLLECTED IN THE LITTORAL AND/OR SUBLITTORAL ZONE OF SECTION I.

LITTORAL ZONE	SUBLITTORAL ZONE
Platyhelminthes	
Tubellaria (flatworms)	
Dugesia tigrina (Girard)	
Annelida	
Oligochaeta (aquatic earthworms)	
Limnodrilus spp.	*Limnodrilus spp.* Lumbriculidae (family)
Hirudinea (leeches)	
Helobdella stagnalis (Linn.)	
Arthropoda	
Crustacea	
Isopoda (aquatic sowbugs)	
Asellus spp.	
Amphopoda (scuds, sideswimmers)	
Hyalella azteca (Saussure)	
Decapoda (crayfish, shrimp)	
Palaemonetes paludosus (Gibbes)	
Arachnoidea	
Hydracarina (water mites)	
Arrenurus spp *Hydrachna spp* *Limnesia spp*	*Hydrachna spp* *Limnesia spp*
Hexapoda or Insecta	
Ephemeroptera (mayflies)	
Caenis diminuta (Walker) *Ephemerella trilineata* (Berner) *Hexigenia munda marilandica* (Traver) *Paraleptophlebia bradleyi* (Needham) *P. volitans* (McDunnough)	*Hexigenia munda marilandica* (Traver)

TABLE 1—Continued

THE INVERTEBRATE ORGANISMS OF LAKE CASSIDY COLLECTED IN THE LITTORAL AND/OR SUBLITTORAL ZONE OF SECTION I.

LITTORAL ZONE	SUBLITTORAL ZONE
Odonata Anisoptera (dragonflies)	
Celithemis bertha (Williamson)	
C. ornata (Ramber)	
Gomphus cavillaris (Needham)	
Libellula incesta (Hagen)	
Pachydiplax longipennis (Burmeister)	
Tetragoneuria sp.	
Zygoptera (damselflies)	
Argia translata (Hagen)	
Enallagma traviatum (Selys)	
Ischnura posita (Hagen)	
Neuroptera (spongilla flies)	
Climacia areolaris (Hagen)	
Trichoptera (caddis flies)	
Leptocella sp.	
Oecetis sp.	
Oxyethira sp.	
Polycentropus interruptus (Banks)	
Lepidoptera Pyralididae (aquatic caterpillars)	
Nymphula sp.	
Coleoptera (beetles)	
Stenelmis lateralis (Sand)	
Diptera (flies, mosquitoes, midges) (Tanypodinae)	
Clinotanypus sp.	*Clinotanypus sp.*
Pentaneura sp A (Beck)*	*Pentaneura carnea* (Fabricius)
P. carnea (Fabricius)	*P. sp D* (Beck)
P. sp D (Beck)	*Procladius culiciformis* (Linn.)
P. illinoense (Malloch)	
P. monilis (Linn.)	
P. pilosella (Loew)	

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* Species designated by a letter have not been formally described by Beck for publication.

TABLE 1—Continued

THE INVERTEBRATE ORGANISMS OF LAKE CASSIDY COLLECTED IN THE LITTORAL AND/OR SUBLITTORAL ZONE OF SECTION I.

LITTORAL ZONE	SUBLITTORAL ZONE
(Chironomini)	
Chironomini sp L (Beck)	
Chironomus (Chironomus) *decorus* (Joh.)	*Chironomus* (Kiefferulus) dux (Joh.)
Cryptochironomus sp.	
Cryptochironomus fuluus (Johannsen)	*Cryptochironomus fuluus* (Joh.)
Endochironomus (Endochironomus) *nigricans* (Joh.)	
Glyptotendipes sp.	
G. sp A. (Beck)	
G. sp B. (Beck)	
G. (Phytotendipes) *lobiferus* (Say)	
G. (Phytotendipes) *paripes* (Edwards)	
Harnischia sp.	
Harnischia sp G. (Beck)	
Lauterborniella varipennis (Coquillett)	
Limnochironomus sp.	
Microtendipes pedellus var. aberrans (Joh.)	
Polypedilum sp.	
P. (Tripodura) *halterale* (Coquillett)	
P. (Polypedilum) *illinoense* (Malloch)	
Polypedilum (Tripodura) *scalaenum* (Schrank)	
Pseudochironomus fulvientris (Joh.)	
Stictochironomus devinctus (Say)	
(Tanytarsini)	
Atanytarsus sp A (Beck)	
A. tanytarsus sp C (Beck)	
Rheotanytarsus sp A (Beck)	
R. exiguus (Joh.)	
Tanytarsus sp.	
Tanytarsus sp A (Beck)	
Tanytarsus sp B (Beck)	
(Chaoborinae)	
	Chaoborus punctipennis (Say)
(Ceratopodonidae)	
Culicoides spp.	*Culicoides spp.*
(Tabanidae)	
Chrysops sp.	

In addition to these dipterous larvae, the burrowing mayfly (*Hexigenia munda marilandica); aquatic earthworms* (*Limnodrilus sp.*) and several species of water mites (Hydracarina) inhabited this area.

The littoral and sublittoral zones are also inhabited by several species of fish. These fishes may have a very important affect on invertebrate populations.

Fish Population

Although many macroscopic invertebrates prey upon one another, the major predators of these organisms are fishes, (Ball, 1952). In 1957, a fish population investigation was conducted by Byrd, and Wilson using four major collecting devices:

1. Fishtox (1 gallon)
2. 50 foot Cotton Trammel net
3. 100 foot Nylon Gill nets
4. Rotenone (1 gallon)

Results of this study indicated Lake Cassidy had a trend toward over-population of bluegill. The food of the bluegill consists largely of insects and their larvae, especially mayflies, damselflies and midges (Harlan & Speaker, 1956). They feed upon these aquatic invertebrates during most of the active growing season (Ball, 1948) but turn to plant food to supplement or replace the animal food during the midsummer season, when the supply of invertebrates reaches its lowest point of the year.

Table 2 contains a list of the fishes collected (Byrd and Wilson, 1957). Only 2 of the 14 species collected are strictly non-bottom feeders.

Seasonal Succession

Factors including the lake bottom, vegetation and fish, affecting invertebrate population have been briefly mentioned. Now let us look at the physical and chemical changes of the water which affect invertebrate population.

Many chemical and physical changes took place in Lake Cassidy during the winter months. The major changes were that of temperature and light. As the length of day and angle of sun incidence decreased the waters became cooler. Bottom water temperatures dropped from 21° to 13° C in a period of one month (November to December). The pH remained almost constant at

5.4 and dissolved oxygen content began to rise as temperatures fell; oxygen tension increased from 7.1 to 9.3 mg/1. The rapid drop in water temperature was followed by a sharp increase in invertebrates the next month. The number of organisms in December was 3,666 per square meter, while organisms collected in January totaled 6,946 per square meter. Though population doubled in January the recorded number of species differed only slightly. There were 33 species of insects collected in December and 31 in January. Species of the Classes Turbellaria, Oligochaeta, Crustacea, and Arachnoidae were similarly comparable. This rise in population was due therefore to numerical increases of certain insects and crustaceans, rather than the presence of new species. The scud (*Hyalella azteca*) increased at a ratio of 4 to 1, while in the insect group, the midge larvae (*Harnischia sp G; Microtendipes pedellus aberrans;* and *Tanytarsus sp.*) contributed most to this increase.

TABLE 2

THE FISHES OF LAKE CASSIDY

1.	Yellow Catfish	*Ameiurus natalis* (Le Sueur)
2.	Northern Largemouth Bass	*Micropterus salmoides salmoides* Lacepede
3.	Warmouth	*Chaenobryttus coronarius* (Bartram)
4.	Bluegill	*Lepomis macrochirus purpuresceus* Cope
5.	Dollar Sunfish	*Lepomis marginatus* (Holbrook)
6.	Tadpole Madtom	*Noturus mollis* (Hermann)
7.	Star-headed Topminnow	*Fundulus notti notti* (Agassiz)
8.	Eastern Mosquito Fish	*Gambusia affinis holbrooki* (Girard)
9.	Everglade Pigmy Sunfish	*Elassoma evergladei* Jordan
10.	Florida Swamp Darter	*Etheostoma barratti* (Holbrook)
11.	Spotted Gar	*Lepisosteus* sp.
12.	Eastern Chubsucker	*Erimyzon sucetta* (Lacepede)
13.	Southern Brown Bullhead	*Ameiurus nebulosus marmoratus* (Holbrook)
14.	Bowfin	*Amia calva* (Linnaeus)

After the January maximum, invertebrate population began to decrease slowly until spring. The early spring collections showed a sharp decline in population. The number of recorded organisms decreased from 6,029 to 4,910 per square meter from February to March. During this period, water temperatures increased rapidly from 11° to 16° C and other environmental factors were affected to a lesser degree.

Population increased slightly in April because of an increase in sublittoral organisms. However, May samples showed a 1,777 organism per square meter reduction. During this period water temperature increased to 20° C. and bluegill fry hatched and began feeding on aquatic insect larvae. (Harlan & Speaker, 1956) Concurrently, several insect casts were seen on the surface of the water indicating a recent emergence. The increased water temperature was probably an important factor in the occurrance of these two events.

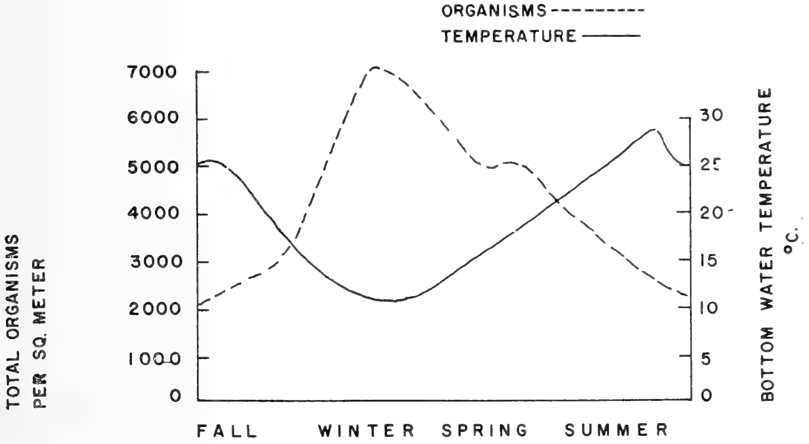

Fig. 5. Seasonal fluctuations of temperature and invertebrate populations.

Another observed factor which seemed to have direct relationship with the organism reduction was dissolved oxygen. Dissolved oxygen is largely dependent on temperature conditions (Welch, 1952 p 97) but it is also affected by other variables. In May the dissolved oxygen began to decrease rapidly and reached a low of 2.0 mg/1 by July. This was only 24.5% saturation. Oxidation of the organic matter on the lake bottom probably caused the reduction and as oxygen demand was met the percent saturation increased. The following month, August, oxygen increased yet invertebrates continued to decrease until their low of 2,393 per square meter in September. Therefore, the close relationship between oxygen changes and population decrease was probably only a coincidence.

The correlation between water temperature and invertebrate population remained constant. As the summer days became longer and the sun's light and heat became more intense, the water temperature slowly increased. This rise in water temperature was accompanied by a steady decrease of invertebrates. Figure 5 shows the inverse correlation between water temperature and invertebrate population.

SUMMARY AND CONCLUSIONS

This study has shown the seasonal changes of selected factors in a northwestern Florida Lake and the affects of these changes on certain bottom organisms.

Vegetation in the littoral zone remained green throughout the year providing thick entanglement for invertebrate life. Greater numbers of species inhabit this area and these organisms indicated environmental conditions of the lake shoreline.

Benthic invertebrates of the sublittoral zone had but a single habitat, the mucky bottom. This area was subjected to adverse conditions such as reduced oxygen tension, but the invertebrates seemed to be quite tolerant. Midge larvae, aquatic earthworms, water mites and a burrowing mayfly were the only invertebrates collected from this area.

The pH remained acid throughout this investigation, it ranged from 5.1 to 5.9. Acidity was attributed to leeching of tannic acid from vegetation in the lake and surrounding woodland. The invertebrate population changes did not follow pH fluctuation.

Fluctuation in other chemical data including acidity, alkalinity, nitrogen (ammonia), dissolved solids and hardness were diminutive. No correlation was apparent between these chemical factors and invertebrate fluctuations.

Turbidity and color were less than 1 unit except for a non-settling layer of cloudy water which lay just above the bottom. This thin layer was due largely to fine particles, more or less, permanently suspended in the water, as explained by Jackson and Starrett (1959). Benthic organisms were constantly subjected to this environmental factor and it did not appear to have any major affect on their existence.

No time during the year was there extended periods of precipitation or drought, and the depth of the water remained relatively constant. The only physical factors that varied appreciably were temperature and light.

During the winter, water temperature dropped as the days became shorter and the direct sunlight decreased. A minimum of 11° C prevailed on the lake bottom during January and February. This decrease in temperature was accompanied by an increase in the bottom invertebrate population. In contrast, as the warm summer months approached, water temperatures increased and invertebrates decreased. Water temperature reached a maximum late in the summer; and this corresponded with the invertebrate minimum.

Throughout the year, the number of invertebrates rose and fell with temperature fluctuations, yet the variety of organisms remained relatively constant.

It is highly doubtful that any one factor was completely responsible for population differences. However, population fluctuations were more closely correlated with water temperature than any other observed factor.

ACKNOWLEDGMENTS

Since appreciation is expressed to the Florida State Board of Health, Bureau of Sanitary Engineering under the direction of Mr. D. B. Lee, for allotting time and laboratory facilities for this study; to Dr. L. Berner for identification of Ephemeroptera and Dr. M. J. Westfall, Jr. for identification of Odonata; to Mr. W. M. Beck, Jr. and Dr. A. A. Paloumpis for offering suggestions and criticisms in the preparation of the manuscript; to Mrs. R. F. Schneider, Mr. M. F. Skipper, Mr. C. G. Mauriello and Mr. A. R. McLeod for technical assistance in field sampling and laboratory work; and to Mrs. M. E. Glasscock for the final preparation of the manuscript.

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THE THOMAS FARM FOSSIL QUARRY

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Florida Geological Survey

The Tertiary deposits of the western United States have yielded a remarkably complete story of the history of land mammals throughout the entire extent of the Age of Mammals. Although the Pleistocene and the last phase of the Tertiary are well represented in the eastern United States and a few marine deposits of Miocene age are known, only one early terrestrial deposit of any consequence is present in the known sedimentary rocks east of the Mississippi River. The reason for this lack of fossil record, in this part of North America, is due to the early Tertiary sediments being dominantly marine in nature and hence containing no land mammals. The one exception to this barren record lies in north central Florida. This deposit, the richest bone bed of Miocene age in eastern North America, is located in Gilchrist County in a most unpromising-appearing setting of low, sandy flatwoods having none of the "usual" surface outcrops visible with which vertebrate fossils are associated. The circumstances that led to the discovery, purchase and development of the now famous Thomas Farm quarry are worthy of relating here in some detail.

In September 1931, Mr. J. Clarence Simpson, of the Florida Geological Survey, was investigating a reported Indian graveyard that had turned up while plowing through a depression in an abandoned field of the old Raeford Thomas Farm located between Bell and Ft. White. Mr. Simpson determined correctly that these bones were not of human origin but represented, instead, the remains of the small three-toed horse *Parahippus* and were similar to those obtained from the fuller's earth pit at Midway, Florida, in Gadsden County. A small collection of fragments from those that littered the surface of the shallow depression which marked the original site, were sent back to the Geological Survey office. The Survey Director at that time, Dr. Herman Gunter, forwarded these scraps to Dr. G. G. Simpson at the American Museum of Natural History. Dr. Simpson recognized the scientific importance of this find and urged that more material be collected if possible.

Dr. Gunter secured permission to excavate and several more trips were made to the farm by personnel of the Geological Survey between 1931 and 1932. An account (Simpson, 1932) of the first material obtained at this dig was published in 1932.

In 1939, Dr. Thomas Barbour, Director of the Museum of Comparative Zoology at Harvard College, made one of his frequent trips to Florida to obtain fossils. During the course of his stay in Tallahassee, Barbour had occasion to examine the fossils that had been obtained from the deposits at the Thomas Farm.

The result of this visit was a desire, on Barbour's part, to purchase the forty acres of land that contained the fossil quarry so that it would be protected for future scientific excavations. The property was purchased and deeded to the present owner, the University of Florida, with the understanding that Harvard University and the Florida Geological Survey would also enjoy the privilege of collecting fossils from the Thomas Farm quarry, for scientific study or display. The Florida Geological Survey has received the cooperation of both universities in its endeavor to obtain a series of vertebrates from this locality for state collections housed in the Survey's quarters at Tallahassee.

The nature of this locality, as it appeared in Miocene times, has not been solved to the satisfaction of all concerned. Indications point to a partially filled sinkhole or to a cavern or rock shelter having considerable depth, located perhaps at the edge of a stream. That a cavern of some sort was present is attested to by the numerous bat remains that are found in the rubble of a boulder bar or breakdown of a long collapsed cave roof. That this cavity was at times water fed is indicated by the various amphibian, alligator and aquatic turtle remains that are present in the sediments. However, no reliable or identifiable fish bones have been found in the nearly three decades of digging since the quarry was first discovered. Another indication that this deposit was periodically stream fed, while the animals were being entombed, is substantiated by the waterworn scraps of bone and by the evidence that no articulated or individually associated skeletons have been found. Instead, it is not unusual to find five or six horse skulls nesting together or half a dozen or so femora, of the same side of the animals represented, lying in close contact. Although quite a few complete skeletons are known of the small horse *Parahippus,* the different elements composing these complete skeletons probably represent several individuals rather than belonging to one animal as is usually the case in most vertebrate fossil quarries from which complete mammal skeletons are known.

The varied fauna includes no less than 52 species either described or in process of description, of which 7 are amphibians, 6 are reptiles, 10 are birds, and 28 are mammals. The recorded fauna will be considerably enlarged when studies now in progress are completed. Significant additions will certainly be made among the snakes, perching birds, and bats. It is probably safe to predict that the fauna will ultimately include no less than 65 species, with the additional novelties appearing primarily among the smaller vertebrates as a product of washing operations. A list of the known fauna generally agreed to be Arikareeanin age has been compiled by C. E. Ray (1957).

Faunal List[1]

AMPHIBIA: Frogs, Salamanders, and Allies
- Anura: Frogs
    - *Scaphiopus* cf. *holbrooki,* Spadefoot Toad
    - ? Leptodactylidae, Frog of uncertain familial affinity
    - *Bufo praevius,* Toad
    - *Hyla goini,* Tree Toad
    - *Microhyla,* sp. Indet., Toad
    - *Rana,* sp. Indet., Frog
- Urodela: Salamanders
    - *Siren hesterna,* siren

REPTILIA: Turtles, Snakes, Lizards, and Crocodilians
- *Pseudemys,* sp. Indet., Terrapin
- *Geochelone tedwhitei,* Land Tortoise
- *Peltosaurus floridanus,* Glass Lizard
- *Neurodromicus stanolseni,* Boid Snake
- *Ogmophis pauperrimus,* Boid Snake
- *Alligator olseni,* Alligator

A considerable herpetofauna (notably snakes) is present, but is as yet undescribed.

AVES: Birds
- *Phalacrocorax subvolans,* Cormorant
- *Promilio floridanus,* Kite
- *Promilio epileus,* Kite

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[1] This fauna is generally agreed to be Arikareean in age.

Promilio brodkorbi, Kite
Boreortalis laesslei, Chachalaca
Rhegminornis calobates, Shore Bird
Columbidae, Doves, 2 undescribed species
Coraciiformes, 2 undescribed species, one a Barbet and one representing a new family
Compsothlypidae, Gen. et. sp. Indet., Wood Warbler
Several undescribed passerine (perching) birds are present.

MAMMALIA: Mammals
Soricidae, Shrew, undescribed species
Suaptenos whitei, Vespertilionid Bat
Miomyotis floridanus, Vespertilionid Bat
Several undescribed species of bats are present.
Mesogaulus, sp. Indet., Rodent, undescribed species
Sciuridae, Ground Squirrel, undescribed species
Proheteromys magnus, Pocket Mouse
Proheteromys floridanus, Pocket Mouse
Cricetidae, New World Mouse, undescribed species
Cynodesmus iamonensis, Coyote-sized Dog
Tomarctus canavus, Coyote-sized Dog
Enhydrocyon spissidens, Small Dog
Amphicyon longiramus, Large-Dog-like Bear
Absonodaphoenus bathygenus, Small Dog
Aelurodon johnhenryi, Bear-sized Dog
Oligobunis floridanus, Large Mustelid
? *Miomustela,* sp. Indet., Weasel-like Mustelid
Leptarctus ancipidens, Badger-like Mustelid
Anchitherium clarencei, Large conservative Horse
Parahippus blackbergi, Small Advanced Horse
Parahippus leonensis, Large Advanced Horse
Rhinocerotidae, Gen. et. sp. nov., Large Rhinoceros
Diceratherium (*Menoceras*), sp. nov., Small Rhinoceros
Desmathyus olseni, Peccary
Floridatragulus dolichanthereus, Camel
Nothokemas floridanus, Camel
Synthetoceras (*Prosynthetoceras*) *australis,* Artiodactyl belonging to extinct family
Blastomeryx (*Parablastomeryx*) *floridanus,* Small Deer
Machaeromeryx gilchristensis, Small Deer

One of the interesting things concerning this locality, as compared with those of similar age found in the western United States, is the total lack of the remains of either felids or *Oreodonts*. Both of these groups of animals are well represented in similar quarries throughout the western United States and the latter animals are so numerous in some areas that certain layers that contain their bones have been dubbed "Oreodon beds". No delinitive statements can be made, based on our present knowledge of these forms, as to why they would occur in great abundance in one area and be totally absent in another.

The present limits of the excavation, that contain the most productive collecting area, measure approximately 30 by 60 feet and reaches a depth of 15 feet below the surrounding terrain. Test borings indicate that the bone-bearing beds extend to a depth of about 30 feet below the present bottom of the pit and become barren of bone about 100 feet out from the present center of operations.

This quarry has actively been worked by one party or another from each of the three institutions concerned since 1941. Dr. A. S. Romer of Harvard University has postulated that the pit would not be completely excavated until aproximately 2000 man-years of labor had been expended.

It must be stressed that anyone contemplating visiting the Thomas Farm quarry will have to have written permission from the head of the Biology Department at the University of Florida. This precaution is to prevent uncontrolled wandering over the bone deposit, which would destroy scientific material that could not be replaced.

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CICHLASOMA PASIONIS, A NEW SPECIES OF CICHLID FISH OF THE *THORICHTHYS* GROUP, FROM THE RIO DE LA PASION, GUATEMALA[1]

Luis Rene Rivas
University of Miami

Introduction

Among cichlid fishes recently collected by the writer in Guatemala, an apparently undescribed species of *Cichlasoma* was detected, during the process of identification. The present new species belongs to the group originally described as the genus *Thorichthys* by Meek (1904: 222). Recently, *Thorichthys* was discussed by Miller and Nelson (1961) and provisionally regarded by them only as a species group within the genus *Cichlasoma.*

This paper is the result of an expedition conducted in Guatemala, during June, 1961, by the Ichthyological Laboratory and Museum of the University of Miami. Esso Standard (Guatemala), Inc., kindly provided living quarters and transportation at Sayaxché, Department of El Petén. The author is indebted to Mr. Walter B. Spangler of Esso Standard, whose initial encouragement and continued cooperation made the expedition possible. The cooperation of Panamerican World Airways is also gratefully acknowledged.

The type specimens and other material referred to in this study are deposited in the University of Miami Ichthyological Museum (UMIM).

Measurements and counts were made according to methods already described by the author (Rivas, 1960: 131, 132) with the following modifications and additions. The head length was measured to the posteriormost point on the margin of the opercular membrane. The length of the middle caudal rays was measured from the middle of the caudal base. The length of the sixth and the last dorsal spine and of the last anal spine was measured from the base of the erect spine. All the gill rakers on the first arch were counted, including those above the angle. The standard length is always stated as "length" and the proportions are expressed in thousandths of the length.

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[1] Contribution No. 45 from the Ichthyological Laboratory and Museum, Department of Zoology, University of Miami.

Cichlasoma pasionis, new species
Figure 1

Fig. 1. Three syntopic species of *Cichlasoma* of the *Thorichthys* group, from the Río de la Pasión at Sayaxché, Guatemala. Upper, *C. hyorhynchum,* 52 mm. in length, UMIM 4019. Middle, *C. pasionis,* holotype 61.3 mm. in length, UMIM 4872. Lower, *C. champotonis,* 55.2 mm. in length, UMIM 4016. (Photographed by the author).

The holotype is an adult specimen 61.3 mm. in length, collected by Luis Rene Rivas in the Río de la Pasión, of the Río Usumacinta system, at Sayaxché, Department of El Petén, Guatemala, on June 14, 1961 (UMIM 4872). The paratypes, collected with the holotype, comprise one adult specimen 54.5 mm. in length, two young 24.5 and 25.1 mm. in length, and four juveniles 13.0 to 15.4 mm. in length (UMIM 4017).

In the following description, the proportions and the number of gill rakers and lateral line scales do not include those of the four juvenile paratypes in which the characters are not all fully developed. The lateral line scales are not fully developed in the two young paratypes. The proportions of the holotype are given first, followed by those of the adult and the young 24.5 and 25.1 mm. paratypes respectively, in parentheses.

Predorsal length, 455 (448, 442, 438). Prepelvic length, 413 (408, 429, 415). Preanal length, 617 (615, 612, 578). Head length, 408 (403, 400, 399). Snout length, 175 (162, 131, 124). Maxillary length, 126 (114, 110, 108). Orbit diameter, 129 (128, 143, 147). Suborbital width, 111 (96, 61, 64). Interorbital width, 134 (110, 118, 112). Body depth, 455 (422, 421, 415). Caudal peduncle depth, 147 (143, 131, 135). Pectoral fin length, 397 (374, 352, 370). Pelvic fin length, 363 (356, 322, 350). Anal fin length, 538 (534, 490, 518). Middle caudal rays length, 320 (323, 326, 347). Sixth dorsal spine length, 224 (233, 192, 227). Last dorsal spine length, 193 (200, 184, 199). Last anal spine length, 180 (184, 163, 191). Dorsal base length, 555 (534, 530, 518). Anal base length, 333 (319, 306, 322).

Dorsal spines 15 and dorsal rays 10 in the holotype and the seven paratypes. Anal spines 8 in the holotype and six paratypes and 9 in one juvenile paratype. Anal rays 7 in one juvenile paratype, 8 in the holotype, the adult paratype, the 24.5 mm. paratype and three juvenile paratypes, and 9 in the 25.1 mm. paratype. Pectoral rays 13 in one juvenile paratype and 14 in the holotype and the other six paratypes. Gill rakers 18 in the 24.5 mm. paratype, 19 in the holotype and the 25.1 mm. paratype, and 20 in the adult paratype. Upper lateral line scales 19 in the holotype and 21 in the adult paratype. Lower lateral line scales 10 in the holotype and the adult paratype.

In the young and adults, the predorsal contour is very slightly convex, nearly straight. In the juveniles, the predorsal contour is more markedly convex. The dorsal contour, evenly convex along the dorsal fin base, converges with the equally convex ventral contour along the anal fin base, to the beginning of the caudal peduncle. The dorsal and ventral contour of the caudal peduncle, are very slightly concave and converge towards the vertical from the caudal base. The depth of the caudal peduncle, at the caudal base, is about three fourths of the distance between the ends of the dorsal and anal fin base. The highest point on the dorsal contour occurs at the origin of the dorsal fin. The lowest point on the ventral contour occurs about midway between the anus and the insertion of the pelvic fin. The greatest depth of the body occurs on the vertical from the lowest point on the ventral contour. The preventral contour, from the mandible tip to the insertion of the pelvic fin, is nearly straight and less convex than the predorsal contour in the juveniles and young. In the adults, the preventral contour is somewhat more convex than the predorsal contour.

The dorsal fin origin is about on the same vertical that passes through the insertion of the pectoral fin. The dorsal spines increase rather rapidly in length from the first to the sixth and seventh which are the longest and subequal in length; thence, the spines gradually decrease in length to the twelfth and thirteenth which are slightly shorter than the last two spines. In the holotype and the adult paratype, the soft dorsal fin is produced into a filament that reaches to (paratype) or beyond (holotype) a vertical from the middle of the caudal fin. In these two specimens, the anal fin is sharply pointed but not filamentous and its tip reaches to a vertical from the basal third of the caudal fin. In the juveniles and young, the soft dorsal and anal fin reach to about the same vertical from the basal third to fifth of the caudal fin. The anal origin is on a vertical from the ninth dorsal spine. The anal spines increase rapidly in length to the fourth which is about equal to the fifth, sixth and seventh. The last and longest anal spine is slightly longer than the preceding four. The pectoral fin is sharply pointed and reaches to the vertical from the base of the eighth anal spine. The pelvic fin is produced into a filament that reaches to the base of the sixth anal spine or slightly beyond, but not to the base of the seventh spine. The insertion of the pelvic fin is slightly in advance of a vertical from the insertion of the pectoral fin. The caudal fin is evenly emarginate with rather sharp angles not produced into filaments. There are no supplementary lateral lines on the caudal fin.

The mouth is well protractile and the premaxillary processes extend to a vertical from the anterior margin of the orbit. The lower jaw projects slightly beyond the upper with the mouth closed. The margin of the lower lip is continuous but not the entire lip-fold which has an incipient frenum. The posterior tip of the maxillary reaches to the vertical from a point midway between the nostril and the anterior margin of the orbit.

The outer canine teeth, in both jaws, are uniserial and much larger than the inner canines. There are about 17 or 18 on each side in the upper jaw, gradually increasing in size towards the symphysis. In the lower jaw, about 5 of the outer canines on each side of the symphysis are more or less abruptly larger than the rest. In both jaws, the inner canines are arranged into about three ill-defined rows which converge backwards, on each side, into a more or less irregular single row. The outer and some of the inner teeth have brown tips.

The following color description is based on the holotype and the adult paratype only, after six months of preservation. The eight type specimens were fixed in ten percent formalin in the field and transferred to sixty percent ethyl alcohol about ten days later.

Sides of body with seven dark brownish-gray vertical bars wider than the pale gray interspaces. The first bar crosses the nape in front of the dorsal fin and fades at the beginning of the upper lateral line. The second bar extends under the first to fifth dorsal spines and fades at the upper lateral line. The third bar extends under the sixth to tenth dorsal spines and fades gradually at about the level of the lower lateral line. The fourth bar extends below the eleventh to fourteenth dorsal spine and forms a squarish, well-defined black blotch between the upper lateral line and the level of the lower. Below the blotch, the bar is faint and fades just before reaching the anal fin base between the fourth and sixth spines. The fifth bar extends under the first to fourth dorsal rays and fades just before reaching the anal fin base between the seventh spine and the second ray. The sixth bar extends from the end of the dorsal base to the end of the anal base. The seventh bar occurs on the caudal peduncle, somewhat closer to the caudal base than to the sixth bar. The third bar is the widest and the width of the others and of the interspaces gradually decreases anteriorly and posteriorly from it. A median, well-defined vertically elongate black blotch occurs behind the caudal base and in contact with it.

A more or less diffuse longitudinal band extends from the beginning of the upper lateral line to the third vertical bar. Below this band, the sides of the body have silvery reflections. The belly and breast are white, sharply contrasting at the isthmus with the dark-pigmented branchiostegal membrane which is jet-black under the subopercle.

The nape, interorbital, dorsal surface of the snout and the upper lip are dark gray gradually merging into light brownish-gray on the suborbital, cheek and preopercle. The interopercle is silvery-white. A diffuse dark blotch covers the middle third of the posterior half of the subopercle. The rest of the subopercle is silvery. The opercle is silvery, somewhat dusky above. The chin and the lower lip are dusky. There is a row of three or four chalky-blue spots under the eye and one or two similar spots on the preopercle.

The upper lateral line is set off from the lighter background color by small, well-defined black spots, one on each scale. The lower lateral line is unspotted.

The dorsal and anal fin are dusky with alternating dark and light spots on the interradial membranes. Similar spots occur on the basal half of the dusky caudal fin. The pectoral fin is colorless and the pelvic is dusky.

In the two young and the four juvenile paratypes, the branchiostegal membrane is not yet pigmented with dark and the chalky-blue spots and the subopercular blotch are not developed. In the juveniles, the spotting on the fins is still undeveloped. Otherwise, these specimens agree with the above color description.

The present new species is a typical member of the well defined *Thorichthys* group, recently discussed and diagnosed by Miller and Nelson (1961: 1, 2). These authors also listed the eight nominal species currently referable to *Thorichthys* and their original references which therefore will not be repeated here.

The higher number of gill rakers and the coloration of the upper lateral line, distinguish *Cichlasoma pasionis* from the other species of the *Thorichthys* group. It is further distinguished from *Cichlasoma aureum, C. helleri* and *C. ellioti* by the absence of supplementary lateral lines on the caudal fin, the more numerous pectoral rays and the longer anal base. Specimens from southern Mexico (Rio Jaltepec, UMIM 3541; Rio Jalcomulco, 3542) with which the types of *C. pasionis* have been compared, are referable to either *C. helleri* or *C. ellioti.* These two nominal species are very closely related and further study may show that *C. ellioti* is synonymous with *C. helleri.* The form tentatively referred to *C. aureum* by Miller and Nelson (1961: 4) appears to be conspecific with the specimens from southern Mexico discussed above. An adult specimen from the Rio Motagua, Guatemala (UMIM 4015) with which *C. pasionis* has also been compared, represents, in the author's opinion, the true *C. aureum.* In *C. aureum,* the pectoral fin is much shorter and less pointed than in *C. pasionis.*

In addition to the greater number of gill rakers and the coloration, *Cichlasoma pasionis* differs from *C. callolepis* in the less numerous dorsal spines, greater number of anal spines and the longer pectoral fin. Young to adult topotypes of *C. callolepis* (UMIM 4898), recently redescribed by Miller and Nelson (1961) and kindly sent by Miller, have been examined.

The less numerous anal spines, greater number of gill rakers, longer pelvic fin and the coloration of the upper lateral line, distinguish *Cichlasoma pasionis* from *C. affine* and *C. meeki.* In the number of dorsal spines and dorsal rays, *C. pasionis* agrees with *C. meeki* but differs from *C. affine* in which the number of dorsal spines is greater and the dorsal rays less numerous. The subopercular spot is well defined and conspicuous in *C. meeki,* diffuse and much smaller in *C. pasionis* and obsolete or nearly so in *C. affine.* Topotypes of *C. affine* (UMIM 4018) and *C. meeki* (UMIM 2335), have been examined.

Two species of the *Thorichthys* group, *Cichlasoma hyorhynchum* and *C. champotonis,* are syntopic with *C. pasionis* in the Río de la Pasión at Sayaxché. The three species were collected together with a seine along the bank, in water up to about three feet deep. Fifty young to adult specimens of *C. hyorhynchum* (UMIM 4019) and fortynine juvenile to adult specimens of *C. champotonis* (UMIM 4016) were obtained. Both *C. hyorhynchum* and *C. champotonis* were previously recorded only from their type localities. Further exploration may show that *C. pasionis* is more widely distributed in the Rio Usumacinta system.

The number of dorsal rays, anal spines and gill rakers, and the coloration, distinguish *Cichlasoma pasionis* from *C. hyorhynchum* and *C. champotonis.* It agrees with *C. hyorhynchum* in the number of pectoral rays and in the absence of supplementary lateral lines on the caudal fin, but differs in these characters from *C. champotonis.* In the number of dorsal spines, *C. pasionis* agrees with *C. champotonis* and differs from *C. hyorhynchum* in which the number of dorsal spines is greater. The three species are compared in Tables 1 through 5 on the basis of meristic characters.

In addition to *Cichlasoma hyorhynchum* and *C. champotonis*, twentyone species of fishes were collected with *C. pasionis* in the Río de la Pasión at Sayaxché. These species are comprised in sixteen genera and nine families as follows: *Lepisosteus tropicus* (Lepisosteidae); *Rhamdia guatemalensis* (Pimelodidae); *Potamarius nelsoni* (Ariidae); *Ictalurus meridionalis* (Ictaluridae); *Astyanax fasciatus, Chirodon compressus, Brycon guatemalensis* (Characidae);*Belonesox belizanus, Gambusia sexradiata, Carlhubbsia kidderi, Phallichthys fairweatheri, Mollienesia sp.* (Poeciliidae); *Thyrinops guatemalensis* (Atherinidae); *Cichlasoma salvini, C. multifasciatum, C. octofasciatum, C. melanurum, C. irregulare, C. maculicauda, Petenia splendida* (Cichlidae); *Batrachoides godmani* (Batrachoididae). Two other species, *Megalops atlantica* (Megalopidae), the tarpon, and *Centropomus sp.* (Centropomidae), the snook, were frequently seen in the area but not collected. The total of twentysix species in eighteen genera and eleven families, known to occur at Sayaxché, indicates a relatively rich and varied fish fauna for the Río de la Pasión.

TABLE 1

FREQUENCY DISTRIBUTION OF NUMBER OF DORSAL SPINES, DORSAL RAYS AND PECTORAL RAYS IN THREE SYNTOPIC SPECIES OF *CICHLASOMA* FROM THE RÍO DE LA PASIÓN AT SAYAXCHÉ, GUATEMALA.

		Dorsal spines					Dorsal rays					Pectoral rays				
Species	No.	14	15	16	17	Mean	9	10	11	12	Mean	13	14	15	16	Mean
C. champotonis	46	1	43	2		15.0		5	35	6	11.0		2	41	3	15.0
C. pasionis	8		8			15.0		8			10.0	1	7			13.9
C. hyorhynchum	50		5	41	4	16.0	37	13			9.3	9	41			13.8

TABLE 2

FREQUENCY DISTRIBUTION OF NUMBER OF ANAL SPINES AND ANAL RAYS IN THREE SYNTOPIC SPECIES OF *CICHLASOMA* FROM THE RÍO DE LA PASIÓN AT SAYAXCHÉ, GUATEMALA.

		Anal spines						Anal rays			
Species	No.	6	7	8	9	10	Mean	7	8	9	Mean
C. champotonis	46	3	41	2			7.0		25	21	8.5
C. pasionis	8			7	1		8.1	1	6	1	8.0
C. hyorhynchum	50			2	39	9	9.1	12	36	2	7.8

TABLE 3

FREQUENCY DISTRIBUTION OF NUMBER OF GILL RAKERS ON FIRST ARCH IN THREE SYNTOPIC SPECIES OF *CICHLASOMA* FROM THE RÍO DE LA PASIÓN AT SAYAXCHÉ, GUATEMALA.

		Gill rakers											
Species	No.	10	11	12	13	14	15	16	17	18	19	20	Mean
C. champotonis	46	2	27	17									11.3
C. pasionis	4*									1	2	1	19.0
C. hyorhynchum						2	8	31	9				15.9

* Gill rakers not fully developed in the four juvenile paratypes.

TABLE 4

FREQUENCY DISTRIBUTION OF NUMBER OF SCALES IN UPPER AND LOWER LATERAL LINE IN THREE SYNTOPIC SPECIES OF *CICHLASOMA* FROM THE RÍO DE LA PASIÓN AT SAYAXCHÉ, GUATEMALA.

		Upper lateral line							Lower lateral line								
Species	No.	16	17	18	19	20	21	Mean	6	7	8	9	10	11	12	13	Mean
C. champotonis	46			2	23	13	8	19.6			1	4	13	26	1	1	10.5
C. pasionis	2*				1		1	20.0					2				10.0
C. hyorhynchum	50	3	6	19	18	4		18.3	2	9	15	16	8				8.4

* Lateral line scales not fully developed in the two young and the four juvenile paratypes.

TABLE 5

FREQUENCY DISTRIBUTION OF TOTAL NUMBER OF SCALES IN LATERAL LINES IN THREE SYNTOPIC SPECIES OF *CICHLASOMA* FROM THE RÍO DE LA PASIÓN AT SAYAXCHÉ, GUATEMALA.

		Upper and lower lateral line											
Species	No.	23	24	25	26	27	28	29	30	31	32	33	Mean
C. champotonis	46				1		2	7	21	10	4	1	29.5
C. pasionis	2*							1		1			30.0
C. hyorhynchum	50	1	4	7	8	17	6	6	1				26.7

* Lateral line scales not fully developed in the two young and the four juvenile paratypes.

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A TEAL FROM THE LOWER PLIOCENE OF KANSAS

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Among fossil birds sent for identification by Dr. Claude W. Hibbard is a specimen of a teal from the Lower Pliocene of northwestern Kansas. Only six Tertiary teals have been described, and these are referable to the living genera or subgenera *Querquedula* Stephens and *Nettion* Kaup.

The record of *Querquedula* starts in the Lower Miocene with *Q. natator* (Milne-Edwards, 1867) from the Aquitanian of France and *Q. integra* A. H. Miller (1944) from the Rosebud formation of South Dakota. The only other Tertiary species is *Q. pullulans* Brodkorb (1961) from the Lower Pliocene of Juntura, Oregon.

Nettion first appears in the Middle Miocene with *N. velox* (Milne-Edwards, 1867) from the Helvetian of France. This is followed in the Lower Pliocene by *N. eppelsheimensis* (Lambrecht, 1933) from the Dinotheriensande of Germany. In the Upper Pliocene *N. bunkeri* Wetmore (1944) occurs in the Rexroad formation of Kansas and the San Pedro Valley formation of Arizona. It has also been identified from the Middle Pliocene at McKay, Oregon (Brodkorb, 1958), and the record of this genus from the Hemphill formation of Texas (Compton, 1934) may also apply here.

The fossil from northwestern Kansas represents an additional species of *Nettion*.

Nettion ogallalae, new species

Figure 1

Holotype. Distal half of left humerus, University of Michigan Museum of Paleontology, no. 41458. From Ogallala formation of Lower Pliocene, in the SW corner of section 15, Township 11 South, Range 22 West, Trego County, Kansas. Collected by Claude W. Hibbard and Jerry Paulson, August 2, 1959. The type locality lies 6½ miles north and 1¾ miles west of Ogallah, Kansas, or 6½ miles northeast of the county seat of Wakeeney.

Diagnosis. Agrees with *Nettion* in having ectepicondylar process inclined distally toward palmar face of bone (process nearly parallel with shaft in *Querquedula*); entepicondylar prominence compressed and rotated anconally, so that area of origin of pronator longus is produced medially almost to edge of bone and in palmar view largely overhangs area of origin of flexor carpi ulnaris (in *Querquedula* anconal rotation slight, with area of origin of flexor carpi ulnaris produced medially far beyond scar of pronator longus); upper end of scar of flexor carpi ulnaris distal to upper end of scar of pronator longus and distal to bend in entepicondyle (in *Querquedula* upper end of scar of flexor carpi ulnaris extends proximally from those points).

Differs from living *N. crecca* (Linnaeus) in having ectepicondyle with its distal end rounded in lateral view and falling short of distal end of external condyle (in *N. crecca* ectepicondyle produced in a

Fig. 1. *Nettion ogallalae,* n. sp. Holotype humerus (actual length, 24.8 mm.).

point that extends distally about as far as distal end of external condyle); largest foramen on palmar face located close to tip of external condyle (foramen more medial in *N. crecca*); scar of pronator longus with even stronger medial thrust; size smaller than in this or described fossil species.

Measurements. Distal width, 8.7; width of shaft, 4.0 mm. Corresponding measurements of eight specimens of *N. crecca* are 9.0-9.5 and 4.2-4.6 mm. *N. velox* is similar in size to *N. crecca.* In *N. eppelsheimensis* the distal width is 9.8 mm. The humerus of *N. bunkeri* is still unknown, but this species is also relatively large, for the coracoid, carpometacarpus, and tibiotarsus are larger and more robust than in *N. crecca.*

Associated fauna. Vertebrates previously reported from the Ogallala formation in Trego County include a catfish (*Ictalurus lambda* Hubbs and Hibbard), a beaver (*Eucastor* cf. *tortus* Leidy), a small mylagaulid rodent (*Epigaulus minor* Hubbs and Phillis), a small horse (*Nannippus* sp.), and an indeterminate small camel (cf. Hibbard and Phillis, 1945; Hubbs and Hibbard, 1951).

It is of interest that three of the mammals from this locality are small, and the teal described above is the smallest member of its genus. A similar tendency toward small size is exhibited by the birds from the Lower (and Middle?) Pliocene beds at Juntura, Oregon (Brodkorb, 1961). Under Bergmann's rule this is to be interpreted as reflecting elevated temperatures in the northern parts of the Great Plains and Great Basin during early Pliocene time.

Acknowledgment. This study has been aided by the National Science Foundation through grant number G-19595, including photographs taken by Robert W. McFarlane.

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ABSORPTION AND TISSUE DISTRIBUTION OF P^{32} FROM DIFFERENT INORGANIC SOURCES IN RATS[1, 2]

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The degree of absorption of phosphorus from various inorganic sources is of importance in supplying phosphorus to livestock and poultry. Several different phosphate compounds are used and their value depends in part upon the biological availability of the phosphorus present. Methods which have been used to measure availability have generally been evaluations based upon growth, bone ash, bone and blood phosphorus, phosphorus balance and retention, and utilization by micro-organisms. Labeled phosphorus in solution has been used in many experiments to study absorption and tissue accumulation of the element (Cohn and Greenberg, '38; Manly and Bale, '59; Feaster, *et al.*, '53; Arrington and Davis, '55). Few studies have been reported in which labeled phosphorus in compounds, not in solution, were evaluated. Davis, *et al.* ('53) and Arrington, *et al.* ('59) have reported values for the absorption of labeled phosphorus in compounds which were administered orally to cattle and swine. Lofgreen ('60) employed an isotope dilution technique in studying the availability (true digestibility) of different phosphate compounds for sheep.

The objective of this study was to determine the absorption and tissue deposition of P^{32} from dicalcium phosphate, defluorinated rock phosphate, soft phosphate and phosphoric acid as a measure of the relative biological availability.

Procedure

Samples of reagent grade dicalcium phosphate, defluorinated rock phosphate and soft phosphate with colloidal clay were irradiated in the pile at Oak Ridge National Laboratory to convert a portion of the P^{31} to P^{32}. Defluorinated rock phosphate and soft phosphate were produced in Florida and samples were obtained by the authors at mining areas. Following the two-week service

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[2] Supported in part by grants from Smith-Douglass Company, Norfolk, Va. and Soft Phosphate Research Institute, Ocala, Fla.

[3] Present Address: Sperry Corporation, Gainesville, Fla.

irradiation, the labeled compounds were administered as a single oral dose in the dry form to growing rats. The dosage for each rat amounted to 20-50 mg and was adjusted to provide approximately 5 μc of activity. The compounds were administered with a stomach tube which was flushed with 2 ml of distilled water. A solution of P^{32} labeled phosphoric acid in weak HCl was also given orally to eight rats. One-half ml of the solution provided the same activity as that administered in the other forms. Eight additional rats were given a single subcutaneous dose of the P^{32} solution which had been diluted with physiological saline to provide the same activity administered orally to the other experimental rats.

The rats were of the Long-Evans strain, 9 to 11 weeks of age. The composition of the diet in percent was ground yellow corn, 78; gluten, 18; Brewer's yeast, 2; NaCl, 1; and $CaCO_3$, 0.6; and contained 0.34% of calcium and 0.36% of phosphorus. Following administration of the labeled phosphates, rats were confined to metabolism cages for quantitative collection of feces and urine. Tissue distribution studies were made on selected tissues removed from rats sacrificed as follows: phosphoric acid, 8 rats at 72 hours; subcutaneous P^{32}, 8 rats at 72 hours; dicalcium phosphate, 6 rats at 12 hours, 6 at 24, 3 at 48 and 3 at 72 hours; defluorinated rock phosphate, 5 at 12 hours, 5 at 24, 4 at 48 and 5 at 72 hours. Accumulation of P^{32} in the tissues of rats given the soft phosphate was not studied. Measurement of the deposition in the tissues of rats given dicalcium phosphate and defluorinated rock phosphate at the time intervals shown was undertaken in order to observe the rate of P^{32} deposition.

The urine was diluted with weak HCl for radioactivity measurement. Feces and tissues were wet digested in nitric acid and radioactivity determined with a commercial GM dipping tube and scaler. The amount of labeled phosphorus excreted in the feces and urine was calculated as the percent of administered dose. Tissue accumulation was calculated on the basis of percent of dose per gram of fresh tissue. Statistical calculations were based on the analysis of variance according to Snedecor, '56.

Results and Discussion

The cumulative fecal and urinary excretion of P^{32} is shown in Figure 1. Rats which had received the P^{32} solution orally excreted significantly less ($P<0.01$) of the labeled phosphorus in the feces than did any of the other groups receiving the other phosphate compounds. These rats also excreted less in the urine suggesting a greater retention as well as greater absorption. These values are slightly higher, but are of the same order as those earlier reported by Arrington and Davis ('55). A significantly smaller proportion ($P<0.05$) of the reagent grade dicalcium phosphate was excreted in the feces than of defluorinated rock phosphate or soft phosphate. If the difference between the total dose administered and total fecal P^{32} is used as a measure of absorption, the phosphorus as phosphoric acid was absorbed to the greatest degree followed by dicalcium phosphate, soft phosphate and defluorinated rock phosphate. Absorption values for soft phosphate and defluorinated rock phosphate were not significantly different. The values represent apparent absorption since no correction for endogenous P^{32} was applied.

Statistical calculations were based upon the cumulative excretion at 48 hours. Approximately 98% as much of the isotope was present in the feces at this time as at 72 hours, and a greater number of values were available for the 48 hour period. Urinary excretion by 48 hours was 92% as much as at 72 hours.

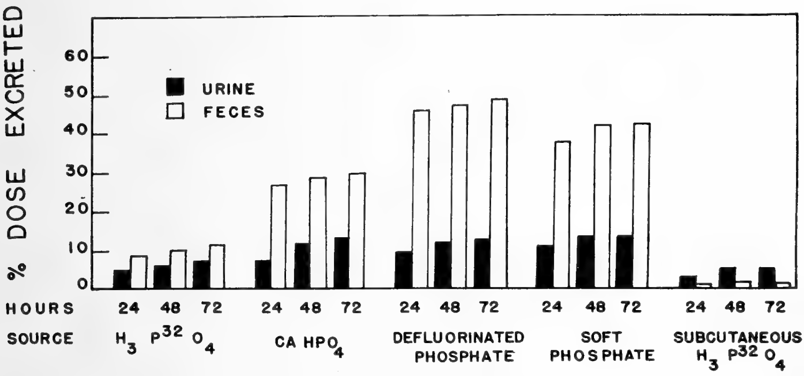

Fig. 1. Cumulative urinary and fecal excretion of P^{32} as affected by phosphorus source.

Elimination of the labeled phosphorus which was administered subcutaneously occurred to a greater degree through the kidney than through the gut (Figure 1). At 72 hours after administration only 1.5% of the dose had been excreted in the feces compared to 5.5% in the urine. This is a ratio of approximately 3.5:1. At 24 hours after administration 61% as much as at 72 hours had been eliminated in the urine. During the same time 45% as much as at 72 hours had been eliminated in the feces. Different relative rates of excretion were also observed between the two methods of administration. At 24 and 48 hours the fecal excretion of P^{32} given orally was 76.7 and 96.4% as much as at 72 hours, respectively. At the same time intervals, excretion from the subcutaneous doses were 45.4 and 81.8% as much as at 72 hours.

Tissue deposition of the labeled phosphorus is shown in Figure 2 as percent of dose per gram of fresh tissue at 72 hours after administration. Relative absorption values indicated in Figure 1 are reflected in the tissue accumulation of the labeled phosphates from the respective compounds. The proportion of orally administered P^{32} in all tissues from the solution was numerically greater than for the other two phosphate compounds and was significantly greater for kidney and muscle ($P<0.05$) and femur ($P<0.01$). Concentration of P^{32} in all tissues except femur was greater in rats which had received dicalcium phosphate than in tissues of rats which had received defluorinated rock phosphate.

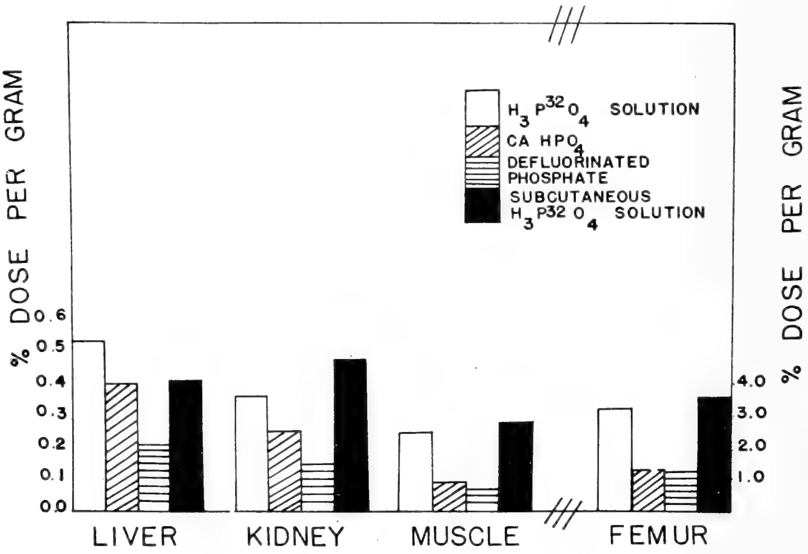

Fig. 2. Tissue deposition of P^{32} from different phosphate sources.

Labeled phosphorus in the blood at 72 hours from all sources was less than one tenth percent of the dose, but the amounts represented the same relative pattern of accumulation.

Rats which had received dicalcium phosphate and defluorinated phosphate were sacrificed at intervals of 12, 24, 48 and 72 hours and measurements of P^{32} in the tissues were made in order to observe the relative rates of deposition. The results for 12 to 48 hours are recorded in Table 1 and for 72 hours in Figure 2. The amounts present at 12 and 24 hours were of the same order with a decrease to 72 hours. The greatest proportional decrease occurred between 24 and 48 hours.

TABLE 1

TISSUE ACCUMULATION OF PHOSPHORUS-32 FROM DICALCIUM PHOSPHATE AND DEFLUORINATED ROCK PHOSPHATE.

		Hours		
Tissue	Source	12 % dose per gram fresh tissue	24	48
Blood	$Ca\ H\ PO_4$	0.175	0.169	0.058
	Defluorinated P*	0.081	0.066	0.028
Liver	$Ca\ H\ PO_4$	1.345	1.155	0.314
	Defluorinated P	0.515	0.513	0.274
Kidney	$Ca\ H\ PO_4$	0.854	0.835	0.288
	Defluorinated P	0.274	0.267	0.188
Muscle	$Ca\ H\ PO_4$	0.215	0.264	0.084
	Defluorinated P	0.069	0.085	0.056
Femur	$Ca\ H\ PO_4$	2.920	2.172	1.529
	Defluorinated P	1.320	1.630	0.650

* Defluorinated rock phosphate.

SUMMARY

Samples of dicalcium phosphate, defluorinated rock phosphate and soft phosphate were irradiated and administered orally to rats in order to determine relative absorption and tissue deposition of the labeled phosphorus. Radioactive phosphorus in solution as H_3PO_4 was administered orally and subcutaneously to additional

rats. The P^{32} as phosphoric acid was absorbed in the largest amount and deposited in greatest proportion in the tissues. The proportion of dicalcium phosphate absorbed was greater than either defluorinated phosphate or soft phosphate but less than P^{32} in solution. No significant differences were observed in the absorption of defluorinated phosphate and soft phosphate. Phosphorus-32 administered subcutaneously to rats was excreted largely through the kidney.

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NEWS AND NOTES

Edited by

J. E. Hutchman

Florida Southern College

Editorial Speaking: At the next council meeting an effort will be made to change the name of this department to, "Extractions." The following few items are the result of over 200 letters and several additional phone calls to all the schools on our list.

If you wish the News and Notes continued now is the time to prove it by sending me a letter TODAY. It may not be NEWS by the time it appears but it can still be NOTES.

Lakeland: Florida Southern College revised its timetable by scheduling the fall semester September 3rd to December 22nd. The second semester will be January 16th to May 13th.

Billy Williams returned to our campus with a Doctor's degree to help turn our better science teachers. Dr. Margaret Gilbert, chairman of the Science Division, was a panelist for the St. Louis NSF Undergraduate Research Participation Program evaluating the applications for 1963-64 proposals. Dr. J. B. Funderburg, Jr., was chosen to attend SE Wildlife Conference in Charleston, S. C. October 11th-13th. Dr. Howard M. Field, who suffered a heart condition, has recovered and is back on his 16-hour per day schedule.

The Chemistry Department has added Mr. William Wegner to the staff and is looking for two more PhDs. Dr. Juliana Jordan, Chairman of the German Department, was enrolled at the University of Mexico for the 8-weeks summer course. Her activities included Spanish, Mayan Archeology and Mexican Folk Dances. In addition to seeing fifteen plays she visited many of the pyramids and other points of interest throughout Mexico. She has a fine collection of colored pictures to back up her glowing reports of the country and of the friendly people there. The pictures also show five other Florida Southern College members present.

Madison: President Marshall Hamilton announced that the North Florida Junior College has been chosen as a test center for the College Entrance Examination Board. The enrollment at North Florida has reached an all-time high of 422 students. Mr. Marcus W. Cherry who has been on the faculty for the past two years was recently appointed chairman of the Social Science Department filling the position left vacant by Mr. James L. Moncrief, who has accepted a position as assistant professor at Jacksonville State College in Alabama. Mrs. Grace Maxwell in the Social Science Division of North Florida Junior College is director of the weekly college radio program entitled "Sentinel Seminar", on the air Tuesday 5:30 over station WMAF, Madison. The first program featured Dr. Marshall Hamilton, President of the "New" College and Mr. A. J. Hargrove, Dean of Student Personnel and Registrar. Dr. John A. Sands and Mr. R. S. Scruggs also appeared on the program. Congratulations to Louis C. Thompson who won a handsome tennis trophy in the Valdosta Invitational Tennis Tournament.

Cocoa: Dr. Mary Cathryne Park, chairman, Division of Social Sciences and Humanities, supplied the following report: First, a note to the membership chairman—please send at least ten applications for membership. That is not perhaps appropriate material for News and Notes but it is such a good example I could not refrain from including it.

Social Science instructor Miss Emma Jean Walker received a Fulbright Grant to University of Grenoble, France, for 1962-1963. Science instructors Leroy Estergard (to Auburn University) and Charles Matthews (to Brown University) were awarded summer grants under the National Science Foundation. Charles Matthews was awarded a research and teaching grant to Cornell University for 1962-1963. This year Brevard Junior College will offer a 36-class TV series, The American Economy, on TV Station WDBO, Channel 6, Orlando.

This fall, BJC will extend its evening division to a new center—Patrick Air Force Base—as well as maintaining its centers at Cocoa, Titusville, and Melbourne. Better than $100,000 has been approved through NDEA funds for BJC projects, in addition to money for two to three new chemistry and physics labs. BJC will move to its new campus in Cocoa, in 3 new buildings on Clear Lake, in December, still utilizing its old campus in downtown Cocoa. Mr. Marm Harris, head of the Science and Math Division, becomes this year Assistant to the President in charge of Business Affairs. NDEA has awarded to BJC new language labs, closed circuit TV facilities and extensive audio-visual materials. New faculty: Dr. Bernard Bonniwell, in psychology, from VillaNova, University. Dr. Kurt von Forstmeyer, in social sciences, Air Force Educational Consultant ret. Dr. Seymour H. Hurt, in education, former Director Laboratories and Assoc. Prof. of Education, Alabama College. Dr. Frank J. Reynolds, in Biology, former Plant Pathologist Administrator to Ministrator of Agriculture, Peru. Dr. Howard H. Woeber, in Chemistry, from Testing Div., Florida State Road Dept. Dr. Sammie Ross, as Dean of Women, from University of Connecticut Deanship (women).

Jacksonville: Dr. William B. Stewart, President of Edward Waters College, was the keynote speaker for the fall convocation of Kittrell College, Kittrell, North Carolina, on October 11th. The following faculty members did advanced study during the summer: Theodore Dansby, University of Miami; Paul Driver, Washington University; James Espy, University of Minnesota; Elizabeth Redding, Drexel Institute of Technology; Saramae Richardson, University of Illinois; Brilla Thomas, University of Miami; Mildred Tucker, Sanford University.

Lakeland: Mr. L. Ralph Welch received a scholarship from the County School Board for summer study at Peabody College in Nashville, Tennessee. The grant was for the study of methods of teaching mentally retarded and blind children.

Gainesville: Assistant Dean E. Ruffin Jones was elected president-elect of the Association of S. E. Biologist. Dr. Eugene Bovee has been invited to speak on protoplasmic movement at the international symposium of specialists at Princeton University in April, 1963. Dr. Archie Carr, Raymond E. Crist, Ray Voggle and Hugh Popenoe participated in a seminar in human ecology in Guatemala. Dr. James B. Lackey visited Paris for participation in discussions on water conservation and pollution in Europe. Dr. George W. Hunter, III, is serving as resident coordinator for the International Center for Medical Research and Training sponsored by Louisiana State University at the University of Costa Rica in San Jose, C. R. Dr. James Layne returned to Puerto Rico this summer to continue studies on reproductive behavior of monkeys. Dr. Sam Martin, known for his research on experimental tuberculosis became the new provost of the J. Hillis Miller Health Center August 1st. He will continue his hospital duties.

The Bacteriology Department of the University of Florida received a training grant from NIH for a 5-year period to aid in teaching Bacteriology at the Graduate level. Drs. W. S. Silver, D. B. Pratt and M. E. Tyler attended the International Congress for Microbiology in Montreal, Canada. Dr. Mendel Herzberg, spent the summer teaching and participating in research at the University of California, Berkeley. He is interested in the development of better immunizing agents. Drs. A. B. Otis, M. J. Fregley and E. B. Wright attended the International Physiological Congress in Leiden, Holland. Dr. Harry Sisler is visiting professor of chemistry at Harvard University this semester. Dr. Darwin W. Smith attended the International Summer Institute on Quantum Chemistry and Solid State Physics in Uppsala, Sweden. Professor Werner Bingel who is visiting associate research professor at University of Florida from the Max-Plank Institute for Physics and Astrophysics spent a summer month with Dr. Joseph Hirschfelder, Theoretical Chemistry Laboratory, University of Wisconsin.

Dr. James Garvin has been appointed Associate Professor of Anatomy and Anthropology at the University of Florida. He has a breeding colony of forty Rhesus monkeys to study postnatal growth of laboratory born monkeys. His animals are housed at the new Primate Colony on the Campus. Dr. Jean Linenmann of the University of Zurich is Visiting Assistant Professor of Microbiology, the College of Medicine. He discovered interferon. Dr. E. W. Suter, Head Professor of Microbiology participated in the International Congress of Internal Medicine in Munich by reading a paper on his research on non-specific resistance. Dr. George E. Gifford is spending a year in research at National Institute for Medical Research, Millhill, London.

Orlando: We have this request from Frederick W. Sleight, Director of the Central Florida Museum, "We are developing here at the Central Florida Museum a reference library in the natural and physical sciences. Fortunately we possess a complete series of the Journal of the Florida Academy of Science, with the exception of Volume X, No. 1. It is a shame not to have a complete series of this valuable publication and, therefore, would appreciate your possibly inserting a search request in the News and Notes of the next quarterly indicating our interest in obtaining this missing item.

Panama City: The math-science-technology division at Gulf Coast Junior College here made the greatest strides forward in size of faculty this year with the addition of six new members: Tom M. Coggins, Marshall E. Gilmer, Cecil N. Goff, Thomas H. Myers, H. Lomax Reynolds, and Ivan J. Scott. Reason for the six new members is the greatly expanded technological programs with emphasis on electronics. The division lost only two members from last year's staff. It now includes ten members and is headed by Robert Tinney. Other new developments at Gulf Coast finds a new $1,790,000 library being constructed and the temporary library being converted into classrooms and technical laboratories.

Madison: Coach Louis Thompson and Peter Webb, the faculty representatives of North Florida Junior College, attended the Florida Junior College Athletic Association meeting in Ocala September 21st. This meeting resulted in the raising of academic standards for any student participating in conference athletics. Mr. Webb, representing the Social Science Dept., spoke on September 2nd at Jasper, Fla. He discussed the 1961 law requiring the public school system to teach a course in "Americanism vs. Communism."

Miami: Dade County Junior College Science and Mathematics Division opened its doors for the first time on the new and permanent campus this September. However, due to the fact that we will be one of the units that move into "Building A" when it is completed sometime during the summer of 1963, we are in temporary labs, classrooms, and offices transformed from military barracks. With some minor renovations and a new coat of paint, we are settling down for the herculean task ahead of us this semester. Though we have added several new instructors, we were still somewhat less than two-thirds prepared for the flood of 5,500 students which descended on us. We are regrouping and shifting where possible and are well under way as this is written.

New to our staff this fall are the following people: Lynn R. Jackson—Math; Earl E. King—Biology; David B. Robinson—Physics; Donald G. Scott, Jr.—Biology; Raymond Taylor—Math; and Shirley Jean Wright—Chemistry.

Madison: North Florida Junior College is on the air each Tuesday at 5:30 p.m. for 15 minutes over WMAF, Madison, giving the latest news, interviews and events of the college community.

Pensacola: Mr. Ron Head returned to the Chemistry Dept. of Pensacola Junior College after a year's leave of absence to study in the College of the Pacific, Stockton, Calif. New persons added to the Science Division are: Dr. Virginia Foster, Biology Dept. She taught formerly at California Western University, San Diego, in the Dept. of Biology. Dr. O'Neal Hendricks, Physical Science, taught school for ten years and is a recent graduate from the University of Georgia. Mr. Robert Leacock, Physics, is a recent graduate from the University of Florida.

Bradenton: Dr. J. G. Montgomery, Chairman of the Science Dept., has announced the following additions to the staff of Manatee Junior College. Carl R. Keeler, Professor of Biology, comes to us from the University of Omaha where he was a member of the Dept. of Biology for two years. Prior to that, Prof. Keeler was associated with Northwestern University. He is a former member of the Nebraska Academy of Science and presently a member of the Chicago Academy of Sciences. Anne Barber, Professor of Chemistry, comes to us from the University of Tennessee where she was chief tutor for chemistry majors. Prior to that, she was associated with the public school systems of Georgia, Alabama and Tennessee.

Palatka: Congratulations to President A. B. Williams as he takes up his new position at Collier-Blocker Junior College. We could always count on news from Florida Normal Industrial and Memorial College while he was our contact man there.

St. Petersburg: Gibbs Junior College will have its full complement of science laboratories soon. The third building phase of the College's expansion program will be completed by mid-semester and laboratory facilities will be located in the addition to the General Education Building. The entire north wing of the Comprehensive Studies Building was set up permanently for science instruction. Consistently large enrollments called for expanded facilities.

Science Department head LeRoy Johnson estimates that 50% of the student body is taking courses in his department. Faculty members, Peter Williams and Paul Mohr, were participants in National Science Foundation-sponsored study programs this summer. Williams, a science instructor, attended the University of Illinois' Chemistry Institute. Mohr, a mathematics instructor, attended Michigan State University. The latter will serve this year as one of the Florida Academy of Sciences' Visiting Scientists.

West Palm Beach: The academic year of 1962-63 opened at Roosevelt Junior College on September 5th with an increase in the freshman enrollment. The Science-Math Club is being organized for the new academic year. Miss Ruby L. Bullock and Mr. Samuel H. Cooke are sponsors of the club. We are looking forward to a fuller and more interesting year. Miss Ruby L. Bullock was a group leader at the Palm Beach County Pre-planning Conference for teachers and at the 8th District meeting of the Florida State Teachers' Association in Fort Pierce. Mr. Samuel H. Cooke was elected chairman of the Science Division of the 8th District meeting of this association.

The Science Division of the 8th District of the Florida State Teachers' Association had their first meeting of all Science teachers of the district at the high school in Stuart on September 29th. The Science Department of the District is planning on having regular monthly meetings of the district Science teachers. The discussion at the meeting September 29th was "New Trends in Biology and the Biological Science Program."

Winter Park: We had a phone call from Dr. Paul A. Vestal, Director of the Visiting Scientists Program, who reports that the request for speakers is coming in at a gratifying rate. They can arrange for a total of 135 talks out of funds provided by the National Science Foundation. Since that is the limiting number, the program is being conducted on a first come, first served basis. High school teachers are requested to get their applications in for speakers as soon as they can arrange a date.

Coral Gables: From President Alfred P. Mills we learn that Dr. George K. Reid has resigned as Chairman of the Conservation Section. He has agreed to continue to serve as a member of the committee. Dr. O. E. Frye, Jr., has agreed to serve as Chairman of both the Section and Committee. The name of Dr. Paul A. Vestal has been added to the Conservation Committee.

Additions to other committees announced are Virgil G. Sleight—Registration (Univ. of Miami) and Claude F. Carter—Audio-Visual Aids (Univ. of Miami).

Washington: Nobel Laureate Joshua Lederberg and Carl Sagan, writing in the September Proceedings of the National Academy of Sciences, propose some interesting interpretations of observed cloud effects and changes on the Martian surface. By their interpretations, the various spots on the surface of Mars might be favorable for life forms to survive and proliferate. They propose specific tests and observations on future space probes of Mars. The studies by Lederberg and Sagan have been supported by the National Aeronautics and Space Administration.

Winter Park: The Science Division of Rollins College was one of the recipients of the Undergraduate Instructional Equipment Grants from the National Science Foundation for $23,160. This was matched with $25,000 from Rollins College to be expended for the equipment and instrumentation needed to modernize the biology offerings to give them a more physiological-biochemical orientation.

The Department of Chemistry at Rollins College has received a grant in the amount of $2,911 from the Atomic Energy Commission for the purchase of equipment in nuclear technology.

Secretary, Dr. James B. Lackey, has furnished the following additional names to our membership list:

Binger, Robert D.
State Dept. Ed.
Tallahassee ST

Clinton, James H.
Chipola Jr. College
Chipola B

Funderburg, John B. Jr.
Florida Southern
Lakeland B

Hazlett, William I.
18610 N.W. 8th Court,
Miami M

Hocutt, Max
Univ. of South Fla.
Tampa S

Krivanck, Jerome O.
Univ. of South Fla.
Tampa B

Maybury, P. Calvin
Univ. of South Fla.
Tampa P

Reuning, Ernest G.
Univ. of South Fla.
Tampa P

Webster, W. C.
Box 211 Gonzalez,
Fla. B

Weise, Gilbert N.
8601 Emerald Isle Circle
N. Jacksonville B

Wright, Peter C.
Univ. of South Fla.
Tampa S

Winthrop, Henry
Univ. of South Fla.
Tampa S

The following list of applications for membership and check for dues was reported by Dr. Margaret Gilbert, from Florida Southern College:

Lott, J. R.
Florida Southern
Lakeland S

Luce, Samuel W.
Florida Southern
Lakeland P

Lyle, William R.
Florida Southern
Lakeland P

Arnolds-Patron, Paul
Florida Southern
Lakeland S

W. E. Wegner
Chemistry Department
Florida Southern College
Lakeland, Florida

Notice to all schools: Please funish this office the name, department and address of each of your new staff members so they may be published in the next issue of the Journal.

FLORIDA ACADEMY OF SCIENCE

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(As usually written, Dr., M., Miss, Prof., etc.)

Mailing Address ....

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....

Type of membership:

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....	Life	100.00
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....	Contributing . . .	7.50
....	Regular	5.00
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.... Biological Sciences
.... Medical Sciences
.... Physical Sciences
.... Social Sciences
.... Science Teaching
.... Conservation

PERSONAL RECORD

Colleges and Schools attended

Name	Location	Dates	Degrees

Scientific and Learned Societies, Fraternities, Academic and Scientific Record: (attach additional sheet as needed)

....

Date .... Signature of Applicant ....

Sponsor ....

Rec'd by Sec.-Tres. .... Council Action ....

* Undergraduate. 50¢ goes to the Senior Academy Treasury
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The above is a reproduction of membership application. Fill out this form and send it with appropriate fee to Dr. John S. Ross, Treasurer, F.A.S. Rollins College, Winter Park, Florida.

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1 page	8.00	7.00

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ILLUSTRATIONS.—Photographs should be glossy prints of good contrast. All drawings should be made with India ink; plan linework and lettering for at least ½ reduction. Do not mark on the back of any photographs. Do not use typewritten legends on the face of drawings. Legends for charts, drawings, photographs, etc., should be provided on separate sheets.

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Quarterly Journal
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Florida Academy
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VOL. 25 SEPTEMBER, 1962 No. 3

NOTES ON *CAMPANULARIA MARGINATA* (ALLMAN, 1877) AS A STINGING HIDROID.[1]

LAWRENCE R. PENNER
University of Connecticut, Storrs

While our knowledge of the hydroids as a whole is incomplete, it has been generally accepted that most are harmless to man. However, a number of species have been implicated as dermatitis producers. These include *Lytocarpus philippinus* (Kirchenpauer, 1872), a large bushy plumularian which is a known stinger found in shallow waters along the coast of Florida. Phillips and Brady (1953) reported it to inflict a painful sting on contact with the skin. Chu and Cutress (1955) reported hydroid dermatitis in Hawaii caused by free-floating parts of *Syncoryne mirabilis* (Agassiz, 1862) of variable severity persisting not more than three weeks, with purple scarring in some cases. Another widely distributed hydroid, common in Florida waters, *Pennaria tiarella* (Ayres, 1854) was reported by Hutton (1952) to cause dermatitis when tried on human subjects.

On June 28, 1955, fresh hydroid colonies were collected from pilings at the municipal pier in Key West, Florida, by Mr. G. S. Maxwell at depths up to 15 feet. As Mr. Maxwell was stung by something while collecting the colonies, experimental application of these fresh hydroids was made only on my forearm and on that of Mr. Alvin Wagner's. We both experienced a prickling sensation and reddening of the exposed areas. Although Mr. Maxwell's exposures had proceeded from large white hive-like wheals which turned red, to marked edema and reddening, no such response ap-

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[1] Contribution from the Cape Haze Marine Laboratory, the Archbold Biological Station and the Department of Zoology and Entomology, University of Connecticut. Aided in part by Grant E-740 from the National Institutes of Health.

peared on our arms. Within two hours Mr. Wagner and I noted fine papular eruptions which became much more pronounced in 9 to 10 hours. Itching developed in intensity and alcohol was rubbed on the areas without much relief. The dermatitis on Mr. Wagner's arm was more than twice as severe as that on mine. Lesions disappeared in three weeks but the site of each papule could be determined by a purple blemish for several weeks following the exposures.

Specimens from this collection have been identified as *Campanularia marginata* (Allman, 1877) by Dr. Edward S. Deevey of Yale University, who at the same time suggested the possibility that the poison from *C. marginata* might be something besides the usual coelenterate poison, inducing dermatitis in allergic individuals only.

Again at the Key West municipal pier on August 3, 1957, I observed considerable dermatitis on the back and sparse dermatitis elsewhere on an adult male lobster fisherman who had been collecting lobsters the previous night around the pilings. He reported experiencing dermatitis annually coinciding with the opening of the lobster season.

Inasmuch as both *C. marginata* and *Lytocarpus philippinus* were present in the area, either or both could have been responsible for his dermatitis. Therefore, both species were collected and applied independently to the arms of two 13 year old males. Only slight irritation and dermatitis occurred on both volunteers from both species.

A small colony of *Lytocarpus* was brushed gently across the left wrist of Mr. G. S. Maxwell. This elicited an immediate and strong white reaction with numerous hive-like wheals measuring over 1 cm in diameter appearing. These lasted about 30 minutes, subsiding to reddening with edema and inflammation spreading to peripheral areas. Following this, similar results were obtained when another small colony was brushed across the right wrist. Almost no reddening or dermatitis remained an hour later. For comparative purposes, *Campanularia marginata* was brushed across his upper forearm. No white reaction occurred; however, redness and definite lesions with itching continued for nearly 12 hours before subsiding.

Lytocarpus produced inflammation and resultant itching on my left forearm for about 12 hours, followed by an itchy papular dermatitis lasting nearly a week. *Campanularia*, however, when applied to my right forearm, produced a marked reddening and a more severe dermatitis lasting nearly three weeks.

All individuals exposed experimentally to *C. marginata* (more than 7) have developed variable degrees of dermatitis.

Acknowledgments

Appreciation is expressed to Dr. Edward S. Deevey for his identification of *Campanularia marginata* and to Messrs. G. S. Maxwell, Alvin Wagner, and a number of volunteers for technical assistance.

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PROTOZOAN INQUILINES FROM FLORIDA REPTILES. III. *RIGIDOMASTIX SCINCORUM* N. SP.; *CERCOBODO STILOSOMORUM* N. SP.; AND *CRYPTOBIA GECCORUM* N. SP.

EUGENE C. BOVEE AND SAM R. TELFORD, JR.[1]
University of Florida

A study of protozoan inquilines from reptiles in Florida not previously examined has revealed a number of new species. Some of these have already been described in an earlier paper (Bovee and Telford, 1962).

We here describe and depict three more species: (1) an ameboflagellate of the genus *Rigidomastix* from the endemic Florida sand skink, *Neoseps reynoldsi* Stejneger. (2) An ameboflagellate of the genus *Cercobodo* from the short-tailed snake, *Stilosoma extenuatum arenicolor* Highton. (3) A flagellate of the genus *Cryptobia* from the reef gecko, *Sphaerodactylus notatus* Baird.

MATERIALS AND METHODS

Fecal samples were taken from reptiles by methods previously discussed (Bovee and Telford *loc. cit.*). Included were: Eleven *N. reynoldsi* from sandy mounds of Polk County, Florida; two newly captured adult *Stilosoma e. arenicolor,* one from Citrus County, the other from Hillsborough County, Florida; and five adult S. *notatus* from Miami, Florida.

Each fecal sample was placed in a separate Stender dish with 15 ml of Trager's (1934) solution A. The *Rigidomastix* were found after 48 hours in material from stomach and intestine of an *N. reynoldsi* from Winter Haven, Florida; and in a sample from one from Lake County, Florida. The *Cercobodo* were seen, after 48 hours, in a sample from the *Stilosoma e. arenicolor* from Hillsborough County, and after 160 hours in the sample from the snake from Citrus County. One of the five S. *notatus* had numerous *Cryptobia.*

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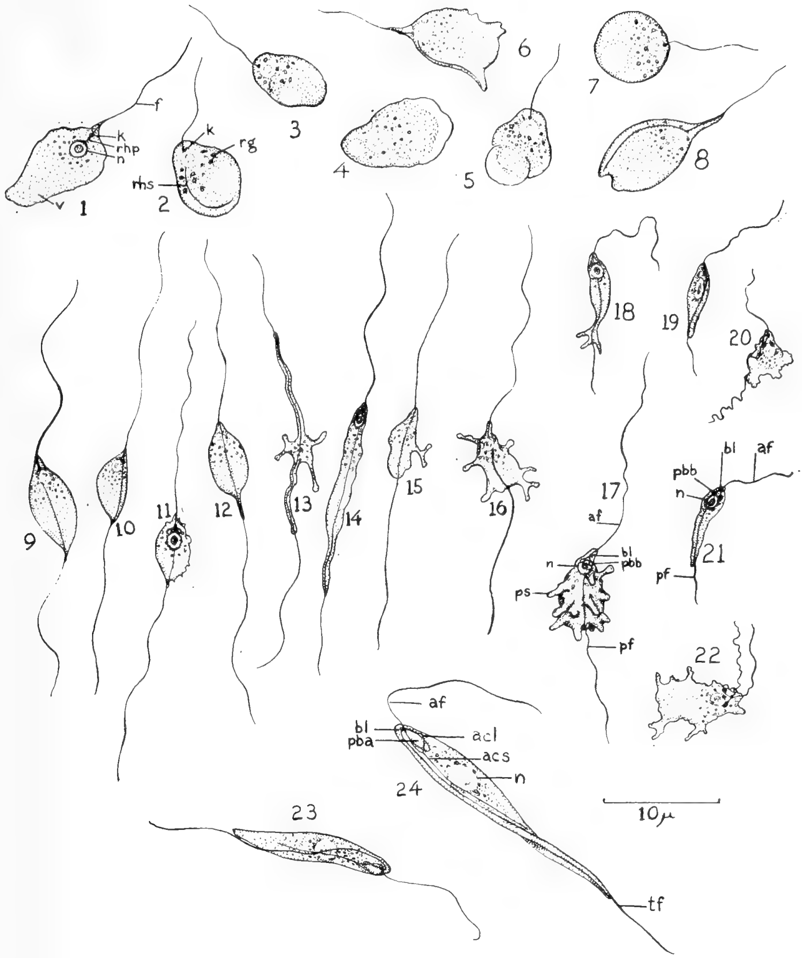
[1] Present address: Zoology Department, University of California, Los Angeles, California.



Figs. 1-8. *Rigidomastix scincorum* n. sp.

Fig. 1. Ameboflagellate form. Fig. 2. Flagellated, with a rhizostyle. Fig. 3. An ovate flagellate. Fig. 4. Completely ameboid. Fig. 5. A pyriform flagellate with a large vacuole. Fig. 6. An ameboflagellate. Fig. 7. A spherical flagellate without a rhizostyle. Fig. 8. Another ameboflagellate with a rhizostyle. *f* - flagellum; *k* - kinetosome of flagellum; *rhp* - rhizoplast from flagellum to nucleus; *rhs* - rhizostyle; *n* - nucleus; *v* - vacuole; *rg* - refractile granule.

Figs. 9 - 22. *Cercobodo stilosomorum* n. sp.

Figs. 9, 10, 11, 12. Flagellates, drawn from live specimens. Figs. 13, 14, 15, 16, 17. Ameboflagellates, also from live specimens. Figs. 18, 19, 21. Flagellates, fixed and stained. Figs. 20, 22. Ameboflagellates, fixed and stained. *af* - anterior flagellum; *bl* - blepharoplast; *pbb* - parabasal body; *n* - nucleus; *pf* - posterior flagellum.

Figs. 23 - 24. *Cryptobia geccorum* n. sp.

Fig. 23. A small one, shaped like a slightly twisted spindle. Fig. 24. A large somewhat flattened individual. *af* - anterior flagellum; *acl* - acicular loop; *acs* - acicular shaft; *bl* - blepharoplast; *pba* - parabasal apparatus; *n*-nucleus; *tf* - trailing flagellum.

The organisms all were observed alive by brightfield, phase contrast and interferometric microscopy at 100 x to 1000 x. They were then fixed in 4% formalin and air dried to coverslips, and were observed unstained by phase contrast and interferometric microscopy. Then they were lightly stained in modified Gomori's hematoxylin (Melander and Wingstrand, 1953) and counterstained with eosin, and observed by brightfield. Measurements were made at 400 x, 430 x, 970 x and 1000 x with calibrated ocular micrometers.

Rigidomastix scincorum n. sp.

Morphology of the Protozoan: *Size and Shape*: The organism has five forms: (a) oval, slightly pyriform and flagellated, 7.2—9.7 μ long and 5.5—7.2 μ broad (Figs. 2, 5); (b) spherical and flagellated, 6—8 μ diameter, averaging 6.8 μ (Fig. 7); (c) ameboflagellated, generally ovate, but irregular at the rear, and pointed at the flagellar end, 9—10 μ long, 6—7 μ broad (Figs. 6, 8); (d) ameboflagellated, whole body ameboid, 10—12 μ long, and 6—8 μ broad near the anterior, flagellum bearing end, tapering irregularly to 2.5—3 μ broad at the blunt rear end (Fig. 1); (e) completely ameboid, resembling a very small dientamoeba, 9—12 μ long in locomotion, 6—8 μ broad at the advancing end, and about 2.5—3 μ broad at the rear end (Fig. 4).

Inclusions: *The Nucleus*: This is 1.7—1.9 μ diameter with a refractile endosome 0.75—0.9 μ diameter. The nucleus of the flagellated organism is anterior, attached to the kinetosome of the flagellum by a short rhizoplast (Fig. 1). In ovate and spherical flagellated individuals, the kinetosome of the flagellum is next to the nucleus (Fig. 2).

Vacuoles: A clearly defined spherical vacuole is near the rear end, 2—3.6 μ diameter. If it be a contractile vacuole, its cycle of formation and expulsion is extremely slow, and was not observed. No other vacuoles were seen.

Rhizostyle: A slender, curved, acicular fibril attached to the flagellar kinetosome is present in some of the ovate and semi-ameboid organisms, but was not seen in most. It is extremely delicate, about ¾ as long as the body, barely resolvable in live organisms, and seen clearly only by phase microscopy in fixed but unstained organisms. It was not seen in the ameboid forms nor the spherical forms of the protozoan. (Figs. 2, 6, 8).

Crystals and Granules: A number of crystalloid, highly refractile granules are usually located near the nucleus. They are 0.3—0.6 μ diameter. Others, scarcely resolvable, generally distributed, are also present (Figs. 2, 7).

Flagellum: This is anterior, with kinetosome adjacent to the nucleus, or very near it, and attached to the nucleus by a slender rhizoplast (Fig. 1). The flagellum is very slender and slightly longer than the body, 8—10 μ. It is 0.4 μ diameter at its base tapering to a tip which is barely resolvable, less than 0.2 μ in the live organism. The flagellum beats rapidly and vigorously, but it is not used as a swimming organelle.

Discussion: This ameboflagellate appears to be midway in morphology between *Rhizomastix gracilis* (MacKinnon, 1914) and *Rigidomastix coprocola* (Alexieff, 1929). It also resembles the *Histomonas meleagridis* figured by Bishop (1938), but is only about half the diameter of that organism. Dobell (1940) reported that *Dientamoeba fragilis* has a similar flagellated stage, as well as an ameboid form. The fully ameboid form of this ameboflagellate resembles the figures of the ameboid form of *Dientamoeba fragilis* (Dobell, *loc. cit.*), but is smaller.

Alexeiff (1929) established the genus *Rigidomastix* to include the ameboflagellate *R. coprocola,* found in horse manure. Apparently none other than Alexeiff has since reported it, nor any other protozoan assignable to the genus. Neither genus nor species is generally recognized. Protozoology texts usually ignore it (Grell, 1956; Hall, 1953; Jahn and Jahn, 1949; Kudo, 1954; Reichenow, 1952). Grassé (1953) mentions the organism, calling it a flagellate of uncertain status, perhaps a colorless chrysomonad.

The protozoan cannot be placed taxonomically with accuracy. We assign it to the genus *Rigidomastix* because it is a coprophile, has several forms, ameboid and flagellate, and it more nearly resembles *R. coprocola* Alexeiff than it does any other protozoan we have found described in the literature.

Its affinities above the generic level are so indefinite we believe it presently best to adhere to Grassé's (1953) assignment of it as a flagellate of uncertain status. We do not agree, however, with Grassé's (*loc. cit.*) question-marked statement that *Rigidomastix* spp. may be colorless chrysomonads. They are ameboflagellates, wherever those may be considered to reside, taxonomically.

Cercobodo stilosomorum n. sp.

Morphology: *Size and Shape*: Alive, this protozoan is ovate, tapering abruptly to an acute tip at either end, the anterior tip being slightly rounded at the apex, the posterior tip pointed. It is 6—8.5 μ long, and 2.5—3.5 μ broad (Figs. 9-12). It takes this ovate form when swimming, which it does infrequently, or when creeping on a surface, its usual mode of progress. The body is very ameboid and metabolic, and may briefly become elongate, 15 μ long by slightly more than 0.1 μ broad (Figs. 14, 21). It forms pseudopods, 0.5—3.0 μ long, digitate in form, slightly tapered from base to tip, 0.4—0.5 μ diameter at the bases, and 0.25—0.3 μ diameter at the tips. When these tips touch the substrate they flatten and broaden, ovate to disc-like, about 0.5 μ diameter. Pseudopods are usually single; but two, and sometimes three, may extend from a common basal "stalk" (Figs. 13, 16, 18). Pseudopods may also be sent out along and surrounding the two flagella to lengths of 1—10 μ (Figs. 13, 14), being 0.5 μ or less in breadth. When disturbed, the organism releases its pseudopods from attachment to the substrate and swims, slowly retracting them (Fig. 17).

The Flagella: Two are present. One is anterior, beating above or ahead of the body; the other trails, usually under the body as it moves. Each is about 18—20 μ long in the live animal. The anterior one is 0.45 μ diameter at its base, tapering to a barely resolvable tip, less than 0.2 μ diameter. When fixed and stained the flagella either contract, or the tips break off, and they measure about 0.5 μ diameter and 6—12 μ long. Both arise from a kinetosomal complex at the anterior end.

Inclusions: *The Parabasal Complex*: There are two parabasal bodies, nearly spherical, or short rods with rounded ends. These rest against the nucleus. Each is attached to the kinetosomal complex ("blepharoplast") of the flagella. In fixed organisms the nucleus appears to be attached to the blepharoplast by a rhizoplastic fibril of fibrils. The parabasal bodies are about 0.5 μ long and 0.35—0.45 μ broad. Fibrils which attach them to the blepharoplast are barely resolvable.

The Nucleus: This organelle is anterior, just behind the parabasal bodies and blepharoplast, to which it is attached. It is broadly ovate, nearly spherical, somewhat elastically plastic 1.25—

1.5 μ diameter, with a nucleolar, central endosome 0.5—0.75 μ diameter.

Refractile bodies: Some 15—20 amorphous, perhaps crystalline bodies are present in the anterior third of the body, near the nucleus. Each is 0.3—0.5 μ diameter. Many other tiny granules, too small to be resolved clearly, give the cytoplasm a hazy appearance under phase microscopy.

Vacuoles: None were seen.

Movement and Locomotion: The organism changed form swiftly, from that in Fig. 9 to that of Fig. 12 in three seconds; to that form in Fig. 13 in the next seven seconds; to that in Fig. 14 in another five seconds; to that of Fig. 15 in still another five seconds; then to the form of Fig. 16 in the succeeding twelve seconds. It remained mastigamebid (Fig. 16) for several minutes, was disturbed and swam off, retracting pseudopods. Its non-locomotive movements are very actively ameboid. Locomotion is mainly by the action of the anterior flagellum. As it swims, that flagellum beats at about an angle of 40° to the directional path of progress, the body gyrating in an erratic spiral around the path of advance. The flagellate moves 10—15 μ per second. Swimming is rare, however. The protozoan usually glides along the substrate, with the anterior flagellum acting as a *tractellum,* similar to that of *Petalomonas* or *Peranema.* Only the most anterior ¼ of the flagellum is in motion. The other flagellum trails passively, except during a change of direction. Then it may whip sharply once or twice, swinging the body into a new direct orientation behind the anterior tractile flagellum. The pseudopods are not used in locomotion, and rarely are present when the animal is in progress.

Discussion: Most authors accept *Cercobodo* Krassilstschick as the genus for these semi-ameboid bodonids, assuming *Cercomonas* Dujardin to be a synonym (Hollande, 1953; Pascher and Lemmermann, 1914; Reichenow, 1953; Skuja, 1948). Others accept *Cercomonas* as the generic name (Kudo, 1954; Manwell, 1961). Still others consider both to be distinct and valid genera (Calkins, 1926; Hall, 1953; Jahn and Jahn, 1949). Either genus, when recognized is usually assigned to the family Bodonidae. Many species have been described (Pascher and Lemmermann, *loc. cit.;* Hollande, 1942, 1953; Skuja, 1948, 1956).

The general shape of the body of *C. stilosomorum* n. sp. resembles that of *C. crassicauda*; but *C. stilosomorum* is shorter and smaller, with proportionately longer flagella. The ameboid propensities of *C. stilosomorum* are equalled or exceeded only by *C. draco* Skuja, and *C. cometa* Hollande. *C. stilosomorum* also grossly resembles *C. heimi* Hollande, and has a paired parabasal apparatus similar to that of *C. heimi*, but differs in being more ameboid, and in having longer flagella than *C. heimi*.

C. stilosomorum was found only in the short-tailed snake, though we examined fecal material from over 200 snakes from a wide variety of locales, including 65 species. This rarity, and its presence only in this highly endemic snake further indicates the distinctness of *C. stilosomorum* as a species.

Cryptobia geccorum n. sp.

Morphology: *Size and Shape*: The body is a long slender spindle with about 190° of torsion, slightly to noticeably flattened, 15.2—23 μ long and 2.8—3.2 μ wide at the widest point (Figs. 23, 24). The blunt end of the spindle is the anterior flagellar pole of the body, and the acute end is the rear.

Flagella: two of these arise from the blunt end of the body and extend from the flagellar kinetosomes, which together form a blepharoplast 0.6 μ diameter. The flagella are very slender, 0.3 μ diameter at the bases, and scarcely resolvable at the tips. The anterior one is 12—15 μ long; and the other, apparently attached to the body surface and following the line of torsion along one edge, trails behind another half body length, being 25—30 μ long.

Inclusions: *The Parabasal Apparatus*: This is sausage-shaped in the live animal, 0.45 μ wide, and about 2.3 μ long; and it is attached to the blepharoplast. When stained it is ovate, slightly longer than broad.

The Aciculum: This is needle shaped, 0.3 μ diameter and 8—12 μ long. The posterior end is barely resolvable. The anterior "eye" of the needle is a loop, rounded at the base where it is attached to the blepharoplast and tapering so that its fibrils join at an acute angle to form the shaft of the aciculum. The open part of the loop is 0.45 μ at its widest, and is 0.8 μ long. The loop surrounds the blepharoplast.

The Nucleus: This is vesicular, broadly oval. Its broader aspect is 2.6 x 3.2 μ; and its narrower, 2.3 x 3.2 μ. In fixed specimens it is practically spherical, 3.3—3.5 μ diameter. It has a dark staining central nucleolar endosome which is approximately spherical, 1.0 μ diameter. The nucleus is located just forward of the center of the body.

Refractile Bodies: About 20 of these, 0.3—0.9 μ diameter are in the forward half of the body. A few are in the rear half. These appear similar to the neutral red stained bodies described in *Cryptobia helicis* by Kosloff (1948). Many smaller granules are visible in fixed and stained specimens.

Vacuoles: None were seen.

Striations and "Myonemes": These structures, reported by Belar (1916) for *C. helicis,* were not seen.

Discussion: The biflagellated protozoa of the genus *Cryptobia* Leidy are inquilines, perhaps parasitic, in the seminal vesicles of snails (Leidy, 1846; Collin, 1914; Fantham and Porter, 1910; Kosloff, 1948), and in the intestinal tracts of leeches (Hesse, 1910), planarians (Fantham and Porter, *loc. cit.*), marine fish (Elmhurst and Martin, 1910; Leger, 1905; Alexeiff, 1910, 1912) and chaetognaths (Hovasse, 1924). Other genera which are sometimes considered synonymous with *Cryptobia* (Hollande, 1953; Kudo, 1954), or distinct (Hall, 1953; Reichenow, 1952) include: (a) *Trypanoplasma* Laverin and Mesnil in the blood of freshwater fish (Laveran and Mesnil, 1910; Leger, 1904; Keysselitz, 1904; Minchin, 1909), with leeches as the vector (Leger, *loc. cit.*; Keysselitz, *loc. cit.*; Robertson, 1911); (b) *Trypanosomoides* Martin in the stomach of marine fish; and (c) *Trypanophysis* in siphonophores (Dubosque and Rose, 1926; Keysselitz, *loc. cit.*). Hollande (1953) also considers the free living genus, *Phanerobia* (Skuja, 1948) to be allied. There are also reports of *Cryptobia* spp. from a salamander (Rankin, 1937) and a frog (Walker, 1910).

C. geccorum n. sp. closely resembles *C. helicis* Leidy in general morphology and size, but the aciculum of the new species is longer, and the parabasal body is shorter and thicker than those structures in *C. helicis.*

No other reptile is reported to be host to *Cryptobia* spp. The reef gecko lives in a habitat well populated by other animals which do harbor *Cryptobia* spp.; *i. e.* a tropical hammock with many species of snails, leeches, fish and amphibians, and could very well have acquired its own cryptobian. Whether the protozoan is an obligate or facultative inquiline we cannot say.

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A CHECKLIST OF FLORIDA CRUCIFERAE

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The Family Cruciferae is a relatively unimportant segment of the flora of Florida. Most of the members are weedy introductions from Europe or the western U. S. The weedy nature of the family here presents some problems with the constant re-introduction of some species and the chance occurrence of others. The mustards are rather poorly collected in Florida. Few species are common and many that are to be expected do not appear in the state herbaria. The species, with few exceptions, are clear. A confusion of names both in the herbaria and the literature prompts a brief reconsideration of this family in Florida.

Material for this study was obtained from the three major state herbaria: Agricultural Experiment Station, University of Florida (FLAS), Florida State University (FSU) and the University of South Florida (USF). I should like to thank the curators, Dr. Dan Ward, Dr. Robert Godfrey and Dr. James Ray for the loan of their specimens. The following is a working list of Florida Cruciferae in these three herbaria to date. A list of specimen citations is available on request.

Key to Flowering Material

1. Flowers yellow 2
  2. Petals small, up to 5mm long 3
    3. Leaves simple, lanceolate; petals 3-5mm long; pubescence trifid .... *Erysimum cheiranthoides* (19)
    3. Leaves pinnate or pinnatifid 4
      4. Plants densely stellate pubescent; leaves pinnate .... *Descurainia pinnata* (20)
      4. Plants glabrous or with scattered simple pubescence 5
        5. Pedicels as thick as the ovary, appressed to the stem .... *Sisymbrium officinale* (18)
        5. Pedicels thin, diverging from the stem .... *Rorippa* 6
          6. Leaves bipinnatifid, the segments irregular .... *Rorippa walteri* (25)
          6. Leaves once-pinnatifid, often with rounded sinuses 7
            7. Pedicel short or lacking, less than half the length of the ovary, style short, flattened .... *Rorippa sessiliflora* (24)
            7. Pedicel longer than half the length of the ovary, style elongate .... *Rorippa islandica* (23)

2. Petals large, 6-15mm long .... *Brassica* 8
  8. Leaves not clasping .... *Brassica juncea* (15)
  8. Leaves clasping, auriculate at the base 9
    9. Inflorescence concave in outline, young buds below the open flowers, petals pale yellow, 12-16mm long .... *Brassica rapa* (17)
    9. Inflorescence convex in outline, young buds overtopping the open flowers, petals bright yellow; 6-11mm long .... *Brassica napus* (16)

1. Flowers white to pink or purple 10
  10. Plants aquatic 11
    11. Leaves dimorphic, basal ones pinnately dissected with linear segments, emersed leaves simple, entire or serrate .... *Armoracia aquatica* (21)
    11. Leaves all pinnate with rounded or oblong leaflets, margins entire .... *Nasturtium officinale* (22)
  10. Plants terrestrial 12
    12. Ovary transversely jointed; fleshy plants of the beach strand .... *Cakile* 13
      13. Leaves deeply dissected *Cakile lanceolata* var. *fusiformis* (11)
      13. Leaves nearly entire, serrate or crenate 14
        14. Inflorescence elongate, 10cm or more; leaves thin, lanceolate, entire or undulate .... *Cakile lanceolata* var. *lanceolata* (10)
        14. Inflorescence up to 8cm long; leaves fleshy, obovate or oblanceolate, crenate or serrate 15
          15. Beak pointed; ovary with four longitudinal ridges .... *Cakile edentula* (8)
          15. Beak truncate; ovary with eight longitudinal ridges .... *Cakile harperi* (9)
    12. Ovary not transversely jointed; non-fleshy plants of inland areas, if coastal then weedy 16
      16. Cauline leaves simple, margins entire, undulate or remotely toothed or incised 17
        17. Plants arising from a basal rosette 18
          18. Pubescence stellate; ovary oblong .... *Draba brachycarpa* (1)
          18. Pubescence simple or lacking; ovary triangular .... *Capsella* 19
            19. Petals 2-4mm long; sides of ovary straight or only slightly curved .... *Capsella bursa-pastoris* (5)
            19. Petals 1-1.5mm long; sides of ovary concave .... *Capsella rubella* (6)
        17. Plants not arising from a basal rosette 20
          20. Cauline leaves remotely toothed or incised; ovary circular, or nearly so, flattened or winged; weedy 21
            21. Plants densely villous .... *Lepidium campestre* (3)
            21. Plants glabrous or with scattered pubescence 22

22. Petals 1-2mm long; ovary one-seeded in each locule, pod not winged........ *Lepidium virginicum* (4)

22. Petals 3-4mm long; ovary 2-many seeded in each locule; pod broadly winged........ *Thlaspi arvense* (2)

20. Cauline leaves entire or undulate; ovary linear; not weedy........23

23. Flowers few in racemes; pods not stipitate; root tuberous with small nodules; moist meadows or bottomlands....*Cardamine bulbosa* (26)

23. Flowers numerous in globular heads; pods stipitate; root not tuberous; sandhill scrub........ *Warea* 24

24. Leaf blades rounded or auricled at the base, sessile or clasping, leaves ovate or ovate-lanceolate........*Warea sessilifolia* (32)

24. Leaf blades cuneate at the base, often petioled, leaves lanceolate, apex rounded........*Warea cuneifolia* (31)

16. Cauline leaves divided, dissected pinnate or pinnatifid........25

25. Leaves palmately divided into linear leaflets, these remotely toothed; root tuberous in fusiform segments........ *Dentaria laciniata* (30)

25. Leaves pinnate or pinnatifid; root normal or swollen but not in fusiform segments........26

26. Plants large, coarse, rough hispid; petals 15-20mm long, often dark veined........*Raphanus* 27

27. Petals whitish or pale yellowish with dark veins; ovary elongate, to 5mm broad, constricted around the seeds........ *Raphanus raphanistrum* (13)

27. Petals pale purple; ovary thick 6-10mm broad, not strongly constricted....*Raphanus sativus* (14)

26. Plants small, thin leaved; pubescence lacking or of fine hairs; petals 2-5mm long, not dark veined........28

28. Ovary rounded, each valve nearly spherical, wrinkled........*Coronopus didymus* (7)

28. Ovary linear, valves smooth........29

29. Leaves lyrate pinnatifid; stem hirsute at the base, plants stiff, much branched........ *Sibara virginica* (29)

29. Leaves pinnately divided........30

30. Plant glabrous, stiff, reddened at the base; leaves finely pinnately dissected with linear leaflets; usually in dry sandy areas..*Cardamine parviflora* (27)

30. Plants pubescent at the base, lax,

green throughout; leaves irregularly dissected nearly to the midrib, terminal segments obovate or orbicular; wet places, ditches, stream banks, meadows .... *Cardamine pensylvanica* (28)

Key to Fruiting Material

1\. Fruit transversely jointed, the upper and lower sections indehiscent; plants fleshy; of the beaches .... *Cakile* 2
  2\. Beak truncate, to 3mm broad; pod 8-ribbed; leaves mostly obovate; east coast from Brevard Co. northward .... *Cakile harperi* (9)
  2\. Beak acute, less than 1mm broad; pod 4-ribbed or ribs lacking 3
    3\. Leaves serrate or crenate but not deeply cleft or dissected 4
      4\. Upper joint of the fruit broadest above the base, curving to the apex; leaves fleshy, obovate, crenate; inflorescence to 8cm long .... *Cakile edentula* (8)
      4\. Upper joint of the fruit broadest at the base, straight tapering to the apex; leaves thin, oblanceolate to lanceolate; inflorescence 10 or more cm long .... *Cakile lanceolata* var. *lanceolata* (10)
    3\. Leaves deeply cleft or dissected; west coast only .... *Cakile lanceolata* var. *fusiformis* (11)

1\. Fruit indehiscent or jointed longitudinally; plants rarely fleshy; of inland areas 5
  5\. Fruit a silicle, less than 3x as long as broad, not linear 6
    6\. Pods flattened, at least partially, or broadly winged 7
      7\. Fruits triangular .... *Capsella* (8)
        8\. Margins of the pod straight or only slightly curved, top straight .... *Capsella bursa-pastoris* (5)
        8\. Margins of the pod definitely convex, apex cordate .... *Capsella rubella* (6)
      7\. Fruit circular or elliptical 9
        9\. Plants densely villous; pod only partially flattened, broadly winged elliptic .... *Lepidium campestre* (3)
        9\. Plants glabrous or with scattered pubescence; pod entirely flattened, circular 10
          10\. Fruits about 10mm in diameter, each locule many-seeded .... *Thlaspi arvense* (2)
          10\. Fruits about 3-4mm in diameter, each locule 1-seeded .... *Lepidium virginicum* (4)
    6\. Pods inflated or plump 11
      11\. Pods large, more than 12mm long, corky; plants rough, coarse, hispid .... *Raphanus sativus* (14)
      11\. Pods small, less than 5mm long, not corky 12
        12\. Plants aquatic with dimorphic leaves, the basal ones pinnately dissected with narrow linear segments .... *Armoracia aquatica* (21)
        12\. Plants terrestrial, leaves pinnately parted with irregular segments 13

13. Fruits thin-walled, plump with many tiny seeds .... *Rorippa islandica* (23)
13. Fruits thick-walled, each valve nearly spherical, 1-seeded .... *Coronopus didymus* (7)
5. Fruit a silique, linear, 5x or more longer than broad 14
14. Leaves simple, entire or nearly so 15
15. Root enlarged, bearing small nodules .... *Cardamine bulbosa* (26)
15. Root not enlarged with nodules 16
16. Plants stellate pubescent, fruits straight 17
17. Plants tall, 10dm or more; leaves petioled .... *Erysimum cheiranthoides* (19)
17. Plants small to 2dm; leaves sessile .... *Draba brachycarpa* (1)
16. Plants glabrous; fruits curving .... *Warea* 18
18. Leaves lanceolate, apex rounded. cuneate at the base .... *Warea cuneifolia* (31)
18. Leaves ovate or ovate-lanceolate, apex acute, rounded or auricled at the base .... *Warea sessilifolia* (32)
14. Leaves dissected, pinnate or pinnatifid 19
19. Leaves palmately divided into 4-7 linear segments; root tuberous in fusiform segments .... *Dentaria laciniata* (30)
19. Leaves simple or pinnatifid 20
20. Fruits 3 cm long or longer 21
21. Plants more or less hispid; fruits strongly constricted around the seeds .... *Raphanus raphanistrum* (13)
21. Plants glabrous or nearly so, often glaucous; fruits not constricted around the seeds .... *Brassica* 22
22. Leaves all clasping, auriculate at the base; fruit 4-8 plus cm long 23
23. Root thick and fleshy .... *Brassica napus* (16)
23. Root slender or only slightly swollen .... *Brassica rapa* (17)
22. Leaves petioled at least below, upper leaves lanceolate, entire; fruit 4-angled, 3-5cm long .... *Brassica juncea* (15)
20. Fruits up to 2.5cm long 24
24. Fruits closely appressed to the stem .... *Sisymbrium officinale* (18)
24. Fruits divaricately spreading 25
25. Plants densely stellate canescent; leaves very finely divided, with narrowly linear segments .... *Descurainia pinnata* (20)
25. Plants glabrous or pubescent below with simple hairs 26
26. Plants aquatic often forming floating mats; leaves pinnate, leaflets rounded or elliptic .... *Nasturtium officinale* (22)
26. Plants terrestrial; leaves pinnatifid, if pinnate the leaflets linear 27

27. Seeds in two irregular rows in each locule ...... *Rorippa* 28
  28. Pedicels short, 1mm or less; style short flattened; silique 5-12mm long .... *Rorippa sessiliflora* (24)
  28. Pedicels 2mm or more; style narrow about 1mm or more long 29
    29. Stems lax; leaves bipinnatifid with irregular segments; silique 8-14mm long .... *Rorippa walteri* (25)
    29. Stems stiff; leaves once pinnatifid with a large terminal segment; silique 4-9mm long .... *Rorippa islandica* (23)

27. Seeds in a single row in each locule 30
  30. Leaves lyrate pinnatifid; stem hirsute at the base, plants stiff, much branched .... *Sibara virginica* (29)
  30. Leaves pinnately divided 31
    31. Plants glabrous, stiff, reddened at the base; leaves finely pinnately dissected with linear leaflets; usually in dry sand .... *Cardamine parviflora* (27)
    31. Plants pubescent at the base, lax; green throughout; leaves irregularly dissected nearly to the midrib, terminal segments obovate or orbicular; wet places, ditches, stream banks and meadows .... *Cardamine pensylvanica* (28)

1. *Draba brachycarpa* Nutt.

Occasional in dry sandy fields, collected only once in Florida in *Leon*[1]. Introduced.

2. *Thlaspi arvense* L. Pennywort

A weed of sandy waste places and roadsides. Reported from *Escambia, Leon, Palm Beach* and *Polk,* to be expected throughout. Introduced.

3. *Lepidium campestre* (L.) R. Br.

Reported only once, from *Washington* to be expected infrequently in waste places. Introduced.

4. *Lepidium virginicum* L. Poor Man's Pepper, Pepper Grass

The most common of the Florida mustards, reported from 36 counties, to be expected in all. The closely related *L. densiflorum* apparently has not been collected here but is to be infrequently expected. Introduced.

5. *Capsella bursa-pastoris* (L.) Medic. Shepard's Purse.

Very common, collected in only 5 counties, *Alachua, Jackson, Jefferson, Leon* and *Santa Rosa,* but undoubtedly occurs in all populated areas. Introduced.

6. *Capsella rubella* Reut.

Infrequent in waste places, has been reported from *Alachua, Escambia* and *Jackson* to be expected elsewhere. Introduced.

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[1] All italicized place names refer to counties.

7. *Coronopus didymus* (L.) Smith

A frequent weed of waste places near cities, reported from *Alachua, Escambia, Jackson, Leon, Walton* and *Washington.* Introduced.

8. *Cakile edentula* (Bigel.) Hook var. *edentula* Sea Rocket

Common on the beach strand north of the Carolinas but here largely replaced by *C. harperi.* Infrequent on disturbed beaches of both coasts. Reported from *Indian River, St. Johns, Santa Rosa, Volusia* and *Wakulla.*

9. *Cakile harperi* Small

Frequent on the upper beaches of our northeastern coast. Easily distinguished by the 8-ribbed fruit with a broad beak and the nearly flat articulation between the two joints. Reported from *Flagler, St. Johns* and *Volusia,* not to be expected south of *Brevard.*

10. *Cakile lanceolata* (Willd.) O. E. Schulz var. *lanceolata*

Native to the West Indies and frequent on our southeastern coast from *Brevard* to *Monroe* counties, replacing *C. harperi.* Reported from *Brevard, Dade, Martin, Monroe, Palm Beach* and *Volusia.*

11. *Cakile lanceolata* (Willd.) O. E. Schulz var. *fusiformis* (Greene) Patman

This variety ranges around the Gulf of Mexico from the Florida Keys to the Mississippi Delta and is the common sea rocket of our west coast, identified by the pinnately dissected leaves. Reported from *Bay, Collier, Escambia, Franklin, Lee, Manatee, Monroe, Pinellas, Sarasota* and *Wakulla.*

12. *Cakile lanceolata* (Willd.) O. E. Schulz var. *lanceolata x* var. *fusiformis*

Endemic, limited to the area from Biscayne Bay to Key West in *Dade* and *Monroe* counties. This hybrid of the previous two varieties occurs where their range overlap and demonstrates many intermediate characters.

13. *Raphanus raphanistrum* L. Jointed Charlock

A coarse weed frequent in sandy waste places. Reported from *Jefferson, Leon, Levy, Madison, Putnam, Sarasota* and *Union.* Introduced.

14. *Raphanus sativus* L. Radish

An escape from gardens, often found in old wet fields or along roadside ditches. Reported from *Alachua* and *Leon.* Introduced.

15. *Brassica juncea* (L.) Cosson

Noted once in cultivation, *Hillsborough.* To be expected as a grain contaminant, though infrequently. Introduced.

16. *Brassica napus* L. Turnip

Collected once in *Jackson.* Persistent after cultivation. To be expected infrequently. Introduced.

17. *Brassica rapa* L. Navette

An occasional weed of waste places, often a grain contaminant. Collected once in *Sarasota.* Introduced.

18. *Sisymbrium officinale* (L.) Scop. var. *leiocarpum* DC

A weed of fields, farmyards and roadsides. Collected to date only once from *Leon.* To be expected infrequently throughout. Introduced.

19. *Erysimum cheiranthoides* L. Wormseed Mustard

A western introduction, collected only once in *Dade.* To be expected infrequently in waste places. Introduced.

20. *Descurainia pinnata* (Walt.) Britt var. *pinnata*

A common weed of sandy waste places, particularly farmyards and old fields. Specimens from *Alachua, Brevard, Columbia, Dixie, Duval, Franklin, Hernando, Lake, Nassau, Putnam, Seminole, Suwanee* and *Volusia.* Introduced.

21. *Armoracia aquatica* (Eat.) Wieg.

Aquatic of cool streams. Collected twice, both *Jackson.* Mariana State Park. To be expected in the rivers of the northern part of the state.

22. *Nasturtium officinale* R. Br. Watercress

Floating aquatic often forming dense mats in quiet moving waters. Frequent throughout the state, *Alachua, Citrus, Clay, Collier, Columbia, Dade, Duval, Holmes, Jefferson, Manatee, Sarasota, Sumter, Tyler, Volusia* and *Wakulla.* Naturalized.

23. *Rorippa islandica* (Oeder.) Borbas var. *fernaldiana* Butters and Abbe

Plants of bottomlands and banks of streams. Collected only once in *Leon.* To be expected frequently in the northern part of the state. This is the glabrous variety, var. *hispida* has not been noted in Florida.

24. *Rorippa sessiliflora* (Nutt.) Hitch.

An inconspicuous plant of sandy banks of rivers and streams. Collected once in *Jackson.*

25. *Rorippa walteri* (Ell.) Mohr. = (*R. tanacetifolia*)

Frequent in moist, sandy flats, stream banks and roadside ditches throughout, *Duval, Hernando, Hillsborough, Leon, Levy, Orange, Palm Beach, Polk, Sarasota, Taylor* and *Wakulla.*

26. *Cardamine bulbosa* (Schreb.) BSP Spring Cress

Occasional in moist shaded situations in bottomland woods, often growing in clumps. Reported from *Alachua, Gadsden, Hillsborough, Jackson, Levy* and *Liberty.*

27. *Cardamine parviflora* L. var. *arenicola* (Britt.) O. E. Schulz

Infrequent in dry, sandy fields. May be confused with the following and with *Sibara.* The plants are usually very small, to 2 dm and have few leaves, finely pinnately dissected, the segments to 1 mm broad, the stems are glabrous and reddened at the base. Collected in *Leon* and *Jackson.*

28. *Cardamine pensylvanica* Muhl.

A common and highly variable species, mostly of moist situations; stream banks, meadows and ditches. Under more xeric conditions it resembles *C. parviflora* but may be distinguished by the pubescence at the base. From *Alachua, Baker, Calhoun, Dade, Gadsden, Hillsborough, Jackson, Jefferson, Leon, Liberty* and *Taylor*. *Cardamine curvisiliqua* Shuttlw. listed as a Florida endemic is undoubtedly a minor variant of this species.

29. *Sibara virginica* (L.) Rollins

Similar to Cardamine, low, much branched, leaves lyrate-pinnatifid, segments 2-5 mm broad; stem hirsute below. Of dry sandy places, open woods, fields and sandy flats. Infrequent. Collected in *Leon* only but to be expected elsewhere.

30. *Dentaria laciniata* Muhl. Toothwort

Spring ephemeral, common in low moist riverbottom woods in the northern part of the state. Collected to date only in *Gadsden*. To be expected elsewhere.

31. *Warea cuneifolia* (Muhl.) Nutt. = (*W. carteri*)

Infrequent in sandhill scrub throughout the state, *Dade, Gadsden, Glades, Highlands, Liberty* and *Polk*.

32. *Warea sessilifolia* Nash = (*W. amplexifolia*)

Infrequent in sandhill scrub, having a disjunct distribution in Florida from *Lake, Orange* and *Polk* counties in the central portion to *Calhoun, Escambia, Leon, Liberty, Okaloosa* and *Walton* in the panhandle.

ORNAMENTALS

Erysimum asperum (Nutt.) DC "Wall Flower"
Iberis amara L. "Rocket Candytuft"
Iberis pectinata Boiss. "Fragrant Candytuft"
Iberis umbellata L. "Globe Candytuft"
Lobularia maritima (L.) Desv. "Sweet Alyssum"
Lunaria annua L. "Honesty"
Malcomia maritima R. Br. "Purple Rock Cress"
Matthiola incana (L.) R. Br. "Gilliflower"

OTHERS CULTIGENS

Brassica hirta (L.) Moench Table Mustard
Brassica napus L. Turnip
Brassica oleracea L. Cabbage
Erucastrum abyssinicum (Rich) Fries (For the oil of the seeds).
Raphanus sativus L. Radish

NEW INTERDISCIPLINARY METHODS AND MATERIALS FOR A PROGRAM OF GENERAL EDUCATION

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The intellectual objectives of general education are obviously wider than those of the interdisciplinary approach. An interdisciplinary approach, however, can serve the intellectual objectives even though not all of the objectives of general education are intellectual in nature. When I write of general education I have in mind the 11 objectives stated in the Report of the President's Commission on Higher Education (1948). These were:

> 1. To participate actively as an informed and responsible citizen in solving the social, economic, and political problems of one's community, state, and nation.
> 2. To recognize the interdependence of the different peoples of the world and one's personal responsibility for fostering international understanding and peace.
> 3. To understand the common phenomena in one's physical environment, to apply habits of scientific thought to both personal and civic problems, and to appreciate the implications of scientific discoveries for human welfare.
> 4. To understand the ideas of others and to express one's own effectively.
> 5. To choose a socially useful and personally satisfying vocation that will permit one to use to the full his particular interest and abilities.
> 6. To acquire and use the skills and habits involved in critical and constructive thinking.
> 7. To develop for the regulation of one's personal and civic life a code of behavior based on ethical principles consistent with democratic ideals.
> 8. To attain a satisfactory emotional and social adjustment.
> 9. To maintain and improve his own health and to cooperate actively and intelligently in solving community health problems.
> 10. To understand and enjoy literature, art, music, and other cultural activities as expressions of personal and social experience, and to participate to some extent in some form of creative activity.
> 11. To acquire the knowledge and attitudes basic to a satisfactory family life.

Among these eleven, the most important for purposes of the present paper, are numbers 1 through 6. However, when I use the phrase, "the interdisciplinary approach," I have in mind all those approaches to *educational content* which are concerned with the following broad objectives: (1) the reversal of disciplinary fragmentation both in education, pure research and in the broad solution of practical problems via applications of the findings of both the natural and social sciences; (2) the application of analytical and synthetic methods of organization which have been found to be legitimate and profitable for the achievement of intellectual synthesis; and (3) the *techniques of interpretation,* using this word in a *phenomenological sense,* which aim at amalgamating the findings from several disciplinary studies in order to show the global relevancy of these findings to the major social, psychological, cultural and educational issues of our time. The value of such interpretations has been emphasized in a recent paper by Wild (1961). It is in these senses of the phrase, "the interdisciplinary approach," that three techniques will be described here which are available for interdisciplinary synthesis and which may be useful in extending both the objectives and the philosophy of general education. Although my examples will be drawn from both the natural and the social science areas, I am particularly interested in the relevancy of the interdisciplinary approach for the behavioral and social sciences.

The General Systems Theory Approach. Specialization in education has resulted in the development of conceptual schemas in different traditional branches of the natural, behavioral and social science areas, together with a special terminology for each of these. Where the results of research are expressed mathematically we often find isomorphies among the conceptual structures developed within these broad areas. Several examples of the situation will be mentioned here.

Certain structural models, expressed in differential equations, are all very similar for certain phenomena in mathematical economics, chemical kinetics and the dynamics of biological populations as these have been worked out by Lotka (1956) and Volterra (1931). The following example of this type of isomorphy, with which I have chosen to illustrate this point, will not be found in these authors but nevertheless reflects clearly the considerations I have in mind. The example involves an isomorphy between a situation involving an antagonistic disjunction between animals, drawn from ecology, and a system possessing harmonic motion, drawn from physics. In certain areas of Canada lynx and rabbits are interlocked in an ecological balance in which the rabbits are the natural prey of the lynx and the variation in their respective numbers depends upon the departure from this balance. This is shown by the equations of Figure I in which the change with time in the rate of increase of lynx population, d^2L/dt^2, *is not constant.* The *form* of this equation is the same as that for the simple harmonic motion of a pendulum, in which the acceleration, a, is given by

$$a = -cx \qquad (1)$$

where the acceleration is proportional to the distance of the pendulum from some fixed point (the middle of the pendulum's path) and is always directed towards this point, where c is a constant and where x is the amount of displacement measured from the middle of the path. The analogous factors in this isomorphy are shown in Figure I.

EQUATIONS EXPRESSING THE ECOLOGICAL BALANCE BETWEEN LYNX AND RABBITS

(1) $\frac{dR}{dt} = -K_1 L$

(2) $\frac{dL}{dt} = K_2 R$

(3) $$\frac{d^2L}{dt^2} = \frac{d}{dt}\left(\frac{dL}{dt}\right) = \frac{d}{dt}(K_2 R) = K_2\frac{dR}{dt} = -K_1 K_2 L = -K_3 L$$

EQUATION FOR THE SIMPLE HARMONIC MOTION OF A PENDULUM

4. $a = -cx$

ANALOGUES

1. $\frac{d^2L}{dt^2}$ IS THE ANALOGUE OF a
2. K_3 IS THE ANALOGUE OF c
3. L IS THE ANALOGUE OF x

FIGURE I. DEMONSTRATION OF A DIFFERENTIAL EQUATION ISOMORPHY FROM TWO INDEPENDENT DISCIPLINARY AREAS.

In Figure I equations (3) and (4) express the fact that in each system, if an initial disturbance occurs, the system would continue in perpetual oscillation about a determinate state of equilibrium.

Other isomorphies exist which are equally interesting. One of these refers to some rather well known phenomena, namely, the utility-wealth function in economics and the Weber-Fechner law in psychology. Both of these can be described in terms of the *exponential function.* In investigating the utility of money, Daniel Bernoulli assumed that an increment of monetary gain possesses a utility proportional to this gain but inversely proportional to the amount of money possessed before the gain. A mathematical statement based upon this and some related assumptions, yields the finite difference expression.

$$\triangle U_k = c \frac{\triangle w_k}{w_k} \qquad (2), \qquad k = 0,1,2,\ldots,$$

in which $\triangle U_k = U_{k+1} - U_k$ is the increment of utility resulting from an increment $\triangle w_k = w_{k+1} - w_k$ of wealth. If we further assume that the amount of wealth needed to keep body and soul together is w_o (*the subsistence level of wealth*), then we can set $U_o = O$. If we now suppose that $U_k = kh$, where kh is k times a unit of utility, h, we then obtain

$$\triangle w_k = \frac{h}{c} w_k \qquad (3), \qquad k = 0,1,2, \ldots$$

whose solution is

$$w_k = \left(1 + \frac{h}{c}\right)^k w_o \qquad (4), \qquad k = 0,1,2, \ldots .$$

Now consider the relationship between the intensity of a stimulus and the magnitude of a sensation (or response) resulting from it. Fechner assumed that an increment in sensation, $\triangle R_k$, where R is the response (sensation) due to an increment $\triangle S_k$, in a stimulus, S, will be given by the finite difference expression

$$\triangle R_k = c \frac{\triangle S_k}{S_k} \qquad (5), \qquad k = 0,1,2, \ldots .$$

in which R_k denotes the magnitude of the response to a stimulus of intensity, S_k. If we assume that $\triangle R_k = h$ in the Weber-Fechner law, in which h, of course, is a unit in which sensations can be measured and discriminated, then the expression (5) becomes

$$\triangle S_k = \frac{h}{c} S_k \qquad (6)$$

thus yielding the solution

$$S_k = \left(1 + \frac{h}{c}\right)^k S_o \qquad (7)$$

where S_o is defined as the *threshold stimulus.*

Although the expressions for w_k and S_k are the finite difference analogues of the more traditional differential equations, we are more interested in the fact that the equations for these two variables are *structurally isomorphic,* although the phenomena to which they refer are of basic concern to two different disciplines in the behavioral-social science area, namely, economics and psychology. It is in the study of isomorphies of this nature that general education may find one new avenue along which to expand.

Many other phenomena of interest to different disciplines illustrate these interdisciplinary structural analogies. Models used in the epidemiology of insect or human vectors are very similar to those used in behavioral diffusion theory. It is noteworthy that similar feedback models can be applied to descriptions of physiological homeostasis, input-output flows in economics, communication in groups, animal ecology, adjustive behavioral sequences in learning theory and dozens of other phenomena of inquiry, too numerous to mention here. Models in the theory of the optimum size of social organization are similar to models of growth stability in biological organisms. Some of Rashevsky's (1947) models which study the *constructive* activities of the human species are isomorphic with some of Richardson's (1960) models which deal with the *destructive* activities of the human species, developed by him in his mathematical theory of war. Examples of such similarities could be extended endlessly for they exist between pairs of disciplines one member of which is invariably in the area of either the natural, behavioral or social sciences.

In order to avoid duplication of effort but even more importantly in order to find models of the widest applicability which shall be descriptive and predictive within many areas of specialized study, many scientists have started to work on what is now called *General Systems Theory.* Such generalized models, whether mathematical or not, are intended hopefully to apply to phenomena at various levels of observation, both macroscopic and microscopic in nature, ranging from physico-chemical phenomena through biological and psychological phenomena to social phenomena. This type of approach clearly enough calls for scientific generalists. In 1949 a paper was published by a group of scientists consisting of an engineer, a sociologist, a biologist and a mathematician, asking for the recognition that an education for scientific generalists was now in order. This paper, by Bode, Mosteller, Tukey and Winsor (1949), had this to say.

> "We often fear that 'one man can no longer cover a broad enough field' and that 'there is too much narrow specialization' . . . we need a simpler, more unified approach to scientific problems, we need men who practice science—not a particular science, in a word, we need scientific generalists."

These authors then went on to emphasize that generalists are needed for such fields as physical chemistry, biophysics, industrial chemistry, physics, mathematics and medicine. They declared

> "Any research group needs a generalist, whether it is an institutional group in a university or a foundation, or an industrial group . . . In an engineering group, the generalist would naturally be concerned with system problems. These problems arise whenever parts are made into a balanced whole."

Similar considerations, of course, apply to the behavioral and social science areas, and perhaps more forcefully. Nor was this group the first to suggest this need. Kahler (1957) has proposed an agency for the training of generalists, to be called the Institute for the Integration of Studies, which would have three main tasks: (1) clarification and co-ordination of fundamentals; (2) study of the convergences and correspondences in the findings of different disciplines, and evaluation of the findings of any one discipline with regard to their implications for other disciplines; and (3) the establishment, as a result of the types of study mentioned under (1) and (2), of what Murray (1949) has called "strategic hypotheses." These are hypotheses which are strategic not only in respect to the advancement of knowledge and theory, but in respect to the advancement of fellowship, social integration, and ideological synthesis. They aim at restoring a criterion of essentiality to scientific research.

The point in connection with all the preceding remarks is to emphasize the degree to which a General Systems Theory approach will serve the objectives of general education. We want our students to see life steadily and see it whole. We want them to understand the world about them in a broad-gauge fashion, without getting lost in a mass of detail which is of central concern to the specialist. A General Systems Theory approach for supporting the *intellectual* objectives of general education would be absorbable without too much difficulty, providing the following steps are taken. 1. Select models of the widest possible applicability from the existing literature. 2. Express these models in the simplest possible mathematical form, in terms of flow diagrams or pictorial representations, so that they may be understood by a majority of students who have had functional mathematics and some work in the natural or social sciences. 3. Employ such models in a capstone course required of all seniors or, at least, of all seniors in the natural and social sciences, making use of the relevant background to which these students have already been exposed. I suggest that these steps can be carried out on a practical basis and that the propaedeutic value of a General Systems approach, worked out for a general education program, could prove to be of real value in providing for the intellectual synthesis which knits together the fund of ideas from traditional disciplinary sources with which the undergraduate is already familiar.

The Unity of Science Approach. There is a second way of achieving intellectual unity for all the sciences and this is via some type of continuously available conceptual reductionism. Descriptions of the probable nature of such reductionism have been given by Hempel (1952), Brunswik (1939), Nagel (1961), Oppenheim and Putnam (1958), Pap (1949) and others. The use of this method involves the following considerations. There must be a feasible taxonomy of levels of disciplinary analysis in which one goes naturally from less complex to more complex organization among the entities being studied and these levels must be such that certain criteria of adequacy are satisfied. These criteria of adequacy, as stated by Oppenheim and Putnam, are:

> "(1) There must be several levels.
>
> (2) The number of levels must be finite.
>
> (3) There must be a unique lowest level (i.e., a unique 'beginner' under the relation 'potential micro-reducer'); this means that success at transforming all the potential micro-reductions connecting these branches into *actual* micro-reductions must, *ipso facto*, mean reduction to a single branch.
>
> (4) Any thing of any level except the lowest must possess a decomposition into things belonging to the next lower level. In this sense

> each level, will be as it were a 'common denominator' for the level immediately above it.
>
> (5) Nothing on any level should have a part on any higher level.
>
> (6) The levels must be selected in a way which is 'natural' and justifiable from the standpoint of present-day empirical science. In particular, the step from any one of our reductive levels to the next lower level must correspond to what is, scientifically speaking, a crucial step in the trend toward over-all physicalistic reduction." (p. 9)

These same authors suggest a particular taxonomy of levels for what they call "micro-education" and this taxonomy is shown in Figure II. Although the taxonomy of Figure II cuts across *all the sciences,* equally adequate, although dissimilar, taxonomies can be developed separately for each of the three great groups of disciplinary concerns, namely, the natural, behavioral and social science areas.

LEVEL NUMBER	LEVEL DESCRIPTION
6	SOCIAL GROUPS
5	(MULTICELLULAR) LIVING THINGS
4	CELLS
3	MOLECULES
2	ATOMS
1	ELEMENTARY PARTICLES

FIGURE II. AN EXAMPLE OF ONE TYPE OF TAXONOMY OF PHENOMENAL LEVELS FOR MICRO-REDUCTIVE PURPOSES

Examples of what has been called microreduction can be given at this point. Using the taxonomy of Figure II, a Level 6 phenomenon, the differential behavior of social castes among bees, has been tentatively explained by Bonner (1952) in terms of the Level 5 notion that there are secretions of so-called social hormones in bees. Here we account for the *aggregate* social phenomenon of caste among bees by introducing a variation in the elements which differentiate the castes, this variation being due to certain differences in biochemistry which characterize the *individual members* of these castes. Micro-reduction between these same two levels has been effected for other types of phenomena. Thus pecking order among domestic fowls has been explained by Guhl (1956) in terms of cellular hormone production. In economics many phenomena which are of an *aggregate* nature and which have traditionally been approached by statistical procedures, have in recent years been investigated in terms of the behavior of the individual subject and the psychological mechanisms known to be operating in such behavior. Two distinguished examples of this lie in the work of Siegel and Fouraker (1960) and of Davidson, Suppes and Siegel (1957). In sociology we are beginning to develop models of aggregate behavior by the use of simulation techniques which frequently make some very definite assumptions regarding individual motivation. Guetzkow (1962) has brought together a number of these which are concerned with such large-scale social phenomena as bureaucracy, international relations, human traffic flows, and various types of social processes.

Examples of micro-reductions from Level 5 to Level 4 are also fairly common. In neurology the behavior of the central nervous system as a whole, can be explained in terms of the mass effects of the behavior of individual neurons which are either firing or not firing. McCulloch and Pitts (1943), by postulating various connections between neurons of given nerve nets which possess specified geometrical or topological structure, find that these will account for the mass action of the CNS and for such psychological phenomena as memory, exact thinking, distinguishing similarity or dissimilarity of stimulus patterns, the capacity to abstract the "essential" components of a stimulus pattern, the capacity to recognize a variety of Gestalt patterns in spite of interfering, extraneous stimuli or "noise," and, in general, have found that these micro-reductions can explain so-called "purposeful behavior" as controlled by negative feedback, can explain adaptive behavior and can explain mental disorders. In fact this is the type of micro-reduction which Rashevsky and the Chicago School Of Mathematical Biophysics have made famous. Efforts to confirm such postulated nerve nets are taking place with promising results.

Efforts at micro-reduction from Levels 4 to 3 have also been successfully made. One example of this is furnished by Oppenheim and Putnam (*op. cit.*) from the field of genetics, namely, decoding, duplication and mutation of genetic information. As these authors put it.

> "Biologists have long had good evidence indicating that the genetic information in the cell's nucleus—acting as an 'inherited message'—exerts its control over cell biochemistry through the production of specific protein catalysts (enzymes) that mediate particular steps (reactions) in the chemical order that is the cell's life. The problem of 'decoding' the control information in the nucleus thus reduces to how the specific molecules that comprise it serve to specify the construction of specific protein catalysts. The problem of *duplication* (one aspect of the over-all problem of inheritance) reduces to how the molecules of genetic material can be copied like so many 'blueprints.' And the problem of *mutation* (elementary step in the evolution of new inheritable messages) reduces to how 'new' forms of the genetic molecules can arise." (pp. 20-1)

This last phenomenon, new forms of genetic messages, is what Mayr (1961) refers to as "evolutionary adaptation controlled by natural selection" whose difficulty of prediction provides a genuine but not insuperable difficulty for micro-reduction and the unity of science approach.

Micro-reductions from Level 3 to Level 2 are said to be exemplified in explanations of such phenomena as the high fluidity of water, the elasticity of rubber, the hardness of diamond while Level 2 to Level 1 micro-reductions occur in theories of valence and bondedness between atoms in chemistry.

We are, of course, more interested here in micro-reductions in the social and behavioral sciences. We have already referred to several such micro-reductions which tend to involve adjacent pairs of the first four levels. A further example of a Level 6 to Level 5 micro-reduction occurs in the ontogenetic explanations furnished by various studies of the growth of cooperative behavior in children (L_6) from originally egocentric behavior (L_5), presumably through changes in CNS development (L_5). Numerous studies on the autokinetic phenomenon also show group behavior as a function of individual behavior and judgments. Similar L_6 to L_5 micro-reductions have been described by Infield (1955) in the formation of intentional communities.

Now the point of this discussion on the reductive, unity of science approach is that it demonstrates, I believe, several values for *general education.* 1. It is clearly interdisciplinary. No micro-reduction is possible unless student and teacher are familiar with the relevant information and concepts on the two levels. 2. It serves to diminish the intellectual fragmentation and compartmentalization to which the student is usually exposed, by making him realize that there is a continuous funnel of explanation, that phenomena of one field are not necessarily outside the scope of a neighboring area and that phenomena in any one given area are complex instances of the phenomena in a cognate area. This provides a much needed intellectual synthesis. 3. The possibilities are clearly present for a continuous chain of micro-reductions from L_6 to L_1 *in principle,* while in actual fact they can be shown to stretch from L_6 to L_3 or L_2. Where efforts are made to find such chains, a sense of unity, intellectual synthesis and order, is conveyed to the student, particularly in the behavioral and social science areas. This tends to provide, I believe, for that broad understanding of his world and its social complexity, which eliminates the disjointedness of understanding which is so often the end product of the traditional educational approaches. The unity of science approach can be adapted to general education by carefully selecting micro-reductive material from the first three years of the undergraduate curriculum and introducing this approach in a capstone course of some sort in the senior year.

The Coordination Of Themes Approach. This approach to intellectual synthesis is exemplified by exploring an important theme or problem in one of two ways. We either (1) relate data from an unusual variety of disciplines to its solution, *some of which* are mistakenly thought not to be associated with the theme in question, or (2) we approach the theme by methods rarely, if ever, used to explore and integrate materials contributing to the theme, or we do both of these things. I should like to give several examples of what I have in mind.

The first example comes from the work of David McClelland (1961) of Harvard University. Originally by training McClelland is a psychologist who has specialized in personality theory and motivation. Even within these specialties he has shown a marked talent for intellectual synthesis, his book on personality being a conspicuous example of this. This interdisciplinary penchant is strongly encouraged within the Department Of Social Relations at Harvard, with which McClelland is affiliated. Recently he has branched out into research on the factors which make for economic growth in both advanced and underdeveloped countries. His particular aim has been to show that the thesis of the sociologist, Max Weber, namely, that capitalism is a devolpment fostered more by Protestantism than by Catholicism, can be heavily supported by current research. The objective of such research is to show that the *need for achievement* is directly related to economic development and that this psychological consideration goes further in explaining the status of economically advanced countries than standard and traditional economic explanations. In fact he has been able to show empirically that available economic, political and sociological data invalidate such orthodox explanation and invalidate them even when they come in diametrically opposed pairs of theories. In the process of doing this he has had to cover a vast interdisciplinary territory. He says of his book.

> "This book grew out of an attempt by a psychologist, trained in behavioral science methods, to isolate certain psychological factors and to demonstrate rigorously by quantitative methods that these factors are generally important in economic development. The scope of such an enterprise turned out to be truly alarming for one whose background in the social sciences was slight to begin with. It required specialized knowledge on everything from population problems, to coal imports in England from the 16th to the 19th century, to methods of computing rates of economic growth, to sources of children's books, to management practices in Russia, Italy and Mexico, to the pottery of Ancient Greece and Pre-Incan Peru. Let me confess at the outset (for it will be obvious soon enough) that I have not managed to become a real professional in many of these areas of knowledge, though I have had the advantage of much expert advice and assistance. The dilemma of the 'generalist' trying to acquire specialized knowledge in a hurry is nicely illustrated by what happened to me when I asked a colleague, an eminent Harvard historian, to recommend 'a' book to me that would bring me up to date on English history. I also mentioned that as a budding scientist in college, I had unfortunately managed to escape all courses in history, so that my mind was practically a 'tabula rasa' on the subject. He simply looked at me aghast, murmured 'my God!' and turned away. Perhaps the self-taught scholar deserves such a response—at any rate he sometimes gets it—and so may this book among specialists on particular topics it had to cover in the search for the broadest possible test of the hypothesis that a particular psychological factor—the need for Achievement—is responsible for economic growth and decline." (p. vii)

In the process of validating his thesis he has applied standard statistical methods to history, political science, archaeology, mythology and folklore, religious movements, international differences in management theories, the history of athletics and many other out of the way subjects. The manner in which he has adapted standard statistical methods as well as new experimental techniques to the confirmation of his major thesis—that the need for achievement is as strongly related to economic development as science and technology—is a *tour de force.* Even more importantly McClelland's work demonstrates beyond a shadow of a doubt that typical discursive methods in the humanistic disciplines are going to be largely replaced. Historiography, description, interpretation, deductive methods in economics, imputation of motives to extinct peoples, overimaginative constructions concerning the meaning of symbolism—all these bid fair to become obsolescent and efficiently displaced by what has come to be called "hard methodology." This was originally Clark Hull's (1943) expectation concerning the future of the *Geisteswissenschaften* but Hull looked forward to the mathematical model and learning theory as the conquerors, whereas in McClelland's actual work it is orthodox statistical analysis which is responsible for the takeover.

A second example of the coordination of themes is the work of Richard Meier (1956), originally a chemist, on the relationship between science and economic development. Meier's chief concern has been to deal with the interconnections between the natural and social sciences, with the end in view of finding solutions to some of our leading social and economic problems. Basically this author has sought to project into the future those possibilities for world economic development which are being shaped by recent advances in science and technology. In particular he has tried to formulate solutions for our Neo-Malthusian problems, solutions which are inherent in our current scientific and technical developments. He has tried to show how the strategies for economic development may have to change as a result of emerging technology which is not yet even incident to social and industrial life. Finally he has focused attention on the most economically feasible energy and resource transformation for given areas using current and emerging technologies. All of Meier's work has been done in highly quantitative fashion. Much of it has been done under the University Of Chicago's Program of Education and Research in Planning and a grant from the Cowles Commission.

In order to accomplish his objective Meier has had to exhibit incredible breadth. He has had to range over all the natural and social sciences in order to accomplish this. As he, himself, puts it

> "Thus the invasion of the social studies was carefully considered; it was intended to establish a continuity of analysis that overlaps the experience of social scientists. Only by such means (i.e., the penetration of each other's domain) can the various specialists communicate with each other in order to solve problems of society. The problems, of course, hardly ever respect academic boundaries; they have an economic aspect, a technical aspect, a cultural aspect, and many others, but the solutions require an interleaving and fusion so that the procedures, as employed, quickly lose their identity . . ." (p. viii)

Capping his extraordinary survey has been a treatment of 26 important problems of major significance for world development, which are being neglected because they are not central to the development of existing specialties. Meier knits together all these far-ranging concerns for world development by asserting that

> "One thread runs through all these rather specific areas for exploration. We need a theory of organization, a metric for structure and order, that is superior to anything available today. One feels that it should comprehend a system of categories, a system of levels, a definition of 'freedom to act,' entropy, communication theory, learning theory, and very likely others equally important. Such a theory, if it should ever be formulated, would greatly extend our knowledge-acquiring capacity." (p. 243)

Space does not allow any extended discussion of other interdisciplinary social science materials which reflect what I have called the coordination of themes. However, I do want to mention several more illustrations of such work and state briefly what they have tried to do. Brady (1961) has taken the theme of the scientific revolution in industry and tried to describe its impacts in all areas. To do this Brady has sifted an enormous amount of information from many fields, scouring the natural, social, management and industrial sciences for his material. He has summed up all his results in terms of four aspects of the scientific revolution in industry: the chemical revolution, altering the materials foundations of industry; the standards and specifications revolution, diversifying the criteria for selection of best methods, processes, and products; the automation revolution, changing the processing methods; and the revolution, currently primarily atomic, in the systems of energy supply. Fourastié (1960)[1], trained in political science, engineering and law, insurance and accounting, has produced work which offers a thorough economic and social analysis of our time. In his study of the causes of wealth we find that both the criteria which we have already mentioned for the coordination of themes, is satisfied. Fourastié's work not only shows an extraordinary interdisciplinary range together with new methods and theories for dealing with that range but we also find that at the same time he has created a new hybrid specialty on the borderline between economics and sociology. To illustrate and confirm his theories he has had to employ a wide variety of unusual facts. Among these are such items as the history of window glass based on the paintings of the old masters, the explanation of why silk stockings with runs are repaired in Paris but thrown away in New York, the statistics of sewer connections and the comparative history of barbershop prices. The work of Harrison Brown (1954), the geochemist, on man's future, pulling together data from demography, nutrition, mineral and energy resources, science and technology, oceanography and biology, sociology and economics, and many other areas, should be mentioned here, since the collation of this data was both creative and analytical rather than merely aggregative. Finally the classic interdisciplinary study of Huntington (1959) on the mainsprings of civilization, is apposite here. This classic brings together data from biology, genetics, ecology, anthropology, the history of human culture, climatology, nutrition, medicine, geography and sociology. These data were collated in order to explore their effects on population, religion, human leadership, crime, intellectual activity, cultural efficiency, temperament and conduct.

Obviously there is a substantial amount of work to which we cannot refer because of limitations of space, which reflects what I have called the coordination of themes. The importance of such interdisciplinary materials for general education lies in the possibility of giving a broad meaning to the fragmentary education to which the student has been exposed in its traditional forms. A capstone course, university-wide in nature, or restricted to the social or natural science majors, can make significant and interesting use of the

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[1] Since 1946, Fourastié has been economic advisor to the Commissariat Général of the Monnet Plan, the Modernization and Reconstruction Program which put the French economy on its feet after the war. He has also been president of the Monnet Plan's commission on manpower.

coordination of themes approach. The materials selected will determine the range of eligibility of seniors. Such a capstone course should aim at showing how the major issues and themes of our time can be understood by knitting together data from the numerous traditional disciplines. Such a capstone course lends itself most succinctly to this type of approach. It can clearly deal with more than one theme and give meaning to the specialized courses the senior student has been taking for three years. In this way the objectives of general education will be handsomely served.

The three methods described in the present paper are clearly not the only techniques for achieving intellectual synthesis via interdisciplinary approaches. Kahler, (*op. cit.,*) for instance, has mentioned other possibilities. The three mentioned serve to suggest, however, the kind of thinking which might be fruitful for senior capstone courses in the field of general education—particularly where we wish to keep our graduates abreast of information needed for today's fast-changing scene rather than an outmoded fund of information and a preoccupation with problems which were important perhaps a decade or more ago.

The Current Need For Intellectual Synthesis. All three of the interdisciplinary methods proposed here will, like interdisciplinary proposals in general, meet with some resistance. Inertia will prompt traditionalists in education to ignore such proposals. Specialists in the various parent disciplines from which an interdisciplinary approach must draw its sustenance and its rationale, are likely to invoke arguments and attitudes of long standing in objecting to it. The interdisciplinary approach is generally characterized opprobiously in academic life. It is frequently regarded as superficial and impossible in the face of such considerations as (1) the vast enrichment of our traditional disciplines, (2) the accelerating fragmentation of these disciplines into new and numerous specialties, and (3) the growth of new disciplines which have sprung either from entirely new areas of investigation or which arise from the attempt to investigate problems which are hybrid to two or more traditional areas. In particular, the proliferation of new specialties by splitting them off from traditional areas of study, is, perhaps, the most significant factor obstructing a more favorable attitude towards interdisciplinary studies. As a result of intradisciplinary fragmentation alone, Von Foerster (1960) mentions that at present there exist no less than 1150 different sciences, ranging from Acaralogy to Zymurgy. This same author, himself, however, states the factors which made interdisciplinary fence-jumping an intellectual and professional necessity, quite apart from the need to check the onrushing growth of specialization. He puts it this way.

> "However, the big fence-jumping began when man observed to his surprise that he himself might be a "phenomenon" which was worthwhile to be studied. Confronted with a complexity he never had encountered before and incapable to employ his well established methods of analysis to his enigmatic object of curiosity, each specialist turned to his colleague for help, but only to find out that neither could understand the other one's question.
>
> Some small interdisciplinary groups began to organize themselves to overcome this difficulty, and a few physicists, mathematicians, physiologists, experimental psychologists, zoologists, psychiatrists, sociologists, cultural anthropologists and other specialists got together in an attempt to establish some common ground. But what kind of problems did these people want to solve? Was it desired to describe the mating behavior of octopi in terms of the partial differential equations of physics, or, perhaps, to determine the interaction processes of electrons and ions in an electron gas from a sociological point of view? Today we know these were not the problems these people wanted to solve—although, sometimes, it seemed as if this was their concern. In fact, what they wanted to achieve was to raze the fortifications which were built up between the "sciences" in the course of a few centuries. The problem was to communicate: to share the questions, methods, view points, beliefs, observations, facts, philosophies and prejudices which had developed in each of these specialists domain, and by sharing these, to rapidly increase the information content of the groups as a whole, as opposed to a mere gathering of individual experts. (pp. 2-3)

Out of the emergent interdisciplinary emphases has come such newer areas as operations research and bionics. The former is largely preoccupied with problems which are sometimes hybrid to the social and the management sciences, sometimes cut across the social and the natural sciences and sometimes involve social, natural, management and engineering disciplines, combined. The latter is largely preoccupied with problems which are hybrid to the life sciences, the engineering disciplines, psychological processes and logical relations. These new areas are not only interdisciplinary in nature but they also boast of professionals who exhibit intensity and depth of scholarship in two or more of the traditional disciplines. This multiplicity of background proves to be an inescapable necessity for any realistic approach to the social and scientific problems of a world growing increasingly complex. Thus this needed multiplicity tends to break down the stereotype which associates the interdisciplinary emphasis with superficiality.

The resistance to interdisciplinary needs is usually based, as we have noted, on the *intrinsic* difficulties of intellectual synthesis, in the face of an overwhelming growth of knowledge and skills. Often, however, it is aided and abetted by specialists of limited interests and ability, who shore up their own flagging sense of status and security by refusing to take seriously any effort of an explicitly interdisciplinary nature. Thus the resistance and doubts reasonably manifested in the face of the contemporary plethora of human intellectual achievement, is reinforced by *extrinsic* factors of a socio-psychological nature. These obviously have to be dealt with in a fashion far different from the methods we employ to wrestle with the intrinsic difficulties, themselves. There is no escaping the brute fact, however, that as time passes, the need for intellectual synthesis in higher education will increase more and more. There have been men of high intellect and solid achievement, like Teilhard de Chardin (1959) and Polanyi (1958), who have ventured into areas of wide compass and whose efforts have been highly acclaimed by distinguished scholars, in spite of academic misgivings which accompanied these high-powered syntheses. We need more venturesome spirits of this sort today—men who are unafraid of prevailing academic prejudices with respect to the interdisciplinary approach. We need scholars who can live in the penumbra of contempt with which many specialists invest such terms as "general education," "intellectual synthesis" and "generalist." Perhaps, most of all, supporters of general education need the sense of humor over the excesses of specialization, described by Presthus (1962). In describing the need for an interdisciplinary approach in the social studies—one which he made use of himself in describing the growth and effects of organizations and bureaucracies in our time—Presthus emphasizes the currently existing and sometimes vicious, academic prejudice towards interdisciplinary effort. He says.

> "Such a mode of analysis clearly requires the insights and conceptual tools of several disciplines. But the existing structure and values of the intellectual market place inhibit such an approach. Each discipline tends to define organizations in terms of its own image, with the result that organizational phenomena are divided into political, economic, sociological,

> and psychological compartments. Professional commitments and power struggles among university departments discourage the integration of social-science theory and methods. The reasons for this situation are found in the conditions of participation set down by academia today. They provide ironic evidence of our major theme by illustrating the extent to which organizational expectations and rewards influence individual behavior.
>
> Unless one has experienced graduate training and apprenticeship in American higher learning, the stress involved in broadening one's approach beyond a single discipline is hard to imagine. Academic training instills a compelling inhibition against venturing beyond a given segment of knowledge. The underlying reason is the passionate specialization of university organization. All the dynamics of training, of values, and of professional recognition push one toward restricted fields of analysis. As a result, trained incapacity, technical introversion, and bureaucratic infighting are characteristic of most university departments. Each discipline carves out for itself a narrow segment of human behavior, concentrates mightily on developing it through research, theory, and immaculate terminology, and in the process accumulates such a bewildering array of facts and fables that the apprentice is submerged by what is called the "basic knowledge in the field." To presume to challenge or to go beyond this revealed wisdom is to risk the most crushing label in the academic lexicon: *dilettante*." (pp. 12-13)

A philosophy of general education must be patient towards such attitudes. Supporters of general education have to exhibit a permanent sense of humor towards those who willfully misunderstand the general education enterprise. Like anything else, general education may be practised superficially by advocates of limited attainments, who therefore give the general education movement a bad name. General education, however, may be revamped at a higher and more solidly intellectual level, both with respect to methods of fence-jumping—three of which have been the concern of this paper—and with respect to the new and enriched intellectual content of inquiry in our time. This revamping calls not only for intellectual bridge-building, but also and more importantly, for novel and drastic curricular revision in which intellectual synthesis may have to play a major role. If supporters of general education and other forms of interdisciplinary objectives, can regalvanize their energies in these much needed newer directions, I think it can be safely assumed that certain much needed intellectual reforms in higher education, can be made concrete and available. The task of curricular revision which this calls for is stupendous but the results, apart from being genuinely needed, cannot but prove to be highly fruitful for a long time to come. The calibre of the educator needed for preoccupation with this task will probably have to be superior to that which academia has traditionally encouraged and tolerated. These considerations tend to sober enthusiasm and effort but they should not be allowed to eliminate it. Clearly the task of intellectual synthesis has to be done. There is no way out. The immediate tasks to be faced are really those which center about the questions of who is to work at the needed synthesis and what do we want the finished product of their labors to look like.

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THE COLORATION OF ROCKS AND SOILS

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Rock Coloration

Perhaps the most colorful area of rocks and soils in the United States is that vast arid tableland known as the Colorado Plateau. This area comprises sedimentary materials which were laid down in extensive inland seas millions of years ago. Its physiography involves jumbled mesas, canyons, valleys, and lesser plateaus. Its multiplicity of color ramifications is due to a combination of a number of minerals present (particularly iron) with its arid climate. Aridity, with its predominantly oxidizing atmosphere, is strongly conducive of high coloration.

Color nomenclature here seems to vary according to the background and purpose of the viewer. Geologists and soils men see reds, browns, yellows, purples, greens, etc. Park officials and real estate operators see colors of blood and fire—of sunup, noon, and sundown. Artists and poets see magentas, beiges, ochers, siennas, etc.

Within the Colorado Plateau areas are several famous national parks which are visited annually by thousands of tourists. Of these parks Grand Canyon, together with the Painted Desert, are perhaps the most famous. All the colors of the spectrum are to be seen here. Zion Park has its Great White Throne rising 3,000 feet above its cliffs of red, and Checkerboard Mesa with its geometrically designed expanse of stone near its east entrance. There is Bryce Canyon with its fiery city of rock formations. Wayne Wonderland has its weird sculpture, including the Great Organ—a symphony of colors which is bewilderingly magnificent. Then there are the cream and yellow buttresses of Cathedral Valley and Nature's gargoyles in the grotesque Valley of the Goblins. Monument Valley, in the land of the Navajos, runs the gamut of nearly every color visible to the eye. Strangely enough, here and there is the greenery of bits of vegetation. Ponderosa pines cling tenaciously to rocky formations where there is seemingly not a cupful of soil present, and sparse growths of certain weeds and grasses exist under the very extenuating circumstances which their environment presents to them.

Numerous elements lend themselves to the over-all picture of pigments in the above-named places. But, of all elements present, iron is the most versatile. Whereas combinations of cobalt, copper, magnesium, manganese, titanium, etc., with various anions, can produce nearly all of the colors of the visible spectrum, hematite can, *by itself*, produce fully as extensive a coloration. It is able to accomplish this by its remarkable repertoire of surface imperfections and differentiations on the crystals of this sesquioxide which are made possible both by its heredity and its environment. When iron is present in its higher oxide form, magnetite, in either dia-, or para-, or both, states its coloration proclivity is exacerbated by new tints and hues.

It is quite possible that more has been written about the colors of rocks and soils by artists, philosophers, and poets than by geologists and soil scientists. The few scientific explanations which have been made of iron coloration ascribe variation in coloration to the presence of differently hydrated oxide forms of *ferric* iron. For example, color distinction can *sometimes* be made between hematite and Goethite. The commonly accepted reason for this is that Goethite is a hydrated oxide and hematite is not. Further, it is believed by some that iron color can be distinguished between certain mineral groups such, for example, as between the large silicate groups—the amphiboles and the pyroxenes. Such distinctions in coloration identity are hazardous, if not impossible, as will become evident further on.

In nature there are many examples of coloration which are produced, mechanically, by light refraction and not by pigments. This is true for both organic and inorganic forms. The iridescence of the feathers of a dove's breast, or of a peacock's tail, is caused by the presence on those feathers of minute excrescences, or, mechanical striations. These striae act as light barriers and "interfere" with incident light as it strikes the feathers. This interference breaks the light down into its component colors in the same manner that a glass prism does. When colors thus result, mechanically, they are referred to as "interference" colors. The colors of soap bubbles, and oil films on water, are interference colors and are due to the fact that these films are quite irregular in thickness. These irregularities cause inequalities in film density which, in turn, act as prisms and produce the rainbow colors.

When a piece of bright, shiny iron is heated to redness and cooled, the heated area is seen to be rainbow-colored. The heating produced a delicate film of iron oxide (ferric) of varying thickness and irregularity of design on the metal surface. This film interferes with light reception at the surface of the iron, acts as a prism, or prisms, and causes the metal surface to evince iridescence. The heating acted as a "super-fast" weathering agent and, if the colored film were allowed to weather further, in open contact with the atmosphere, the iron surface would assume a nature comparable to that of weathered iron in rocks and minerals out in nature. The weathered iron would assume the variable physical nature and properties of hematite and/or magnetite. Hematite, particularly, is known to occur in nearly every color of the rainbow.

Photographic evidence of the mechanism of coloration in the "weathering" of iron metal has become possible only recently (Laukonis and Coleman, 1959). Electron micrography has been improved to the extent that forms less than one micron in diameter can be clearly photographed. These workers have shown that iron oxide crystals have geometrical, mosaic-patterned, surfaces. Also, that oxide platelets and "whiskers" are common products for metals which have been oxidized at red heat. These variously-formed and arranged surface excrescences interfere with surface incident light and cause "artificial" coloration, including iridescence. The chemical formula of iron oxide made by heating metallic iron artificially is identically the same as that of the iron oxide, hematite, formed by the "weathering" of iron compounds in rocks and soils out in nature.

A very interesting side light on the multi-colored forms of hematite is related as follows: In times now past, delicate optical lenses were polished with pulverized hematite, or natural "rouge." When the supply of satisfactory, natural rouge gave out, lens polishers resorted to making their own rouge. This process now involves the complete roasting, at a high temperature, of pure ferrous sulfate. The end product of this treatment is pure ferric oxide—sesquioxide, or hematite. It is very pure, chemically, but not "physically." The color of the individual crystals, and aggregates of crystals, ranges clear across the visible spectrum producing all the colors of the rainbow. The explanation of this phenomenon becomes apparent when the differently colored particles are observed under a high-powered microscope. Not only do the particles vary in size but they have radically different surface physiographies. Some surfaces are smooth and regular and shiny and others are rough and dull, with minute hills and valleys and jagged peaks and buttresses of varying degrees of abruptness and extent. These surface inequalities constitute light barriers which break up incident light and thus produce interference coloration with all of its rainbow hues and tints. It is thus that both natural and artificial hematite, as well as other ferruginous rocks and minerals, can occur from place to place in such a vari-colored array. The optical principles involved in this color variation are, as yet, so tenuous that it is not known just why that a certain crystal should be red, another green or black, etc.

The coloration effects thus far mentioned can be caused by hematite, alone. When hematite combines with magnetite, or with one or more other mineral elements, such as cobalt, copper, manganese, etc., new color combinations can result. However, these differ so slightly from those caused by hematite itself, that their differences are important only theoretically and, perhaps, philosophically. There are very few areas of any size in existence which are colored, predominantly, by the rarer elements. Thus, as far as producing scenes of grandeur, magnificence, and sublimeness is concerned, the rarer coloring agents are substantially insignificant except in very limited and local situations.

The development of high coloration in rocks occurs most strikingly in arid regions. This is due to the fact that weathering processes are more intense in hot areas where weather conditions vary and fluctuate rapidly and between wide extremes. Here the processes of oxidation and reduction (redox) are highly developed. Traces of organic matter and other reducing substances are always present in country dust. When moisture is present these agents cause iron-oxide micelles, or invisible crystals or particles, to dissolve or peptize; to become mobile and move toward each other; to meet, cohere, and grow into aggregates large enough to be visible. The process of micro-particles moving, uniting and forming macro-particles is known in physical chemistry as "agglomeration" which is somewhat analogous to the process of "aggregation" in soils. The process might also, aptly, be called "ferrugination."

From what has been said it can be inferred that the color of any particular rock need have little relation to the total iron content of the rock and that no degree of hydration of the iron oxide is necessary to produce wide degrees of coloration. In fact, some light-colored rocks may be fairly high in iron content while, contrariwise, some highly ferruginated ones can be low in iron content. It can be said, in general, that the degree of iron coloration of rocks depends upon the extent to which weathering processes have agglomerated and made visible the iron particles in the rocks.

Some rocks may contain considerable iron and still give no ferruginous indication of it. This is possible because of the presence, in the rocks, of one or more substances which prevents the mobility and/or cohesion of iron micelles or microcrystals. Certain alkalis, such as lithium and sodium, constitute such retarding agents. If agglomeration, or ferrugination, already exists, the introduction of such alkalis does not cause de-agglomeration. This is evident in certain areas in the country where calcareous red soils and deposits of red limestone exist. In the permian Redbed region in southwestern United States such areas are prevalent. In these particular situations the red coloration is due to the fact that the agglomerated red iron "pigments" were present when the deposits were laid down and have not since been altered by the calcareous admixtures.

Artificial Agglomeration, or Ferrugination

Perhaps a somewhat clearer idea of the process of agglomeration, or aggregation, or ferrugination, by which rocks and soils are made red-colored, may be had by examining certain phenomena known to ceramists, or to brick and tile workers. For example, most clays, but not all, when burned in a kiln, become red colored. The amount of iron present in the clay does not, necessarily, determine the final color of a tile or brick. Neither does the original color of the clay do this.

When fresh clay is burned in a kiln a concatenation of reactions takes place, as follows: moisture is driven out, including water of crystallization or hydration; organic matter is destroyed and any reduced iron present is oxidized to the ferric form, mainly hematitic; iron molecules become mobile, move about and unite with each other to form, at first, sub-microscopic aggregates. These aggregates then unite to form microscopic aggregates and the process continues active until the aggregates become large enough to be seen with the naked eye. It is at this time that the clay assumes the red hematite color—brick red. It is possible, however to regulate to various extents the resulting colors of ceramic products. For example, if a certain kind of clay, such as kaolin, is colored pinkish, or reddish by burning and a white or uncolored product is desired, a "de-agglomerating" agent can be added to the clay before burning. This agent can, in some manner, prevent the iron in the clay from becoming mobile and growing into larger, visible-sized particles. Therefore the usual iron-red color does not result. Agents which have this property are mostly alkalinizing, or reducing, in nature. The mechanism of the pronounced reddish coloration of rocks and soils in nature, commonly known as "weathering", is essentially the same as above described—it just takes much longer to happen.

Soil Coloration

Soil coloration, although it involves the essential mechanisms of rock coloration, is more complicated than the latter because of the influence of organic matter. Soil is a product of rock disintegration and is modified chemically and physically by decomposing plants and animals which become admixed with it. The degree of modification depends upon the genetics of the soil, the climate effect, and the amount of organic matter present.

Organic (humic) matter is acidic in reaction and is the precursor of humus and humic acids. These substances contain phenolic groups, including tannins, quinones, etc., which are brownish to reddish in color. These phenolic, or benzene ring, compounds act not only as acid indicators but also as oxidation-reduction (redox) indicators. Thus soil color can change with varying degrees of acidity, or alkalinity, and with varying moisture and aeration conditions. Furthermore, phenolic radicals have the property of uniting with metallic radicals to form a whole gamut of differently colored compounds. Thus the possibilities of colors in soils are infinite in number. More than 4,000 distinct soil types have been officially mapped in the United States and no two types have the same color (Marbut, 1935). In the official classification of the soils of the U. S., the U. S. Department of Agriculture has emphasized the scheme of soil colors in the different states.

For example, the soils of the Northeastern states belong, mainly, to the Gray Podzolic and the Brown Podzolic Soil Groups. Those of the Southeastern states belong, mainly, to the Red-Yellow Podzolic soils. In the Prairie Region are found the black Chernozem, the Chestnut-Colored, and the Black Waxy soils. West of the Rockies are situated the Inter-Mountain and Desert soils, and the Pacific Coast soils, all of which vary widely in color and other properties. Within the recognized Great Soil Groups there are always smaller, irregularly situated, subgroups which do not conform to the main group in their characteristic color and other properties. This is due to peculiar combinations of soil origins with the local ecological conditions present.

It has already been stated that the color of any iron-colored rock or soil is not necessarily proportional to their total iron contents but is due rather to the degree and extent of agglomeration of their iron particles. Clarke states that where the iron content of a soil is less than five per cent the iron content consists mostly of a thin coat of iron around the soil particles, probably only a few molecules thick (Clarke, 1920). In this case the color could be somewhat proportional to the iron content up to approximately five per cent. MacCarthy found that, in iron-stained sands and clays, the iron content, up to about five per cent, seems to be influenced strongly by the presence in the soils of bases, such as potassium, sodium, etc. (MacCarthy, 1926). Beyond five per cent of iron, however, there seemed to be no correlation of iron color and iron content.

The writer has worked with soils, which had not more than three per cent of total iron, which were as highly iron-colored as were certain other soils which contained five or more times as much iron. The earthy material in the Mesabi Range of Minnesota, containing as much as 65 per cent of iron oxide, is no redder or more ferruginous than are some soils which contain not more than eight or ten per cent of iron, all in the form of ferric oxide. But a great color-difference *potential* between these high and low iron soil materials *can* be present. This may be demonstrated as follows: If small dry samples of each of the high-iron and low-iron soils, of approximately the same color, are placed in mortars and carefully pestled, the color of the high-iron soil will change comparatively little while that of the low-iron soil may be radically changed. In the latter instance the color may be changed from a deep red to a light yellowish ocher color. The change in hue, here, is entirely a physical one since it involves merely the breakdown of the iron aggregates and their dispersion back into the soil matrix.

The effect which organic matter can have on soil coloration can probably be visualized best by aid of the "soil catena" concept (Bushnell, 1942). The term "soil catena" implies areal associations and gradations of soils in their relation to drainage conditions—ranging from excessively drained to permanently water saturated. The ecology of the soil changes with every change in moisture condition as do also the natures of the involved soil processes. In general, the soils at the drier end of the soil chain will receive less organic matter (the species of plant matters little) and will be more acidic in reaction than those at the wetter end of the chain. The well-drained soils are subject to a predominantly oxidizing environment and thus tend toward a lighter coloration. At the wettest end of the scale, not only will more organic matter be formed but that which *is* formed tends to be less decomposable than the drier-land organic matter. The term "ektodynamorphic" was coined to involve all soil processes in connection with the wet situation, and the term "endodynamorphic" for the dry situation (Glinka, 1914). Between these limits range extreme variations in soil acidity and soil aeration (redox) conditions. These variations cause great differences in the nature of the soil humus which is formed and it is the humus which governs soil coloration.

Two terms in humus nomenclature have been invented to account for the humus variation, from the dry to the wet conditions, viz., "Mor", and "Mull" (Romell, 1932). These terms applied originally to forest soils but have now become applicable to all soils (Plice, 1945). Mor humus is formed in the better drained situations, lies mostly on the surface of the ground, and ranges in color from light-brownish to deep reddish brown. Mull humus is mostly incorporated with the mineral soil to various depths and ranges in color from light-gray to black. The processes by which these two humus types are formed are widely divergent in nature. Mor humus is formed in an environment which is dominantly oxidizing in nature (Plice, 1945) and its resulting colors are due to color indicators from plant phenolics which are affected by acids and bases (Thomson, 1958), and (Fairbairn, 1958). Quinones constitute the largest group of natural coloring matters. Mull humus is formed in an environment which is dominantly reducing in nature and its coloration is due to reduced phenolic, or tannic, color—indicating substances. These, due to the fact that much hydrogen and oxygen have been lost in the reduction process in the soil organic matter, take on darker hues because of the relatively large increase in carbon content.

It is quite possible that the process by which mull humus is formed is related to that by which coal is formed and that mor humus formation is similar to lignite formation. Erasmus shows that organic matter which undergoes a "coalification" process during coal formation loses considerable acidity, hydrogen, and oxygen and gains considerable carbon (Erasmus, 1938). The carbon assumes a partial graphitic nature and becomes blackish in color. Further, organic matter which is formed into lignite loses much more carbon and gains more hydrogen and oxygen, relatively, and loses only little in acidity. The color of lignite remains similar to that of the organic matter from which it was formed (Moore, 1940).

In order to get some light on the chemical natures of the two humus forms, mull and mor, combustion analyses were made on the organic fractions of several samples of black prairie (chernozem) (Glinka, 1914) soil from southwestern Minnesota, and of several samples of brown forest soil from central Minnesota. The carbon, hydrogen, and oxygen percentages, respectively, for the mor humus were 30, 7, and 40; and for the mull humus were 47, 5, and 11. The color of the mor humus was reddish brown and that of the mull humus practically the same as that of graphite.

Between the upper and lower limits of ecological situations of the soil catena, mentioned above, great variations exist at all times. The colors of the in-between soils vary with these variations. Perhaps the most difficult to understand of all soil colors is gray, and its variants. In Geology, particularly, it has been mostly assumed that the gray colors of rocks, and of finer-textured rock material, such as glacial clay, are due to the domination in those materials of ferrous, or reduced, iron. In the present work this could not be confirmed. Even the, supposedly, most reliable ferric and ferrous ion indicators, including dipyridyl and ferron, proved to be completely erratic.

In the most difficult of all materials dealt with—glacial clay—it was discerned that the clay contained partially "coalified" organic matter. When this organic matter was peptized by alternate acid and base treatment, with leaching, it was finally, and completely removed from the mineral matrix. The extracted mineral material was now nearly white in color and highly silicious. The organic matter, when purified and dried, was graphitic in color and had a composition very similar to that of the pure mull humus material. From this and related experiments it is believed that the gray colors of soils are due mostly, if not entirely, to the presence therein of varying amounts of the very stable, partially "carbonized" organic matter. Subsequent study of several coal-measure shales revealed the same results; the presence of small quantities of the stabilized, or "mull-ized" organic matter caused light-gray colored shales, and larger quantities caused darker colored shales. Here again it is impossible to predict from the color of the soil how much organic matter it contains. In Russia there are Steppe soils which are nearly as black as coal and which have an organic matter content of only one per cent (Glinka, 1914). The writer has studied samples of Steppe soils and found that the organic matter therein is appreciably higher in carbon, and lower in hydrogen and oxygen, than that contained in the Chernozem soils of the North Red River valley area, in Minnesota and North and South Dakota. The Steppe organic matter has been "coalified" to the extent that, when extracted and powdered, it looks very much like coal dust. In fact, it contains somewhat more than a trace of "fixed carbon", and fixed carbon is the main feature of coal properties. The exact reason for the coloration of any substance is, of course, its ability to absorb, or reflect, visible light, and this ability is closely related to the electron configurations of the substance which also determine all of its other properties.

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THE REPRODUCTIVE CYCLE OF SNAKES IN A TROPICAL REGION, BRITISH HONDURAS

Wilfred T. Neill[1]

In temperate regions, certain activities of animals are correlated with the cycle of the seasons. This appears to be true of breeding activity among snakes of the United States. Thus Schmidt and Davis (1941), reviewing all United States and Canadian snakes, found that young of the live-bearing species appear between late July and early October; and that eggs of the oviparous species, laid mostly in June and July, usually hatch in August and September. Oliver (1955) presented data for 13 snakes from scattered areas of North America. His table revealed that, in general, young of the live-bearing species appear around August and September, occasionally as early as July or as late as October. From May to July the oviparous species lay eggs, and these hatch in about 1½ to 3 months; so that the hatchlings appear concomitantly with the young of the live-bearers. Klauber (1956) concluded that the young of Nearctic rattlesnakes, 15 or more species, were usually born between August 1 and October 15, with a majority of births around mid-September. Wright and Wright (1957), in their account of all United States and Canadian snakes, noted that eggs are laid from late May to September 1, but mostly in June and early July; that the eggs hatch mainly in August and September, at which time the live-bearers are also giving birth.

Evidently, then, in the United States most young snakes appear in August or September, occasionally a little sooner or later. However, the causes underlying this periodicity of reproductive behavior have not been fully investigated.

Causes of a reproductive cycle include both "proximate" and "ultimate" ones. Proximate causes are those that affect the behavior of the individual animal; they may involve an internal physiological rhythm, external physical factors such as light or temperature, or some interaction of internal and external factors (Bullough, 1951). Ultimate causes are those selective forces operative upon the population, rendering one sort of reproductive behavior more advantageous than another. The present paper is concerned only with ultimate causes of the ophidian reproductive cycle; for

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an analysis of proximate ones, see Fox (1952, 1954). Among snakes of the United States, the reproductive cycle appears ultimately to be an adjustment to seasonal temperature changes; it reflects the ophidian necessity of avoiding the low temperatures of winter.

While some snakes, especially of more northerly species, can withstand freezing or even slightly subfreezing temperatures for weeks (Bailey, 1949), they do so only in a virtually inactive condition. Snakes of the United States rarely carry on normal activities, such as feeding or breeding, when the body temperature falls below about 16°C. (Cowles and Bogert, 1944). And, while these ectotherms are capable of some behavioral thermoregulation, even as far south as peninsular Florida there is a period of time, at least from December through February if not longer, when most snakes must curtail their activities and seek shelter from unfavorably low temperatures (author's observations). Such shelter is usually found in ground burrows, rotting stumps, logs, rock crevices, or water. In general, after emergence in the spring, a snake must replace water, fats, and other substances lost during the winter, as well as find and explore an area in which it will live during the summer. It is uncertain whether these activities usually precede breeding. In any event, before breeding, the snake must go through gametogenesis and locate a receptive mate. Apparently, among most snakes of north-temperate regions, the greater part of breeding activity takes place soon after, although perhaps not immediately after, emergence in the spring (Klauber, *op. cit.*; Oliver, *op. cit.*; Schmidt and Davis, *op. cit.*). After fertilization, gestation then requires about 5 to 6 months (Klauber, *op. cit.*; Wright and Wright, *op. cit.*), so that of necessity the young do not appear before late summer or fall. In colder regions, the shortness of summer may even necessitate a biennial rather than an annual cycle, there being fall mating, overwinter storage of sperm *in utero,* and fertilization (without further copulation) immediately following ovulation in the spring (Klauber, *op. cit.*; Rahn, 1942).

What with the importance of a cold season in modifying the annual cycle of snakes in the United States, it is reasonable to inquire as to the reproductive behavior of these reptiles in tropical areas where winter temperatures are not markedly lower than summer ones. Rahn (*op. cit.*) suggested that one might expect to find "several ovulations per year [among reptiles] in tropical zones."

It remains to be proven that this is the case. Kopstein (1938) found that in Java, about 6° to 9° below the Equator, the breeding season of snakes is in some cases adjusted to the local monsoon climate, few eggs being laid during the well-marked dry season. Oliver (1947) examined 22 females of the snake now called *Leptophis ahaetulla nigromarginatus,* collected at Iquitos, Peru, a little less than 40° below the Equator. Females with eggs at least 10 mm. in length were taken in all months except April, September, and October; and Oliver concluded that there was "no indication of a restricted breeding season." However, Oliver's data are subject to a different interpretation. Females with large, supposedly mature eggs, about 25 mm. in length, were taken only during a 6-months period from December to June. The circumstance suggests that the season of oviposition, and therefore of hatching, is restricted to some degree, especially when one recalls that eggs may be retained in the oviducts for long periods (Cagle, 1953; author's observations). Duellman (1958) examined an unspecified number of snakes, of an unspecified form of *Leptodeira* (presumably *L. a. annulata*), from the vicinity of Iquitos. Individuals, considered by him to be hatchlings, were taken in all months except April, June, July, and November; and Duellman concluded that in this region "mating may take place throughout the year." Here again the data are subject to another interpretation, for "females with well-developed eggs were found [only] in January, March, and June;" *i. e.*, during a 6-month period.

What with the paucity of observations on tropical snakes, it is worthwhile also to note certain papers on lizards (which are closely related to snakes and often similar to them in reproductive behavior). Baker (1947a, 1947b) found that a skink, *Emoia cyanura,* under the remarkably constant climatic conditions that obtain on Espiritu Santo at latitude 15° 15′ S in the New Hebrides, reproduces all year; but it has a definite peak of breeding activity in November and December (the local "summer"), and a period when few eggs are laid (May and June, "winter"). Marshall and Hook (1960) studied *Agama agama* almost on the Equator near Nanyuki, East Africa. It has a distinct breeding period, with a peak of egg-laying in July and early August. It was suggested that the lizard's sexual cycle "is timed . . . by the seasonal appearance of proteinous insect food."

Actual studies are too few to permit generalizations about the reproductive cycle of reptiles in the tropics, and there is need for further investigation in areas where weather conditions are fairly constant throughout the year.

One such area is British Honduras (Koeppe and De Long, 1958). This country (except for its relatively dry, extreme northeastern tip, which is not under discussion here) exhibits an "Af" type of climate (tropical, with sufficient heat and precipitation for high-growth trees; average monthly temperature over 64°F.; sufficient precipitation each month). It lies in the Trade Wind Littoral climatic region (mean annual temperature at least 70°F.; annual temperature range generally under 20°F.; rainfall more than 35 inches annually; no month rainless). Although detailed weather data are lacking for much of British Honduras, at the capital city of Belize the mean maximum shade temperature, over a 5-year period, was 85.5°F.; the mean minimum shade temperature 75.3°F.; the extreme maximum shade temperature 96°F. (on June 3); the extreme minimum shade temperature 50°F. (on February 9); and the average annual rainfall, over a 10-year period, 68.95 inches (Anderson, 1958). December through February are relatively cool months, when the "northers" (winds from the north, replacing the otherwise constant northeast trade winds) bring minimum temperatures usually between 60° and 70°F.; March, April, and May are relatively dry (but not rainless), with May especially hot; around latter May or early June the rainy season begins (*idem*; Anon., n. d.). The climate of British Honduras, while by no means monotonous, is more equable than that which obtains anywhere in the United States.

My itineraries, collections, and observations in British Honduras have mostly been described (Neill, 1960b; Neill and Allen, 1959a, 1959b, 1959c, 1960, 1961a, 1961b, 1962). My specimens, and a few from other collections, have been examined for information on the reproductive cycle of snakes in that country. Seasonal changes in the histology and anatomy of the reproductive system have been used by others to determine the breeding cycle of snakes (Fox, 1952; Rahn, *op. cit.*). In general, successful analysis of such changes requires large series of specimens, and rapid autopsy. My series are small, and most individuals were not autopsied rapidly;

thus I have relied on actual records of birth, and on collecting dates of very young snakes.

My estimate of a young snake's age is based chiefly on examination of the umbilical scar. At birth or hatching a snake exhibits a longitudinal slit, involving 3 or more ventral plates, marking the area of yolk sac attachment. This slit heals in about 4 days, but a scar, in the form of an unpigmented groove, persists for a time. The groove soon develops pigment, and gradually becomes shorter and more shallow, vanishing usually during the snake's fifth or sixth month of activity (author's observations in Florida; Klauber, *op. cit.*; Smith, 1947). During an inactive period (roughly December through February for most species in Florida), the scar changes very little. Conceivably, some snake species or individuals might depart from the norm in the rate at which the umbilical scar vanishes; but I believe that in most cases the condition of the scar will permit determination of a young snake's age, with a possible error of no more than ± 3 weeks. A greater margin of error would not notably alter the conclusions; a snake with a well defined umbilical scar, and near the lower limit of size for its species, must be very young.

Unless otherwise noted, specimens are in my preserved collection. Common names have been explained elsewhere (Neill and Allen, 1959a), or are taken from my British Honduras herpetological checklist now in progress. A brief characterization of each species, with pertinent references, is given, in order to show that snakes of diverse habitat and diel cycle may yet be similar in reproductive behavior. The remarks on habits pertain only to the situation in British Honduras. Localities mentioned are in that country unless otherwise noted; these localities have mostly been described elsewhere (Neill and Allen, 1959a). Plant communities in British Honduras have also been described, with particular reference to herpetofaunal distribution (*idem*). The abbreviation "WTN" indicates my collection, "MCZ" that of the Museum of Comparative Zoology at Harvard College.

The following accounts include all the young snakes that have come to my attention from British Honduras; *i. e.*, all with at least some trace of an umbilical scar. These specimens are not many, but they represent 11 genera and 4 families (*Dipsas, Sibon, Leptodeira, Tretanorhinus, Spilotes, Drymobius,* and *Thamnophis* in the

Colubridae, *Micrurus* in the Elapidae, *Boa* in the Boidae, *Crotalus* and *Bothrops* in the Viperidae).

Juvenile Snakes

Dipsas brevifacies. The short-faced snailsucker is a medium-sized, slender, oviparous, arboreal snake, with anatomical modifications for a diet of snails. So far as is known, it lives amid clusters of epiphytic bromeliads and orchids, in trees of the palm and pine savanna, and of the more open woods. It is apt to be mostly nocturnal. See Neill and Allen (1960) and Peters (1960) for observations on the biology of the species.

WTN No. BH-303; about 13 miles W and 1.5 miles S Belize, Belize District; November 1, 1959. Total length 216 mm. Umbilical scar healed but well defined. The snake was probably hatched in middle or latter September.

Sibon sanniola. The Yucatecan snailsucker is poorly known. Probably it is a medium-sized, oviparous, nocturnal, arboreal inhabitant of epiphytes in the sapodilla forest of northern British Honduras and the Yucatán Peninsula. See Neill and Allen (1962) and Peters (*op. cit.*).

MCZ No. 56994; near Xunantunich, Cayo District; November 3, 1959.[1] Total length 176 mm.; a hatchling with prominent umbilical scar. The snake was probably hatched in latter September.

Leptodeira septentrionalis polysticta. The Central American cat-eyed snake is a medium-sized, slender, oviparous, nocturnal reptile. It lives about bromeliads, in the axils of palm leaves, and in brushy thickets, mainly in rainforest, jungle, and cohune ridge. It feeds upon lizards, treefrogs, and the eggs of the latter. See Duellman (*op. cit.*), Neill (1960b), and Neill and Allen (1959a).

WTN No. BH-987; Augustine, Cayo District; August 28, 1960. Total length 315 mm.; a hatchling with prominent umbilical scar. The snake was probably hatched in the month of collection, August.

Tretanorhinus nigroluteus lateralis. The Belize cativo is a medium-sized, oviparous, thoroughly aquatic, fish-eating snake. At night it forages in the shallows of streams, lakes, and mangrove swamps. See Dunn (1939) and Neill and Allen (1959a).

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[1] This specimen's collecting date, conveyed to me as "3-XI-59," was improperly rendered by me as March 11, 1959 (Neill and Allen, 1962: 86). The proper translation is November 3, 1959.

WTN No. BH-289; New River at Tower Hill ferry, 3.5 miles S Orange Walk, Orange Walk District; April 10, 1959. Total length 475 mm.; umbilical scar barely evident. The snake displays the juvenile coloration (Neill and Allen, 1959a). The condition of the umbilical scar suggests hatching the previous November, but only if there had been no period of inactivity. An inactive period involving, say, 2 months, would suggest hatching the previous September. (An inactive period among local snakes will be discussed later.)

Spilotes pullatus mexicanus. The monkey snake is a very large, oviparous, extremely active, diurnal, and chiefly arboreal reptile. It frequents scrubby thickets, black mangrove forest, and the more open woods. It is believed to feed on birds and small mammals. See Neill and Allen (1959a, 1960).

WTN No. BH-296; near Guacamallo (Wacamayo) Crossing, Mountain Pine Ridge, Cayo District; September 1, 1959. Total length 595 mm.; umbilical scar long, and but slightly healed. The snake was probably no more than 2 or 3 weeks old when collected; it is apt to have hatched in August.

Drymobius m. margaritiferus. The speckled racer is a medium-sized, slender, oviparous snake, diurnal and very active. It is found mostly about clearings and open, grassy spots, especially near lakes and streams. It is believed to feed on frogs and lizards. In behavior it is very reminiscent of the North American blacksnake, *Coluber constrictor*; and the 2 genera are related. See Neill and Allen (1959a) and Wright and Wright (*op. cit.*).

WTN No. BH-1814; about 3 miles E Augustine, Cayo District; October 15, 1959. Total length 359 mm.; umbilical scar forming an indistinct groove on 3 ventral plates. The snake was probably hatched in early August.

Thamnophis sauritus rutiloris. The Central American ribbon snake is a medium-sized, slender, active, largely diurnal, live-bearing snake. Semi-aquatic, it frequents savanna, and the edges of ponds and streams in savanna. It feeds on fishes and frogs. See Neill and Allen (1959a).

A specimen collected April 10, 1959, at Maskalls, Belize District, gave birth to 6 young on July 3, 1959. The young were full term and healthy.

There is some indication that *Thamnophis sauritus,* in several parts of its range, produces young earlier than most other snakes, and occasionally gives birth to 2 broods a year. Data on *T. s. proximus* in Louisiana (Tinkle, 1957), and on *T. s. sauritus* in Michigan (Carpenter, 1952a, 1952b), indicate at least some births as early as July. In Richmond County, Georgia, neonatal young of *T. s. sauritus* often appear in July; and in Marion County, Florida, *T. s. sackeni* commonly gives birth in this month (author's observations). On one occasion a large captive female of *T. s. sauritus,* from the Piedmont side of Augusta, Richmond County, Georgia, produced a brood in July and another in early November. Tinkle (*op. cit.*) found a specimen of *T. s. proximus* that "may have been capable of producing two broods per year."

Micrurus affinis alienus.[2] The many-ringed coral snake is a small or medium-sized, oviparous reptile, at times fossorial in leaf litter but given to prowling by day in open, sunny spots along jungle trails, clearings, and stream banks. Its food is unknown, but probably includes lizards and other snakes. See Neill and Allen (1959a).

WTN No. BH-1447; Beaver Dam Creek at its junction with the Belize-Benque Viejo road ("Cayo Road"), Cayo District; July 14, 1959. Total length 268 mm.; umbilical scar forming an indistinct groove on 2 ventral plates. The snake had probably seen about 5½ months of activity; and if it had gone through no inactive period, it may have hatched in late January or early February. Alternatively, it could have hatched in late October or early November of the previous year, entering soon into a period of inactivity lasting from December through February, and emerging in March to begin growth.

Boa constrictor imperator. The imperial boa is a very large, live-bearing, mainly nocturnal snake, usually terrestrial but sometimes arboreal. It is most abundant in red mangrove swamp, but also occurs in streamside thickets, pine parkland, and other situations. As an adult it preys upon iguanas, birds, and medium-sized

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[2] Elsewhere I have noted that the coral snakes of southern British Honduras resemble *Micrurus affinis hippocrepis* (Neill and Allen, 1959a: 57). This is the case with the juvenile specimen described herein. It has since become evident that the respective phenotypes of *M. a. hippocrepis, M. a. alienus,* and *M. a. mayensis* all occur in British Honduras. Pending a detailed analysis, I lump the material here, in text and table, under the name *alienus.*

mammals such as monkeys and tree porcupines. See Neill and Allen (1959a).

On August 10, 1959, a 6-foot specimen gave birth to 16 young. The female parent had been taken in Mountain Pine Ridge about a month previously. Another 6-foot female, from Belize, Belize District, produced 12 young on August 19, 1959. The dates of birth were probably not greatly affected by conditions of captivity, as the young appeared healthy and full term.

Crotalus durissus tzabcan. The tzabcan rattlesnake is a large, live-bearing reptile, active mostly by day. It avoids rainforest and jungle, being characteristic of dry, grassy or brushy situations, such as pine parkland, palm and pine savanna, and cane-fields. The food is not known. See Klauber (*op. cit.*) and Neill and Allen (1959a, 1959c, 1960).

WTN No. BH-806; N side Mountain Pine Ridge, Cayo District; September 12, 1959. Total length 610 mm.; a complete rattle of 4 segments. The snake is too old to exhibit an umbilical scar. However, the studies of Klauber (*op. cit.*) on rattlesnake growth rates permit an estimation of this specimen's age. The average total length of the tzabcan rattler at birth is 315 mm., and this individual accordingly had added about 295 mm. to its neonatal length. Rattlesnakes of other species, comparable to this one in size, add about 300 mm. to the neonatal length in roughly the first 10 months of activity. Assuming no inactive months, the present snake might have been born around the previous January. Alternatively, if it had been inactive from December through February, it may have been born around the previous October. The snake was found at an altitude of 2,800 feet on the north side of Mountain Pine Ridge, a locality exposed to the "northers" for about 3 months. An inactive period is especially likely in the case of the present specimen.

A wild rattler, feeding and shedding normally, and with a winter period of inactivity, is apt to have 4 rattle segments when a year old (*idem*). The present specimen accords well with the generalization.

Bothrops atrox. The fer-de-lance is a large, terrestrial snake, live-bearing, active mainly at dusk and during the early part of the night. It is most characteristic of rainforest and jungle, but also occurs in pine parkland, palm and pine savanna, and black mangrove forest. The food includes birds and small mammals. See Alvarez del Toro (1960) and Neill and Allen (1959a).

WTN No. BH-1816; Augustine, Cayo District; November 4, 1959. Total length 400 mm.; umbilical scar well healed but evident, involving 3 ventral plates. The snake was probably born around latter August.

WTN No. BH-2133; near Augustine, Cayo District; April 11, 1959. Total length 451 mm.; umbilical scar obsolescent. The snake had probably seen about 5 months of activity. With no inactive period, it may have been born in November. Granting inactivity from December through February, it was probably born around August.

Bothrops nummifer. The jumping viper is a small but stocky, terrestrial, live-bearing snake, active by day and by night. It frequents rainforest and jungle in hilly areas. Its food is said to be mostly rats. See Alvarez del Toro (*op. cit.*), March (1929), and Neill and Allen (1960).

WTN No. BH-808; Augustine, Cayo District; August 28, 1959. Total length 246 mm.; umbilical scar not well healed, splitting 3 ventral plates. WTN No. BH-807; north side of Mountain Pine Ridge, Cayo District; September 5, 1959. Total length 278 mm.; umbilical scar somewhat better healed than in No. BH-808, but still involving 3 ventral plates. Both snakes were probably born in August.

ADULT SNAKES

British Honduras collections, examined by me, include about 34 other species of snakes, but the individuals thereof are not juveniles. Little is known about the growth rate of most tropical snakes; and, among these reptiles, the effect of environment on growth may become more pronounced with age. Thus I have not employed these larger individuals in attempting to deduce dates of birth or hatching. However, it is useful briefly to review all the British Honduras snakes in my collection, and for which I have some ecological data (Table I). The following comments pertain to this snake collection in its entirety.

1. Adult snakes of oviparous species, taken in April (*Conophis lineatus, Drymobius, Lampropeltis, Leptophis ahaetulla, Micrurus, Oxybelis aeneus, Tantilla, Tretanorhinus*), did not contain large eggs.

2. Adult snakes of live-bearing species, taken in February (*Crotalus*) and April (*Boa, Bothrops atrox, Crotalus, Thamnophis praeocularis, T. sauritus*), did not contain large embryos.

3. Adult snakes of oviparous species, taken in latter July (*Leptodeira, Masticophis, Micrurus, Ninia, Scaphiodontophis, Spilotes, Stenorrhina*), did not contain eggs.

4. Of live-bearing snakes taken in latter July (*Boa, Thamnophis sauritus*), 2 individuals of *Boa* contained large embryos.

5. Adult snakes of oxiparous species, taken in latter October and early November (*Clelia, Coniophanes imperialis, Conophis lineatus, Drymarchon, Drymobius, Leptophis mexicanus, Ninia, Oxybelis fulgidus, Spilotes*), did not contain large eggs.

6. Adult snakes of live-bearing species, taken in latter October and early November (*Boa, Bothrops nummifer, Thamnophis sauritus*), did not contain large embryos.

(A few snakes, *e. g.*, a *Coniophanes schmidti* and a *Conophis concolor,* listed in the table but omitted from the above comments, are subadults, too large to permit an estimation of their age but probably too young to breed.)

To the above 6 summarizations may be added 3 based on the previously discussed juvenile snakes and birth records.

7. Very young snakes, those with a prominent umbilical scar (*Dipsas, Sibon, Leptodeira, Spilotes, Drymobius, Bothrops atrox, B. nummifer*), were collected only between August 28 and November 4.

8. Somewhat older juvenile snakes, with a less distinct or obsolescent umbilical scar, were taken in April (*Tretanorhinus, Bothrops atrox*), except for a *Micrurus* in July. A *Crotalus,* too old to show an umbilical scar, was collected in September; its size, and number of rattle segments, suggest that it was born the previous October.

9. Actual birth dates, for captive-born litters of live-bearing species, were in July (*Thamnophis sauritus*) and August (*Boa*).

The foregoing 9 summarizations are all consistent with the hypothesis of a definite reproductive season for snakes in British Honduras. Oviposition seems to take place after April but before latter July. Both hatching and birth seem to take place no earlier than July and no later than early November, mostly around August and September.

Discussion

It might be asked whether the snakes are mostly from localities of high elevation, to which published climatic data are not applicable. This is not the case; the juvenile snakes were taken at the following approximate altitudes (in feet): *Dipsas,* well under 200; *Sibon,* about 200; *Leptodeira,* about 1,400; *Tretanorhinus,* under 100; *Spilotes,* 1,200; *Drymobius,* about 1,400; *Thamnophis,* under 100; *Micrurus,* under 200; *Boa,* sea level and about 1,200; *Crotalus,* 2,800; *Bothrops atrox,* about 1,400; *B. nummifer,* about 1,400 and 2,500. Of snakes listed in Table I, the following were collected only in the lowlands: *Clelia, Coniophanes imperialis, Conophis concolor, Dipsas, Drymarchon, Lampropeltis, Leptodeira, Leptophis ahaetulla, Masticophis, Micrurus, Ninia, Oxybelis fulgidus, Scaphiodontophis, Tantilla, Thamnophis praeocularis, T. sauritus, Tretanorhinus.* Of the tabulated snakes, the following were collected only in the uplands of Mountain Pine Ridge: *Bothrops atrox, B. nummifer, Coniophanes schmidti, Conophis lineatus, Crotalus, Oxyrhopus, Stenorrhina.* Of the tabulated snakes, the following were collected both in the lowlands and in the Mountain Pine Ridge uplands: *Boa, Drymobius, Leptophis mexicanus, Oxybelis aeneus, Spilotes.* Mountain Pine Ridge, the only upland area from which I have British Honduras snakes, is cooler than the lowlands to the north and northeast (Anderson, *op. cit.*; Neill, 1960b; Neill and Allen, 1959a). However, it rises to a maximum elevation of only 3,348 feet, and its climate is still tropical. In nearby southern Mexico, where mountains rise to a greater height than in British Honduras, a temperate climate is not met with below about 5,000 feet (Leopold, 1950).

The timing of the reproductive cycle, among snakes of British Honduras, is not merely an inheritance from temperate-zone ancestors. *Thamnophis, Crotalus,* and perhaps *Drymobius* and *Bothrops,* are genera that arose north of the tropics, but *Boa, Dipsas, Sibon, Leptodeira, Leptophis, Tretanorhinus, Spilotes,* and probably *Micrurus,* arose in the tropics (Dunn, 1931; Stuart, 1957).

Nor does the aforesaid cycle appear to be an adjustment to seasonal variation in rainfall. Trips were made to British Honduras in the dry season of 1959, and of 1960; most habitats were found to be not especially desiccated. Many ponds still held water, even in the open savanna; some frogs were calling and others were abundant although not breeding; many snakes were active. Certainly there are seasonal changes in the apparent composition of the British Honduras herpetofauna (Neill and Allen, 1959a), but there is no reason to think that the local dry season is sufficiently dry to curtail the activities of most snakes, or to jeopardize egg clutches if any were deposited at this season.

Seasonal variation in temperature may ultimately be responsible for the reproductive cycle of snakes in Brtish Honduras.

Little is known about the eccritic temperature and the thermal activity range (*i. e.*, the "preferred" body temperature and the "voluntarily" accepted range of temperature) in wild snakes of the tropics. In species of temperate regions, the eccritic temperature is but a few degrees below the upper limit of the thermal activity range, and this limit is but a few degrees below an effectively lethal temperature; but the lower limit of the thermal activity range is well below the eccritic temperature, and a lower lethal temperature well below that (Bogert, 1949, 1959; Cowles and Bogert, *op. cit.;* Lueth, 1941). In other words, temperate-zone snakes are notably cold-hardy. I have pointed out that tropical ones definitely are not (Allen and Neill, 1959). Tropical snakes in captivity are often harmed by even brief exposure to temperatures below about 18°C. After such exposure they commonly develop fatal respiratory infections; a *Klebsiella* may be the causative organism (Neill, 1960a). Other common disorders of captive snakes, such as "mouth-rot," mite infestations, and digestive disturbances, in tropical species are apt to become more severe after exposure to lowered temperatures. Many tropical snakes will refuse food at temperatures not too low for feeding on the part of temperate-zone species.

It seems probable, judging from climatic data and from what is known of snakes' temperature tolerances in captivity, that the tropical species may have a period of winter inactivity in British Honduras. During that country's winter, roughly December through February, temperatures must frequently fall at least a little below those tolerated (in the open, or in an active condition) by most of the local snakes. Indeed, they fall a little below those so tolerated even by most temperate-zone snakes in Florida. And of course, "a little below" is as effective as "far below" in curtailing ophidian activity. The period of winter inactivity may be longer and better defined in upland species than in lowland ones; in savanna species than in rainforest ones; in terrestrial and arboreal species than in subterranean and aquatic ones.

Although I shall not discuss proximate causes of the ophidian reproductive cycle, attention should be called to the studies of Fox (1954) on two species of California *Thamnophis*. He concluded that "the rise and fall of spermatogenic activity . . . may be correlated with seasonal increases and decreases in the number of hours per day the snake can maintain its body temperature within the normal activity range." If this conclusion is applicable to snakes of British Honduras, then in the latter country, to account for a distinct reproductive cycle (at least in the male), one need not postulate complete inactivity throughout the winter, but merely less activity at this season than at any other time.

The reproductive cycle of tropical snakes is a problem with many facets. One of these involves the *in utero* storage of viable sperm. Such has been demonstrated for snakes of high altitudes or latitudes in North America (Ludwig and Rahn, 1943; Rahn, 1940; Trapido, 1940) and Europe (Volsφe, 1944). In some cases it has been interpreted as an adaptation for life in cold regions where the snakes' active season is very short (Klauber, *op. cit.*; Rahn, 1942; Volsφe, *op. cit.*). However, the phenomenon was first noted, and named Amphigonia Retardata, by Kopstein (*op. cit.*), who found it in 3 tropical snake species of the Malayan region. An impressive case of Amphigonia Retardata was that of a *Drymarchon corais couperi* (closely related to the British Honduras *D. c. melanurus*) that, after more than 4 years in solitary confinement, produced one or more fertile eggs (Carson, 1945). Even more remarkable was the case of a *Leptodeira septentrionalis polysticta* (a snake found in British Honduras) that continued to lay fertile eggs for at least 5 years after the last possible copulation (Haines, 1940). Amphigonia Retardata may be widespread among tropical snakes, and is of obvious survival value to these ecologically restricted reptiles. Snakes of British Honduras, like those of the tropics generally, are apt to be confined to one or a few plant communities, and within the community to be still further confined to one or a few microhabitats such as tree holes, clustered epiphytes, dense thickets, palm leaf axils, rotting stumps and logs, vines and leafy twigs, streams and ponds, exfoliated shale, leaf litter, ant hillocks, and ground burrows (Neill and Allen, 1959a). Populations of a given species are apt to be small and widely scattered, and it might often be difficult for a male in breeding condition to find a mate. The possible occurrence of Amphigonia Retardata in snakes of British Honduras is not incompatible with indications of a definite breeding season there. On the contrary, fertilization by means of stored sperm, soon after emergence in the spring, is apt to be more precisely timed than fertilization by copulation. The latter occurs only when a male, psychologically and physiologically ready for breeding, locates and successfully mates with a receptive female; whereas fertilization by stored sperm involves only readiness for such on the part of the female.

One supposes that the present reproductive cycle of snakes in British Honduras is not a very recent development. In past times the cycle may have been even more imperative than at present. Foraminiferal studies, summarized in Neill (1957), imply that the surface waters of the Caribbean were cold during the last glaciation; and evidence from many fields suggests that, during Pleistocene glacial maxima, the boundary between north temperate and tropical climate retreated southward, bringing "subtropical" conditions (like those of, say, present-day central Georgia) to what is now British Honduras (Dorf, 1959). If Hibbard (1960) is correct in believing that the Wisconsin was the coldest of glaciations, then in very recent times, geologically speaking, the snakes of British Honduras may have been exposed to truly cold winters (assuming that they did not retreat southward as the climate grew colder).

SUMMARY

The snakes of British Honduras appear to have a well defined reproductive cycle, with oviposition mostly around late spring or summer, and hatching or birth mostly around late summer or fall. It is believed that the temperatures of the British Honduras winters, while mild by temperate-zone standards, are sufficiently low to curtail the activities of the cold-sensitive local snakes. If so, then the reproductive cycle of snakes in that country, as in the United States, may be thought of as, ultimately, an adjustment to the ophidian necessity of avoiding unfavorable temperatures of winter. The cycle may be engendered, proximately, by a decrease (not necessarily a total cessation) of activity during the period

from December through February, when the usual northeast trade winds are replaced by the colder "northers."

The phenomenon of Amphigonia Retardata is not incompatible with the existence of a distinct breeding season among snakes of British Honduras.

It is probable that British Honduras had a more pronounced cold season during peaks of Pleistocene glaciation, including the Wisconsin.

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TABLE I.

British Honduras snakes in the author's collection, and the months in which they were collected.[1]

Month	Feb.	Apr.	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Species									
Boa constrictor imperator		4		3			1	1	
Bothrops atrox		2						1	
Bothrops nummifer					1	2	1	1	
Clelia clelia							1		
Coniophanes imperialis clavatus							1		
Coniophanes schmidti									1
Conophis concolor		1							
Conophis lineatus dunni[2]		1					1		
Crotalus durissus tzabcan	1	1				1			
Dipsas brevifacies								1	
Drymarchon corais melanurus							1		
Drymobius m. margaritiferus		3					2		
Lampropeltis doliata polyzona		1							
Leptodeira septentrionalis polysticta				1	1				
Leptophis ahaetulla praestans		1			1				
Leptophis mexicanus subspecies[3]						1	1	2	
Masticophis m. mentovarius				1					
Micrurus affinis alienus		1		3					
Ninia s. sebae				4			7	1	
Oxybelis a. aeneus		1				1			
Oxybelis fulgidus							1		
Oxyrhopus petola			1						
Scaphiodontophis a. annulatus				1					
Spilotes pullatus mexicanus				2		1		1	
Stnorrhina f. freminvillei				1					
Tantilla canula brevis		1							
Thamnophis praeocularis		1							
Thamnophis sauritus rutiloris		1		2			1		
Tretanorhinus nigroluteus lateralis		2							

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[1] Collecting was not done in January, March, or May.

[2] *Conophis concolor* and *C. lineatus dunni* are tabulated separately, but are suspected of being color phases of a single form (Neill and Allen, 1961a: 45-46).

[3] The subspecific status of British Honduras *Leptophis mexicanus* has been discussed elsewhere (Neill and Allen, 1962: 86-87); for present purposes the local population may be considered homogeneous.

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THE QUARTERLY JOURNAL OF THE FLORIDA
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OSTEOMETRIC DATA FOR THE FLORIDA BLACK BEAR[1]

RICHARD F. HARLOW[2]
Florida Game and Fresh Water Fish Commission

INTRODUCTION

The Florida black bear, *Ursus americanus floridanus* (Merriam), has been reported as being a larger form of black bear than *Ursus americanus americanus* (Pallas) by Merriam (1896), Anthony (1928), and Hamilton (1939).

However, it appears that this conclusion has been based upon a relatively small number of skulls, and that detailed osteometric data on an adequate sample of sexed and aged skulls of the Florida black bear have not heretofore been available.

Objectives are to present sex and age differences based on cranial measurements of Florida black bear populations, and to compare the skull data of Florida bear with the same cranial measurements collected from Virginia black bear populations.

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[1] A contribution from Pittman-Robertson Project, Florida W-41-R.

[2] Material contributions to the completion of this paper came from the following list of people and agencies: Dr. H. B. Sherman, DeLand, Florida, Dr. James N. Layne, Biology Department, University of Florida, Gainesville, Florida, Dr. Warren F. Jones, Jr., Psychology Department, Stetson University, DeLand, Florida, Mr. Lute H. Harmon and Mr. J. Patrick Figley, students at Stetson University, DeLand, Florida, Dr. Henry S. Mosby, Professor of Game Management and Dr. Burd McGinnes, Wildlife Research Unit, Virginia Polytechnic Institute, Blacksburg, Virginia, Mr. Charles Clymore, Regional Manager, Florida Game and Fresh Water Fish Commission, Lake City, Florida, Mr. R. E. Equivilley, Aripeka, Florida, Mr. Stan B. Wade, New Port Richey, Florida, all Florida Game and Fresh Water Fish Commission employees who assisted this project in any way, the E. Ross Allen and Wilfred T. Neil Museum, Reptile Institute, Silver Springs, Florida, and the U. S. National Museum, Smithsonian Institution, Washington, D. C.

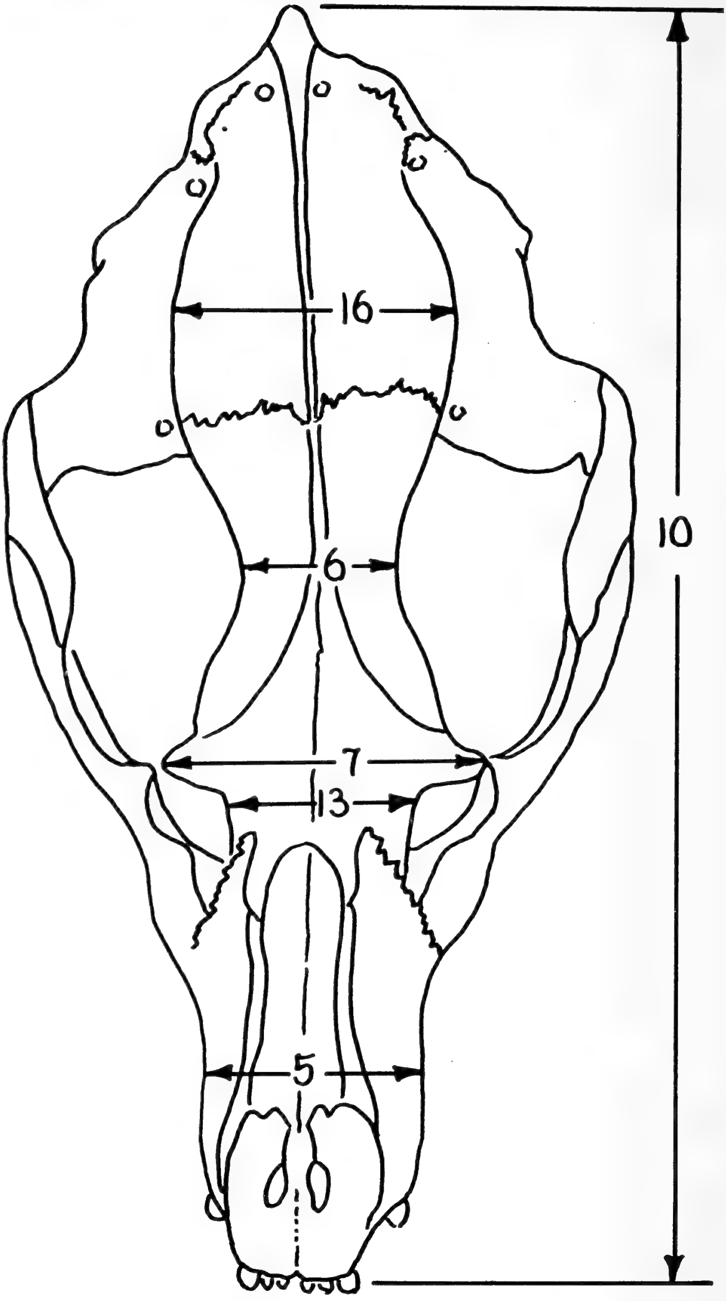

Fig. 1. Selected cranial measurements of the Florida black bear (Dorsal View).

MATERIALS AND METHODS

Florida skull specimens were obtained principally from the following sources: University of Florida Collections at Gainesville, Florida; E. Ross Allen and Wilfred T. Neil Museum, Reptile Institute, Silver Springs, Florida; U. S. National Museum, Smithsonian Institution, Washington, D. C.; and Mr. R. E. Equivilley, Aripeka, Florida. A total of 60 Florida bear skulls were obtained from widely separated locations within the state and reliable information collected on sex and location of kill of 27 adult male and 15 adult female specimens. An equal number of Virginia male and female bear skulls were selected for comparison from a total of 160 black bear skulls belonging to the Virginia Polytechnic Institute's Wildlife Research Unit at Blacksburg, Virginia. A majority of the Virginia skulls were from young animals (2½-3½ years old) based on the aging technique used. An attempt was made to select adult bear skulls.

A recent paper by Rausch (1961) on growth of Alaskan black bear reports condylo-basal and zygomatic breadth data on a large number of skulls. This material has been compared with the same measurements on Florida and Virginia specimens.

Aging of the Florida and Virginia black bear skulls was based on teeth wear, degree of closure of skull sutures, and degree of ridge development on the masseteric fossa. This aging method is the same as that reported on by Stickley (1957).

A number of the skull measurements are those suggested by Thomas (1905), while others are original.

Following is a list of the cranial measurements employed. These are illustrated in Figures 1, 2, and 3.

SELECTED CRANIAL MEASUREMENTS OF THE FLORIDA BLACK BEAR

1. Condylo-basal length—from the posterior end of the occipital condyle to the anterior end of the premaxillary.
2. Posterior end of molars to anterior end of premaxillary.
3. Mastoid breadth.
4. Greatest zygomatic breadth.
5. Greatest width of rostrum.
6. Least interorbital construction.
7. Width of skull over post-orbital processes.

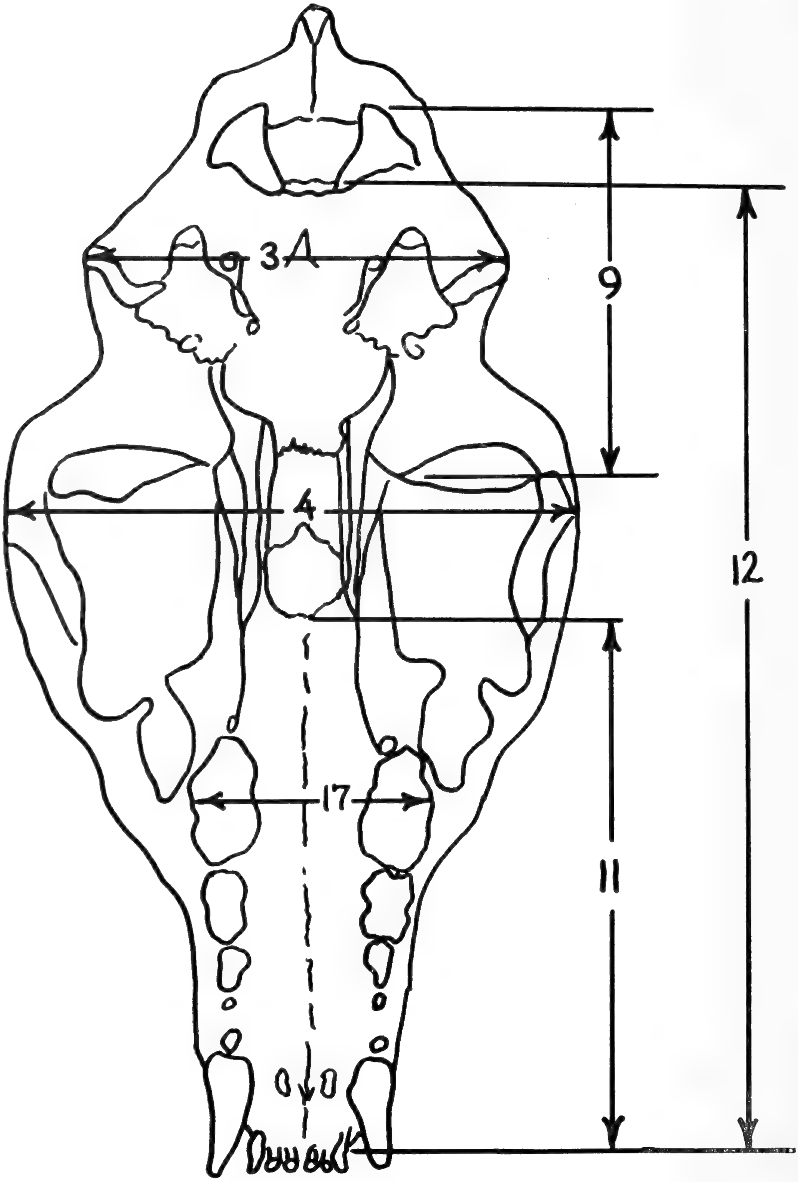

Fig. 2. Selected cranial measurements of the Florida black bear (Ventral View).

8. Width of canine at level of alveolus where it leaves the premaxillary.
9. Bottom of fossa socket of squasmosa to the most posterior point of the occipital condyle.
10. Greatest length of cranium—from the posterior point of the keel to the anterior end of the premaxillary.

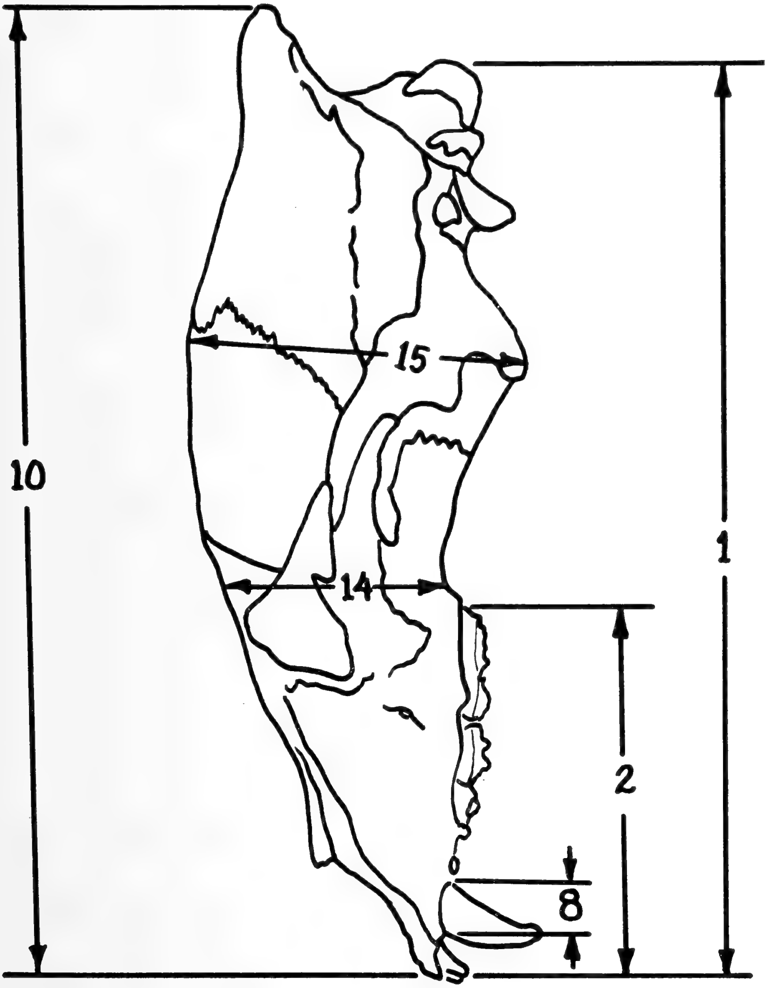

Fig. 3. Selected cranial measurements of the Florida black bear (Lateral View).

11. Palatilar length.
12. Basilar length.
13. Width of frontal just anterior to post-orbital processes.
14. Height of skull directly posterior to molar ridge (ventral) to over the post-orbital processes (dorsal).
15. Height of the cranium from the bottom of the fossa socket of squasmosa (ventral) to the point where the sutures meet on the dorsal part of the cranium which divides the frontal and parietal plates.
16. Cranial width (brain case).
17. Breadth of molar teeth measured across M_3.

Tables 1 and 2 illustrate the difference between the sexes in measurements 1 through 17.

Condylo-basal length and zygomatic breadth of Florida and Virginia black bear skulls, in both sexes, averaged larger than the Alaskan black bear skulls reported on by Rausch (*op. cit.*).

Table 3 compares skull sizes of Virginia, Florida, and Alaskan black bear.

RESULTS

Analyses of the significance of the difference between male and female Florida skulls were run, by calculating confidence intervals $(\bar{X} \pm t.05.\ s_{\bar{X}})$, on measurements 3, 4, 10, 12, and 15. These particular measurements appeared to show a greater difference between the sexes than other measurements taken. Measurement 3 showed a significant difference at the .95 percent level with males averaging larger than females. Measurements 4, 10, and 15 were significantly larger in male bears at the .99 percent level. The most pronounced difference between male and female skulls is found in measurement 15, which is the height of the cranium from the bottom of the fossa socket of squasmosa (ventral) to the point where the sutures between the frontal and parietal bones meet on the dorsal point of the cranium. The only measurement with no overlap between males and females is number 12, basilar length. However, number 12 was significant at only the .90 percent level. Rausch (*op. cit.*) in studies on Alaskan black bears found a significant, but slight, difference in ratio of condylo-basal length to zygomatic width ($P = 0.06$) existing between males and females.

TABLE 1

COMPARISON OF ADULT MALE AND FEMALE FLORIDA BLACK BEAR SKULLS WITH ADULT MALE AND FEMALE VIRGINIA BLACK BEAR SKULLS ON THE BASIS OF SEVENTEEN CRANIAL MEASUREMENTS (mm).

		MALES				FEMALES			
State	Meas.	N	M	m	Range	N	M	m	Range
Florida	1	18	288.33	3.57	263-318*	12	251.75	3.36	226-263*
Virginia	1	15	277.07	3.91	250-304	13	241.31	1.95	234-256
Florida	2	26	122.58	1.00	114-134	15	111.53	0.99	106-118
Virginia	2	27	121.00	1.04	110-132	17	110.12	1.18	102-118
Florida	3	25	136.40	1.88	123-156**	13	115.92	2.29	97-124
Virginia	3	21	127.95	2.31	112-150	14	110.93	1.79	105-121
Florida	4	24	177.63	2.42	157-196*	13	153.31	2.73	128-168
Virginia	4	16	167.85	3.51	146-198	14	146.57	2.18	130-159
Florida	5	27	62.96	0.07	57-71	15	55.47	0.79	51-59**
Virginia	5	27	58.74	0.54	55-67	17	51.88	0.52	49-56
Florida	6	26	67.08	0.69	61-72	13	65.31	0.77	61-70*
Virginia	6	25	65.80	0.61	57-70	16	62.19	0.88	56-67
Florida	7	26	100.31	2.15	82-120	15	86.40	1.70	71-95**
Virginia	7	26	91.58	1.53	75-105	17	79.88	1.36	70-87
Florida	8	26	20.38	0.41	17-28	15	17.33	3.21	15-19
Virginia	8	27	19.67	0.43	16-25	17	16.82	0.34	15-20
Florida	9	18	107.17	1.42	99-120**	12	89.67	1.61	82-96*
Virginia	9	15	100.33	1.90	88-113	14	85.36	1.22	80-96

TABLE 1—Continued

COMPARISON OF ADULT MALE AND FEMALE FLORIDA BLACK BEAR SKULLS WITH ADULT MALE AND FEMALE VIRGINIA BLACK BEAR SKULLS ON THE BASIS OF SEVENTEEN CRANIAL MEASUREMENTS (mm).

		MALES				FEMALES			
State	Meas.	N	M	m	Range	N	M	m	Range
Florida	10	25	309.00	3.20	282-349**	14	264.71	3.29	235-285*
Virginia	10	24	287.67	3.32	262-317	16	255.25	1.81	243-271
Florida	11	23	143.91	0.99	132-157	14	128.64	1.31	118-136
Virginia	11	19	141.89	1.78	131-154	16	126.81	1.19	119-136
Florida	12	20	268.15	2.96	249-299	12	235.17	3.30	211-246**
Virginia	12	18	259.22	3.57	235-286	15	226.80	2.07	218-240
Florida	13	26	73.38	1.39	60-87**	15	64.20	1.12	56-72*
Virginia	13	26	67.92	0.75	60-74	17	60.00	0.81	55-64
Florida	14	24	90.00	1.57	75-105	15	77.33	1.32	72-88**
Virginia	14	26	86.23	1.26	75-98	17	72.06	0.98	67-76
Florida	15	25	123.96	2.06	105-152**	14	101.00	1.38	85-107*
Virginia	15	24	110.00	1.48	101-122	15	94.13	1.18	88-102
Florida	16	23	89.04	1.61	84-93	14	86.43	0.63	83-90
Virginia	16	23	88.39	0.72	82-97	15	86.13	0.70	80-90
Florida	17	26	72.92	0.63	69-81**	14	69.07	1.13	61-77
Virginia	17	26	71.65	0.53	65-77	15	66.81	0.80	61-72

* Sig. at the .95 percent level.
** Sig. at the .99 percent level.

TABLE 2

RATIO OF SELECTED CRANIAL MEASUREMENTS (mm) OF ADULT MALE AND FEMALE FLORIDA AND VIRGINIA BLACK BEARS

State	Ratio	Male	Female
Florida	Basilar length (Measurement No. 12) to	.23	.23
Virginia	mid-point width of rostrum (Measurement No. 5)	.23	.23
Florida	Basilar length to	.50	.49
Virginia	mastoid breadth (Measurement No. 3)	.50	.48
Florida	Basilar length to	.66	.65
Virginia	zygomatic breadth (Measurement No. 4)	.65	.65
Florida	Basilar length to	.25	.28
Virginia	least interorbital construction (Measurement No. 6)	.25	.27
Florida	Basilar length to	.37	.36
Virginia	distance across post-orbital processes of frontal (Measurement No. 7)	.36	.35
Florida	Basilar length to	.33	.33
Virginia	height of skull (Measurement No. 14)	.33	.32
Florida	Basilar length to	.27	.27
Virginia	width of frontal (Measurement No. 13)	.25	.26
Florida	Basilar length to	.46	.42
Virginia	height of skull (Measurement No. 15)	.42	.41
Florida	Basilar length to	.28	.29
Virginia	width of palate (Measurement No. 17)	.28	.29
Florida	Basilar length to	.46	.48
Virginia	measurement No. 2	.46	.48
Florida	Basilar length to	.39	.38
Virginia	measurement No. 9	.39	.37
Florida	Basilar length to	.53	.54
Virginia	palatilar length (Measurement No. 11)	.55	.54
Florida	Basilar length to	.33	.36
Virginia	cranial width (Measurement No. 16)	.34	.37
Florida	Greatest length of cranium (No. 10) to	.57	.57
Virginia	zygomatic breadth (No. 14)	.58	.57

Ratios of skull measurements of the Florida and Virginia populations were similar.

TABLE 3

COMPARISON OF SKULL SIZES OF VIRGINIA, FLORIDA, AND ALASKAN MALE AND FEMALE BLACK BEAR ON THE BASIS OF CONDYLO-BASAL LENGTH AND ZYGOMATIC BREADTH

		MALES						FEMALES					
	Age	Condylo-Basal Length			Zygomatic Breadth			Condylo-Basal Length			Zygomatic Breadth		
State	class	N	M	Range	N	M	Range	N	M	Range	N	M	Range
Florida	2½—13+	18	288	263-318	24	178	157-196	12	252	226-263	13	153	128-168
Virginia	2½—13+	15	277	250-304	20	168	146-198	13	241	234-256	14	147	130-159
Alaska	5—10	81	263	225-297	81	162	124-184	43	234	216-256	43	140	118-156

DISCUSSION

A possible influence on the larger average size of the Florida bear skull over *Ursus a. americanus* is the continual period of growth experienced by the Florida subspecies. Bears from colder regions evidently go into semi-torpid periods during cold weather (when food is unavailable) and growth is temporarily interrupted. Rausch (*op. cit.*) found that growth is closely correlated with the annual cycle and is limited largely to the period of activity in the Alaskan black bears. He was able to determine the age of individual bears from observing growth zones laid down annually on the roots of canines. The attempts of Spencer (1955) on Maine bear, and Stickley (*op. cit.*) on Virginia bear, to use this method of age determination, were inconclusive.

Although the Florida bear skulls averaged larger than Virginia black bear skulls a comparison of weights between *Ursus a. floridanus* and *Ursus a. americanus* did not show the average weights of Florida bear exceeding the weights of bear from further north.

Weights are extremely variable even in an individual bear depending on the season of the year and the supply of available food as evidenced from a trapping and tagging program conducted on New York bear in 1958.

TABLE 4

AVERAGE DEAD WEIGHTS OF ADULT MALE AND FEMALE BLACK BEAR FROM FLORIDA, NEW YORK, AND NEW HAMPSHIRE

		Weights			
	Age	Males		Females	
State	Class	No.	Ave.	No.	Ave.
Florida	3½+	16	304.7	12	189.2
New York	3½+	49	323.9	19	200.0
New Hampshire	Adults	19	262.9	11	183.1

Florida and Virginia bear skull sizes were also compared by age classes. See Figures 4, 5, 6, and 7. Skull measurements used in the age class comparison were total length (from the posterior point of the keel to the anterior end of the pre-maxillary) and mastoid breadth. These two measurements were selected because there were more samples available than in the more commonly compared measurements condylo-basal length and zygomatic breadth.

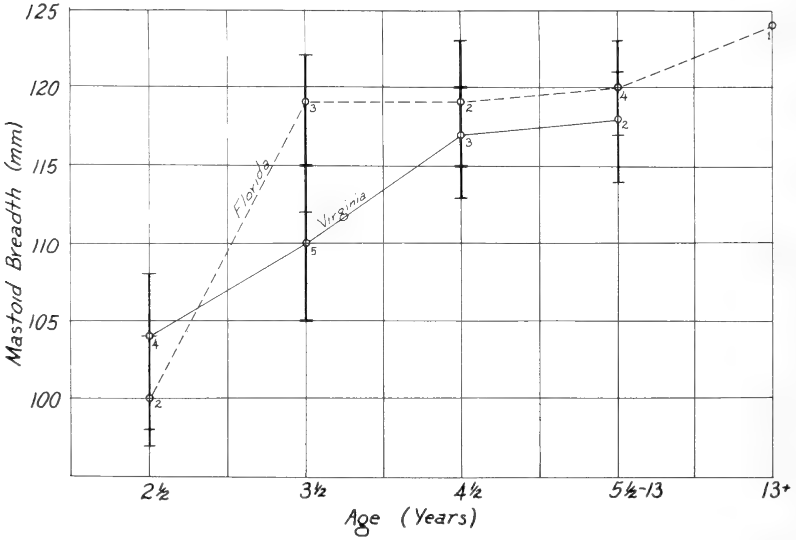

Fig. 4. A comparison of the mean skull size (mastoid breadth) between Virginia and Florida female black bears by age class.

Mean skull sizes of Florida bears averaged larger than the Virginia bears in both sexes in all but the 2½ (female) and 5½-13—length only—(male) age classes. In the 5½-13 year age class, Virginia and Florida male bear skulls were very nearly the same in total length with the Virginia skulls averaging but 1 mm longer, hardly a significant difference.

Considerable variation occurred in skull sizes in the same subspecies within a respective age class. These differences are probably due to a combination of environmental and genetic influences. Both the Florida and Virginia skulls were collected from widely separated localities within each state. If the skulls had been selected from isolated populations (one area), age class differences would probably have been less pronounced, and the age class measurements from 2½ and over would, in all probability, demonstrate a more uniform growth pattern. It is also possible that the probable error in the aging technique contributed to the skull size differences within the same age classes.

This inconsistancy in growth is particularly noticeable in the mastoid breadth of the male and the total length of the female Virginia bears where the 3½ year age class averages larger than the 4½. It was shown that a wild bear may gain as much as 90 pounds in three weeks when food is plentiful (Black, 1958). Sufficient data on weights of known age black bear from Florida is lacking to be able to draw any conclusions concerning the weight of the Florida subspecies with bear from further north. From the little data available it appears that although *Ursus a. floridanus* skulls may average slightly larger than *Ursus a. americanus* weights between the two subspecies are not significantly different.

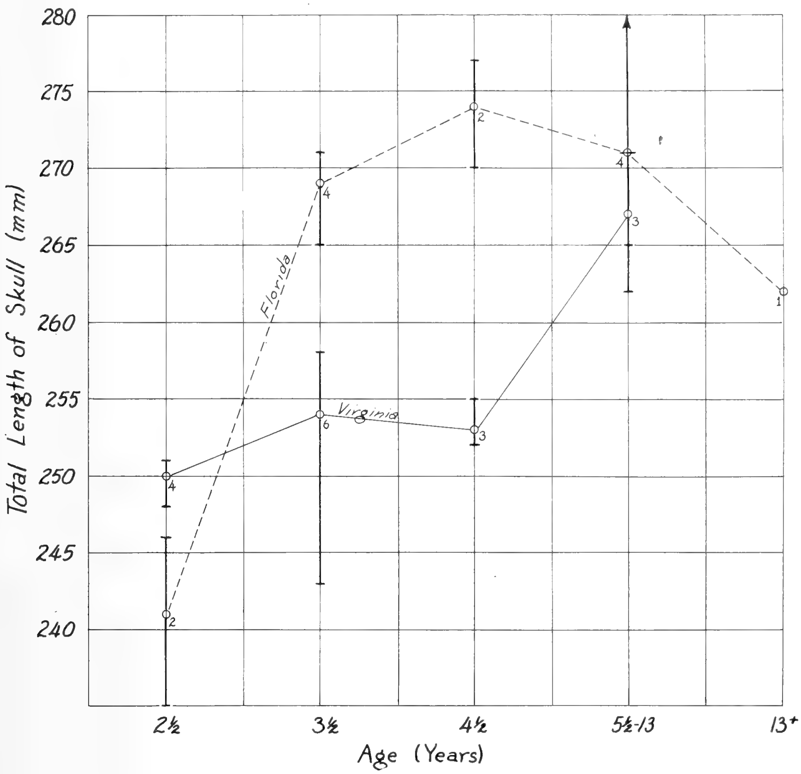

Fig. 5. A comparison of the mean skull size (total length) between Virginia and Florida female black bears by age class.

The largest Florida black bear officially weighed to date was 580 pounds. This large male was captured in Duval County near Jacksonville, Florida in 1954. He had not eaten for seven days before being weighed. The record for a New York bear is 599 pounds. This animal was trapped during the summer of 1958. In 1923 a 633 pound male black bear was killed in Pennsylvania, for their state record. It is evident from these figures that record sized black bear may be found in many states and that from the accumulated evidence one could not justifiably claim that *Ursus a floridanus* averages heavier in weight than *Ursus a americanus* or vice versa.

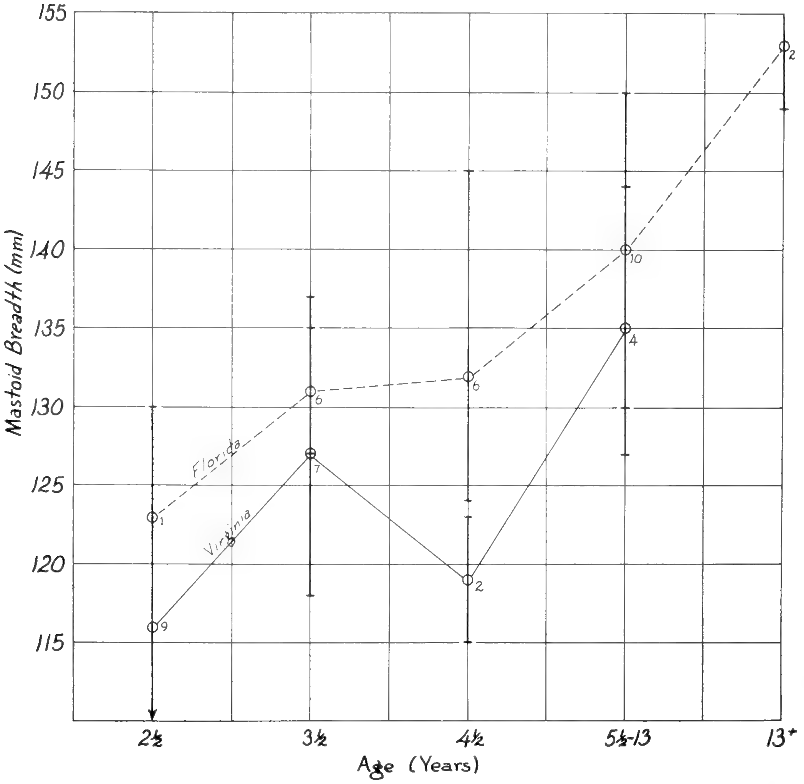

Fig. 6. A comparison of the mean skull size (mastoid breadth) between Virginia and Florida male black bears by age class.

Bergmann's rule[3] states that animals representative of the same species tend to be larger in the northern part of their range. This is because animals give off a certain amount of heat per unit area, and in the north where temperatures are lower they have increased their body weight, or mass, to cut down on heat loss. The black bear may prove to be an exception to Bergmann's rule. At least data to date suggests that black bear from warmer regions may weigh as much, and be as large, as black bear from the colder regions.

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[3] See Simpson, Literature Cited.

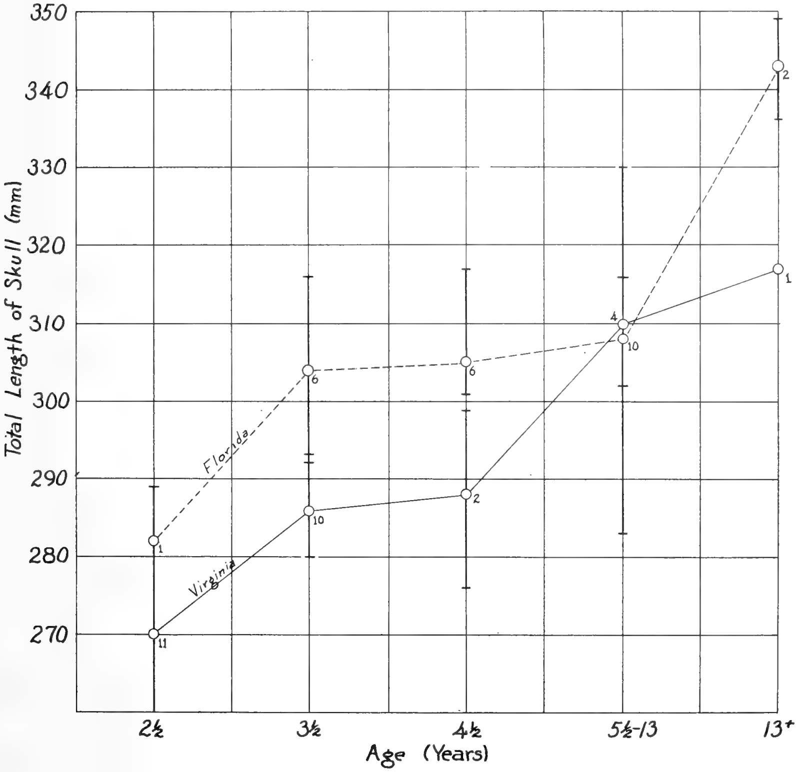

Fig. 7. A comparison of the mean skull size (total length) between Virginia and Florida male black bears by age class.

SUMMARY

Seventeen measurements were taken of equal numbers of adult male and female Florida and Virginia black bear skulls. An analysis of the selected measurements reveal a significant difference between both sexes, in the two subspecies, with the Florida male skulls averaging larger at the .95 percent level in measurements 1 and 4, and at the .99 percent level in measurements 3, 9, 10, 13, 15, and 17. The skulls of the female Florida bears are larger than the Virginia skulls at the .95 percent level in measurements 1, 6, 9, 10, and 13, and larger at the .99 percent level in measurements 5, 7, 12, 14, and 15.

When the skulls were grouped by age classes and compared in total length and mastoid breadth, mean skull size of the Florida bears averaged larger in both sexes in all but the 2½ (female) and 5½-13 male (length only) age classes. In the 5½-13 year age class (male), the Virginia skulls averaged only 1 mm longer.

Ratios of the skull measurements were very nearly the same between both populations.

Although there is overlap in skull measurements between both male and female Florida and Virginia black bears, even within respective age classes, I feel that if a mixed series of known age adult Florida and Virginia bear skulls were exhibited, I could separate the Florida skulls, on a measurement basis, with 70 percent accuracy.

A comparison of condylo-basal and zygomatic breadth measurements of Florida, Virginia, and Alaskan black bear skulls (both sexes) showed the Florida bears averaging the largest with Virginia bears next, and the Alaskan bears smallest.

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NOTES ON THE ALGAE OF THE CORAL REEFS, OFF LA PARGUERA, PUERTO RICO[1]

LUIS R. ALMODOVAR
University of Puerto Rico

La Parguera, a fishing village in the southern coast of Puerto Rico, is located between Guanica and Cabo Rojo. The region is characterized by a series of coral reefs which form two crescent-shaped arcs scattered over an area of some 30 miles. (See figure 1) During the past years several reports as those of Allen (1957), Burkholder and Burkholder (1958), Burkholder, Burkholder and Rivero (1959), Odum, Burkholder and Rivero (1959), Margalef (1959), Goreau and Goreau 1960, and Burkholder and Burkholder (1960) have dealt with several aspects related to coral reefs, however, little attention has been given as to the distribution, taxonomy, and ecology of the marine algal flora of this area. It was with this idea in mind that this study was undertaken.

METHODS

Twenty reefs were visited during January-May 1959 for collecting algae. The area was studied again in September-December 1960. Collections of algae were gathered in plastic bags and in eight ounce bottles. Materials were preserved in three per cent sea-water formalin solution. Later, the algae were taken to the laboratory for microscopic examination. Herbarium specimens were made at this time.

Transects were investigated in September-December 1960. The method used was as follows: A strong cord was properly marked at 10 feet intervals up to 300 feet. The cord was fastened to rocks or to a pole in dry land whenever available. Then, readings as to depth, substrate composition, and kinds of algae were recorded up 25 feet of water. A total of 60 transects were investigated.

The reef was divided into two zones: windward and leeward. Two readings were taken on the windward and three on the later. Data was gathered by swimming using a snorkel, face mask, and

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[1] A contribution from a study of the marine algae of Puerto Rico supported by National Science Foundation Grant 14020.

fins. A piece of plastic board 12″ x 8″ fitted with a float was found suitable to record all pertinent information.

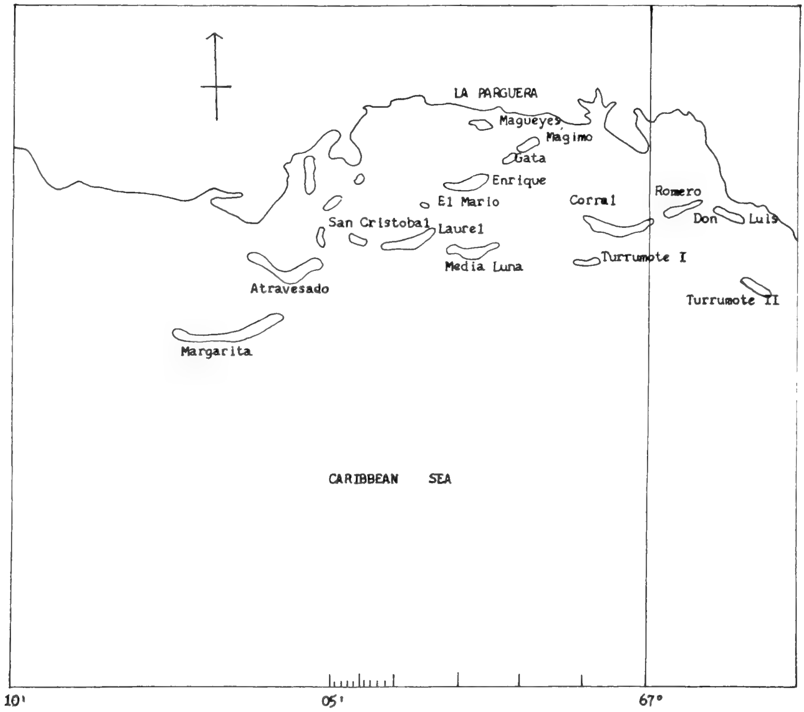

Figure 1.

Observations

The two arcs of coral reefs which surround La Parguera can be divided into two types:

Type A. The oceanic reefs, some 10 miles off shore, are characterized by the lack of phanerogamic vegetation, little or no dry land, except at low tide, and with strong surf in the windward side. The transparency of the waters is that of normal open seas.

Type B. The reefs which form the inner arc comprise those beginning to show an invasion of higher plants. In most cases there is dry land where *Rhizophora, Avicennia,* and *Laguncularia* form extensive growths.

Deep Water (Over 5′)	Living Corals (no algae found)	South
Shallow Water 1′ - 4′ (Strong Wave Action)	*Polysiphonia* *Halimeda opuntia* *Wrangelia argus* *Caulerpa racemosa* *Laurencia obtusa* *Laurencia papillosa* *Cladophoropsis membranacea* *Centroceras clavulatum*	WINDWARD
Blue-green Belt (Rocks wash by spray)		Dry land-Variable (Sometimes awash)
Mangroves (*Rhizophora* & *Avicennia*)	On roots: *Bryopsis pennata* *Bostrychia tenella* *Acanthophora* *Centroceras* *Valonia ventricosa*	LEEWARD
Porites Zone	On living *Porites*: *Valonia ventricosa* *Halimeda opuntia* *Ceramium nitens* On sandy pockets, hot pools, and in muddy sand: *Penicillus capitatus* *Udotea flabellum* *Halimeda monile* *Halimeda opuntia* *Caulerpa cupressoides*	*Thalassia* will invade *Porites* and clear calcareous backreef forming extensive meadows
Calcareous Backreef	On shells, rocks, etc. *Acanthophora spicifera* *Laurencia obtusa* *Dictyota divaricata* *Caulerpa sertularioides* *Coelothrix irregularis*	
Deep Water (Over 25′)		North

Fig. 2. Cross section diagram illustrating algal zonation on reef.

The windward shore showed the same pattern in all reefs. It is nearly devoid of algae at depths of over three feet. Small clumps of *Polysiphonia ferulacea* were collected growing on broken tips of *Acropora palmata, Halimeda opuntia, Wrangelia argus, Caulerpa racemosa, Ceramium nitens,* and stutted *Laurencia obtusa* were found attached to *Porites* and on rocks at depths of three to four feet of water. Extensive growths of *Laurencia papillosa, Cladophoropsis membranacea,* and *Centroceras clavulatum* grow in the splash zone. They are common on dead corals and other calcareous debris piled-up by wave action. These algae form a narrow belt which is exposed at low tide. High above tide line there is the blue-green belt composed of *Hydrocoleum, Lyngbya, Oscillatoria,* and *Hormothamnion enteromorphoides. Valonia ventricosa* is collected frequently among *Halimeda opuntia* and *Porites.* The bladders are twisted and smaller than those on mangrove roots. A cross section diagram of the area is given in figure 2.

The leeward side on the contrary, shows greater diversity of species. The area consists of expanse shallow water with an ever-changing substrate. *Penicillus capitatus, Udotea flabellum, Caulerpa cupressoides, Hypnea spinella, Spyridia filamentosa, Acanthophora spicifera,* and *Caulerpa sertularioides,* were collected in places where loose sand and mud accumulate and in hot shallow pools. Sand is composed for the most part by fragments of *Halimeda opuntia.* (See figure 2).

A marine phanerogam, *Thalassia testudinum* grows abundantly along the north-western shore of the reef. The plants produce runners which attach tenaciously to loose pieces of dead corals, shells, and other debris, forming extensive meadows. These meadows were observed growing past 25 feet of water.

On big rocks and corals in various stages of death, several forms such as *Coelothrix irregularis, Amphiroa fragilissima, Valonia ventricosa,* and *Dictyosphaeria cavernosa* are found. These live among *Thalassia* also.

The following algae were observed as epyphytes on *Thalassia* leaves: *Dictyota divaricata, Dictyota bartayresii, Rhizoclonium,* and *Ceramium byssoideum.*

On the roots of *Rhizophora mangle* and *Avicennia nitida* the commonest algae are: *Bryopsis pennata, Codium isthmocladum, Valonia ventricosa, Centroceras clavulatum,* and *Bostrychia tenella.*

A total of 52 entities were found. Of these, six are reported for first time for Puerto Rico so far as known. The Cyanophyta has been omitted.

Catalogue of Species

Abbreviations used to designate the location of specimens conform to those proposed in the Index Herbariorum, Part 1, Ed. 4 (1959). Exceptions (not found in the Index) are indicated by an asterisk. They are as follows: *COL- Herbarium Lamont Geological Laboratory, *D- Herbarium of Francis Drouet, DUKE- Herbarium of Duke University, *IMB- Algal Herbarium, Institute of Marine Biology, University of Puerto Rico, L- Rijksherbarium, Leiden, NY- The New York Botanical Garden, UC- University of California, US- U.S. National Museum.

Names with an asterisk indicate that this is the first published record from Puerto Rico.

CHLOROPHYTA

Ulvaceae

Ulva lactuca L. var. rigida (C. Ag.) Le Jolis

On shells, etc., Cayo Terremoto, *Almodovar 3408,* 27 Jan. 1959 (IMB); on shells, rocks, etc., north shore, Cayo Romero, *Almodovar 3446,* 3 Feb. 1959 (D, DUKE, IMB, NY).

Cladophoraceae

Chaetomorpha clavata (C. Ag.) Kutzing

In mount of dead corals and rocks, forming erect tufts, strong wave action, Cayo Terremoto, *Almodovar 3392,* 27 Jan. 1959 (IMB, NY); in shallow water, mount of dead corals, Cayo Terremoto, *Almodovar 3525,* 7 May 1959 (D, DUKE, IMB, NY); on rocks, in the surf, Cayo Terremoto II, *Almodovar 3597,* 14 May 1959 (IMB).

Rhizoclonium riparum (Roth) Harvey

Floating in large masses, Cayo El Magimo, *Almodovar 3478,* 10 Feb. 1959 (IMB, NY).

Bryopsidaceae

Bryopsis pennata Lamouroux

On rocks, in the surf, mount of dead corals, Cayo Terremoto, *Almodovar 3397,* 27 Jan. 1959 (D, DUKE, IMB, NY); On *Rhizophora* roots, Cayo El Magimo, *Almodovar 3466,* 10 Feb. 1959 (D, DUKE, IMB, NY); on log, among corals, Cayo Terremoto, *Almodovar 3543,* 7 May 1959 (IMB).

Codiaceae

Codium isthmocladum Vickers

Attached to mangrove roots, Cayo Romero, *Almodovar 3448,* 3 Feb. 1959 (IMB).

Avrainvillea rawsoni (Dickie) M. A. Howe

Among *Thalassia,* in muddy sand, forming a felt-like carpet over a large area, south-western shore, Cayo Don Luis, *Almodovar 3552,* 12 May 1959 (D, DUKE, IMB, NY).

Halimeda opuntia (L.) Lamouroux

In shallow water, north shore, Cayo Terremoto, *Almodovar 3407,* 27 Jan. 1959 (DUKE, IMB, NY); on dead corals, in strong surf, Cayo Enrique, *Almodovar 3436,* 30 Jan. 1959 (IMB); on rocks, corals, and sand, Cayo Romero, *Almodovar 3457,* 3 Feb. 1959 (IMB); on rocks, corals, and in sand, Cayo Margarita, *Almodovar 3499,* 5 May 1959 (IMB; forming dense clusters among corals, in the surf, Cayo Terremoto II, *Almodovar 3579,* 14 May 1959 (IMB).

Halimeda monile (Ellis and Solander) Lamouroux

In muddy sand, shallow water, Cayo Laurel, *Almodovar 3417,* 29 Jan. 1959 (IMB).

Penicillus capitatus Lamarck

Muddy sand, Cayo Laurel, *Almodovar 3425,* 29 Jan. 1959 (IMB); on dead corals and in mud, Cayo Enrique, *Almodovar 3433,* 30 Jan. 1959 (IMB); in muddy sand, north shore, Cayo Romero, *Almodovar 3459,* 3 Feb. 1959 (IMB); on sand, Cayo Don Luis, *Almodovar 3558,* 12 May 1959 (IMB).

Udotea flabellum (Ellis and Solander) Lamouroux

Between rocks and muddy sand, 4 feet of water, Cayo Margarita, *Almodovar 3497,* 5 May 1959 (IMB, NY).

Valoniaceae

Valonia aegagropila C. Agardh

Protected lagoon, *Laguncularia* and *Rhizophora* roots, Cayo Don Luis, *Almodovar 3561,* 12 May 1959 (D, DUKE, IMB, NY).

Valonia ventricosa J. Agardh

On rocks and mangrove roots, Cayo El Magimo, *Almodovar 3479,* 10 Feb. 1959 (IMB); in protected shallow water, north shore, Cayo Terremoto, *Almodovar 3523,* 7 May 1959 (IMB).

Dictyosphaeria cavernosa (Forsk.) Børgesen

On rocks, in about 6 feet of water, Cayo Romero, *Almodovar 3449,* 3 Feb. 1959 (D, DUKE, IMB, NY); on rocks, Cayo Margarita, *Almodovar 3490,* 5 May 1959 (IMB); on rocks, Cayo Don Luis, *Almodovar 3556,* 12 May 1959 (IMB, NY); on dead corals, north shore, Cayo Terremoto II, *Almodovar 3578,* 14 May 1959 (D, DUKE, IMB, NY).

Cladophoropsis membranacea (Ag.) Børgesen

On rocks, beaten by waves, Cayo Terremoto, *Almodovar 3401,* 27 Jan. 1959 (IMB, NY); forming dense clusters on rocks, in the surf, south shore, Cayo Margarita, *Almodovar 3485,* 5 May 1959 (IMB, NY); on dead corals, high above l.t.m., Cayo Terremoto, *Almodovar 3526,* 7 May 1959 (IMB); on sand, Cayo Don Luis *Almodovar 3549,* 12 May 1959 (IMB); on rocks in the surf, Cayo Terremoto II, *Almodovar 3596,* 14 May 1959 (IMB).

Caulerpaceae

*Caulerpa cupressoides (West) C. Agardh var. flabellata Børgesen

In about 6 feet of water, north shore, Cayo Terremoto, *Almodovar 3527,* 7 May 1959 (IMB).

Caulerpa cupressoides (West) C. Agardh var. *typica* Weber van Bosse

On sand, Cayo Laurel, *Almodovar 3422,* 29 Jan. 1959 (DUKE, IMB, NY); in muddy sand, among *Thalassia,* Cayo Romero, *Almodovar 3450,* 3 Feb. 1959 (DUKE, IMB, NY); in muddy sand, north shore, Cayo El Magimo, *Almodovar 3475,* 10 Feb. 1959 (IMB); on sand, rocks and dead *Porites,* Cayo Margarita, *Almodovar 3487,* 5 May 1959 (DUKE, IMB, NY).

Caulerpa racemosa (Forsk.) J. Agardh var. *clavifera* (Turn.) Weber van Bosse

On rocks, Cayo Enrique, *Almodovar 3432,* 30 Jan. 1959 (IMB); in sandy soil, among *H. opuntia,* Cayo El Magimo, *Almodovar 3480,* 10 Feb. 1959 (IMB); on *H. opuntia,* in strong surf, south shore, Cayo Margarita, *Almodovar 3501,* 5 May 1959 (DUKE, IMB, NY); on mount of dead corals and rocks, in strong surf, Cayo Terremoto, *Almodovar 3524,* 7 May 1959 (D, DUKE, IMB, NY).

Caulerpa racemosa (Forsk.) J. Agardh var. *occidentalis* (J. Agardh) Børgesen

In soft muddy sand, north shore, Cayo Romero, *Almodovar 3455,* 3 Feb. 1959 (DUKE, IMB, NY).

Caulerpa racemosa (Forsk.) J. Agardh var. *uvifera* (Turner) Weber van Bosse

On rocks, beaten by waves, south shore, Cayo Terremoto, *Almodovar 3403,* 27 Jan. 1959 (D, DUKE, IMB, NY).

Caulerpa microphysa (Weber van Bosse) J. Feldmann

On rocks, in 5 feet of water, Cayo Laurel, *Almodovar 3427,* 29 Jan. 1959 (D, DUKE, IMB, NY).

Caulerpa sertularioides (Gmel.) Howe *f. farlowii* (Weber van Bosse) Børgesen

In muddy sand, north shore, Cayo Laurel, *Almodovar 3419,* 29 Jan. 1959 (D, DUKE, IMB, NY); on rocks and in muddy sand, Cayo El Magimo, *Almodovar 3476,* 10 Feb. 1959 (IMB); on sand, between rocks, Cayo Margarita, *Almodovar 3493,* 5 May 1959 (IMB, NY); between dead corals and in sand, Cayo Terremoto II, *Almodovar 3581,* 14 May 1959 (D, DUKE, IMB, NY).

Caulerpa sertularioides (Gmel.) Howe *f. brevipes* (Ag.) Svedelius

In muddy sand, Cayo Laurel, *Almodovar 3420,* 29 Jan. 1959 (D, DUKE, IMB, NY).

Caulerpa sertularioides (Gmel.) Howe *f. longiseta* (Bory) Svedelius

In muddy sand, Cayo Romero, *Almodovar 3445,* 3 Feb. 1959 (DUKE, IMB, NY).

Caulerpa taxifolia (Vahl) C. Agardh

In shallow water, in mud, Cayo El Magimo, *Almodovar 3481,* 10 Feb. 1959 (IMB).

RHODOPHYTA

Chaetangiaceae

Galaxaura lapidescens (Ellis & Sol.) Lamouroux

On rocks, protected lagoon, south shore, Cayo Don Luis, *Almodovar 3559,* 12 May 1959 (DUKE, IMB, NY).

Corallinaceae

Amphiroa fragilissima (L.) Lamouroux

On rocks, in the surf, Cayo Margarita, *Almodovar 3496,* 5 May 1959 (IMB); on rocks, protected lagoon, south shore, Cayo Don Luis, *Almodovar 3560,* 12 May 1959 (IMB); forming pink clusters over rocks, Cayo Romero, *Almodovar, 3568,* 14 May 1959 (IMB).

Amphiroa rigida Lamouroux var. *antillana* Børgesen

In muddy sand, shallow water, Cayo Laurel, *Almodovar 3418,* 29 Jan. 1959 (DUKE, IMB).

Gracilariaceae

Gracilaria ferox J. Agardh

On rocks, in lagoon, Cayo Don Luis, *Almodovar 3562,* 12 May 1959 (IMB).

Gracilaria mammillaris (Mont.) Howe

On rocks, south shore, Cayo Terremoto II, *Almodovar 3595,* 14 May 1959 (IMB).

Hypnaceae

**Hypnea spinella* (Ag.) Kutzing

Entangled with *A. spicifera,* Cayo Terremoto II, *Almodovar 3593,* 14 May 1959 (D, DUKE, IMB, NY).

Rhodymeniaceae

Coelothrix irregularis (Harvey) Børgesen

On rocks, forming large irridescent mats, blue-violet in color, Cayo Terremoto, *Almodovar 3393,* 27 Jan. 1959 (D, DUKE, IMB, NY); on rocks, forming blue-violet irridescent mats, Cayo Laurel, *Almodovar 3423,* 29 Jan. 1959 (D, DUKE, IMB, NY); on rocks, irridescent, Cayo Enrique, *Almodovar 3440*, 30 Jan. 1959 (D, DUKE, IMB, NY); shallow cold water lagoon, Cayo Terremoto II, *Almodovar 3592,* 14 May 1959 (D, DUKE, IMB, NY).

Ceramiaceae

**Ceramium byssoideum* Harvey

On *Thalassia,* Cayo El Magimo, *Almodovar 3477,* 10 Feb. 1959 (IMB).

Ceramium nitens (C. Ag.) J. Agardh

On rocks, in the surf, Cayo Laurel, *Almodovar 3428,* 29 Jan. 1959 (D, DUKE, IMB, NY); on rocks, north shore, Cayo Margarita, *Almodovar 3498,* 5 May 1959 (DUKE, IMB, NY); forming a mat over rocks, Cayo Don Luis, *Almodovar 3565,* 12 May 1959 (D, DUKE, IMB, NY); forming large clumps over rocks and dead corals, Cayo Romero, *Almodovar 3569,* 14 May 1959 (D, DUKE, IMB, NY); on rocks and muddy sand, Cayo Terremoto, *Almodovar 3594,* 14 May 1959 (D, DUKE, IMB, NY).

Centroceras clavulatum (Ag.) Montagne

On rocks, in the surf, Cayo Margarita, *Almodovar 3483,* 5 May 1959 (D, DUKE, IMB, NY); in protected shallow water, north shore, Cayo Terremoto, *Almodovar 3524a,* 7 May 1959 (D, DUKE, IMB, NY).

Spyridia filamentosa (Wulf.) Harvey

On *Thalassia,* Cayo Romero, *Almodovar 3458,* 3 Feb. 1959 (D, DUKE, IMB, NY); on sand, rocks, and dead *Porites,* Cayo Margarita, *Almodovar 3488,* 5 May 1959 (D, DUKE, IMB, NY); on *Thalassia,* Cayo Don Luis, *Almodovar 3567,* 12 May 1959 (DUKE, IMB, NY).

Crouania attenuata (Bonnem.) J. Agardh

Blue-green filaments over sand and on various algae, in the surf, south shore, Cayo Margarita, *Almodovar 3512,* 5 May 1959 (IMB); blue-green tuft over rocks, in the surf, Cayo Terremoto II, *Almodovar 3588,* 14 May 1959 (IMB).

Wrangelia argus Montagne

On rocks, mount of dead corals, strong surf, Cayo Terremoto, *Almodovar 3396,* 27 Jan. 1959 (IMB); on *Halimeda opuntia,* Cayo

Enrique, *Almodovar 3434,* 30 Jan. 1959 (IMB); forming small clumps on rocks, strong surf, Cayo Romero, *Almodovar 3441,* 3 Feb. 1959 (IMB).

Delesseriaceae

Caloglossa leprieurii (Mont.) J. Agardh

On *Rhizophora* roots, Cayo El Magimo, *Almodovar 3465,* 10 Feb. 1959 (D, DUKE, IMB, NY).

Rhodomeliaceae

Acanthophora spicifera (Vahl) Børgesen

In shallow water, protected north shore, Cayo Terremoto, *Almodovar 3406,* 27 Jan. 1959 (D, DUKE, IMB, NY); entangled in *Thalassia,* north shore, Cayo Laurel, *Almodovar 3424,* 29 Jan. 1959 (DUKE, IMB, NY); on rocks, in shallow water, common, Cayo Romero, *Almodovar 3456,* 3 Feb. 1959 (DUKE, IMB, NY); on shells and rocks, Cayo El Magimo, *Almodovar 3469,* 10 Feb. 1959 (D, DUKE, IMB, NY); on rocks, in shallow water, north shore, Cayo Margarita, *Almodovar 3491,* 5 May 1959 (IMB, NY); on rocks and dead *Porites,* Cayo Terremoto II, *Almodovar 3580,* 14 May 1959 (D, DUKE, IMB, NY).

Bostrychia tenella (Vahl) J. Agardh

On mangrove roots, high above the water mark, Cayo Don Luis, *Almodovar 3563,* 12 May 1959 (D, DUKE, IMB, NY).

**Polysiphonia ferulacea* Suhr

On rocks, in the surf, forming dense mats, Cayo Margarita, *Almodovar 3482,* 5 May 1959 (D, DUKE, IMB, NY); on *Acropora,* Cayo Terremoto, *Almodovar 3544,* 7 May 1959 (IMB).

**Polysiphonia howei* Hollemberg

On pneumatophores of *Avicennia,* Cayo Don Luis, *Almodovar 3564,* 12 May 1959 (IMB).

Laurencia obtusa (Huds.) Lamouroux

On rocks, north shore, Cayo Laurel, *Almodovar 3416,* 29 Jan. 1959 (D, DUKE, IMB, NY); attached to *H. opuntia,* Cayo El Magimo, *Almodovar 3464,* 10 Feb. 1959 (IMB); on rocks in strong surf, Cayo Margarita, *Almodovar 3492,* 5 May 1959 (IMB); in shallow water, north shore, Cayo Terremoto, *Almodovar 3522,* 7 May 1959 (DUKE, IMB, NY).

Laurencia papillosa (Forsk.) Greville

On rocks, in strong surf, Cayo Margarita, *Almodovar 3489,* 5 May 1959 (DUKE, IMB, NY); on rocks in strong surf, south shore, Cayo Don Luis, *Almodovar 3554,* 12 May 1959 (DUKE, IMB, NY).

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COMMENTS ON THE NESTING BEHAVIOR OF ATLANTIC LOGGERHEAD SEA TURTLES, BASED PRIMARILY ON TAGGING RETURNS[1]

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Introduction

During 1959, the results of a single season's tagging of the Atlantic loggerhead sea turtle, *Caretta caretta caretta* (Linnaeus), were summarized (Caldwell, *et al.*). Certain generalizations were developed as a result of that first year's work in 1958. These were: (1) Individuals nest several times on the same stretch of beach during a single season. (2) Groups of turtles apparently nest together several times. (3) A turtle interrupted in nesting returns on the same or successive nights until she nests successfully. (4) The usual interval between nestings within the season is 12 to 15 days.

Although fewer turtles per year were tagged (Table 1) than the 72 marked in 1958, recent findings made during subsequent seasons, and reported upon here, substantiate these generalizations (Tables 2, 3 and 4), and a detailed discussion of them is not again necessary. It is my purpose to present other data that add to the overall knowledge of the nesting behavior of the Atlantic loggerhead.

The data of Caldwell, *et al.* (1959: 314) demonstrated that the tagged Atlantic loggerhead turtles always returned to the same beach to nest. Hendrickson (1958) and Carr and Ogren (1960) have discussed a similar behavior for green turtles in the Pacific and Atlantic, respectively.

An unusual situation has developed over the years on the Georgia rookery of which Jekyll Island is presently the principal part. It demonstrates one aspect of loggerhead nesting behavior which undoubtedly will influence any future studies of sea turtles there or comparisons with the present and previously published data.

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[1] Field work supported in part by funds provided by the Georgia Game and Fish Commission.

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TABLE 1

NUMBERS OF ATLANTIC LOGGERHEAD SEA TURTLES TAGGED* AT JEKYLL ISLAND, GEORGIA, IN 1959, 1960 AND 1961.

		1959			
3 June	4	14 June	2	7 July	2
9 June	1	18 June	1	8 July	1
10 June	6	19 June	4	15 July	2
11 June	1	30 June	2	17 July	2
12 June	3	5 July	1	21 July	1
13 June	1	6 July	1		
				Total	35
		1960			
6 June	6	18 June	6	23 June	1
7 June	4	19 June	15	24 June	1
16 June	4	20 June	2	25 June	4
17 June	1	21 June	2	26 June	1
				Total	47
		1961			
14 June	3	1 July	1		
18 June	1				
		Total	5		

* Type of tag and method of tagging discussed by Carr and Caldwell (1956) and Harrisson (1956).

Old-time residents of the Brunswick area state that loggerheads once nested in large numbers on St. Simons Island, the next island north of Jekyll and separated by less than a mile of water. Erosion on the seaward side of St. Simons in recent years destroyed most of the suitable nesting beaches there, and only an occasional female is reported to lay on the few remaining sandy spots. Consequently, the sea turtle nesting is concentrated now on Jekyll and Little Cumberland Islands. The latter is the next island adjacent to Jekyll on the south. Concurrent nesting occurred on Jekyll, Little Cumberland and St. Simons, but no records are available to show whether

TABLE 2

RETURNS OF ATLANTIC LOGGERHEAD SEA TURTLES TAGGED AND RECAPTURED AT JEKYLL ISLAND, GEORGIA, IN 1959. (ld) DENOTES TURTLE LAID; (dnl) DENOTES TURTLE DID NOT LAY; (nd) DENOTES NO DATA ON NESTING ACTIVITY.

Tag Number	Date Tagged	Days Elapsed Between Tagging and First Return	First Return	Days Elapsed Between First and Second Return	Second Return	Days Elapsed Between Second and Third Return	Third Return
G 127	3 June (dnl)	15	18 June (nd)	34	22 July (ld)		
G 128	3 June (dnl)	48	21 July (dnl)				
G 129	3 June (dnl)	14	17 June (nd)	18	5 July (dnl)		
G 181	3 June (ld)	27	30 June (dnl)	12	12 July (dnl)		
G 136	9 June (dnl)	1	10 June (ld)	27	7 July (ld)		
G 131	10 June (dnl)	25	5 July (ld)	1	6 July (dnl)	13	19 July (ld)
G 182	12 June (ld)	24	6 July (dnl)	1	7 July (dnl)		
G 189	12 June (dnl)	8	20 June (nd)	19	9 July (dnl)		
G 139* G 9	13 June (ld)	25	8 July (ld)	13	21 July (ld)		
G 185	14 June (ld)	25	9 July (ld)				
G 142	18 June (ld)	32	20 July (ld)				
G 102	18 June (dnl)	33	21 June (nd)				
G 191	30 June (dnl)	1	1 July (ld)				
G 199	5 July (ld)	2	7 July (ld)				
G 197	17 July (ld)	9	26 July (ld)				

* Turtle re-tagged when original tag was found unlocked during second recapture.

the relative numbers of turtles increased on Jekyll and Little Cumberland after the loss of St. Simons' beaches—as some residents believe.

In very recent years, Jekyll has passed from very closely guarded private hands into public ownership, and is now being rapidly developed as a state park, recreation and resort area. When the sea turtle study was begun there in earnest in the summer of 1958, there was little construction activity on the seaward beaches, and consequently the terrain and vegetation behind the beach was,

TABLE 3

RETURNS OF ATLANTIC LOGGERHEAD SEA TURTLES TAGGED AND RECAPTURED AT JEKYLL ISLAND, GEORGIA, IN 1960, OR TAGGED IN A PREVIOUS YEAR AND RECAPTURED MORE THAN ONCE IN 1960. (ld) DENOTES TURTLE LAID; (dnl) DENOTES TURTLE DID NOT LAY; (nd) DENOTES NO DATA ON NESTING ACTIVITY.

Tag Number	Date Tagged	Days Elapsed Between Tagging and First Return	First Return	Days Elapsed Between First and Second Return	Second Return
G 158	6 June (nd)	19	25 June (nd)		
G 159	6 June (dnl)	1	7 June (ld)		
G 161	6 June (dnl)	1	7 June (ld)	15	22 June (nd)
G 165	6 June (ld)	17	23 June (nd)		
G 169	6 June (ld)	17	23 June (dnl)		
G 190	6 June (ld)	16	22 June (ld)		
G 162	7 June (nd)	16	23 June (nd)		
G 164	7 June (ld)	10	17 June (nd)	5	22 June (ld)
G 102*	18 June (dnl)	3	21 June (nd)		
G 61	19 June (nd)	6	25 June (dnl)		
G 65	19 June (dnl)	2	21 June (ld)		
G 71	19 June (ld)	2	21 June (nd)		
G 72	19 June (ld)	43	1 August (nd)		
G 75	20 June (dnl)	1	21 June (dnl)		
G 196	20 June (dnl)	2	22 June (ld)		
G 83	23 June (dnl)	1	24 June (ld)		
G 86	25 June (dnl)	>1	25 June (ld)		

* Tagged initially in 1958, see Caldwell, *et al.* (1959: Table 2).

TABLE 4

MULTIPLE RETURNS OF ATLANTIC LOGGERHEAD SEA TURTLES NESTING AT JEKYLL ISLAND, GEORGIA, IN 1961, BUT TAGGED THERE TWO OR THREE YEARS PREVIOUSLY. (ld) DENOTES TURTLE LAID; (dnl) DENOTES TURTLE DID NOT LAY; (nd) DENOTES NO DATA ON NESTING ACTIVITY.

Tag Number	First Return	Days Elapsed Between First and Second Returns	Second Return
G 40*	25 June (ld)	13	8 July (dnl)
G 4**	25 June (nd)	16	11 July (nd)
G 189†	29 June (nd)	12	11 July (ld)

* Tagged initially in 1958.
** Tagged initially in 1959.
† Tagged initially in 1959, see Table 2 for 1959 recapture history.

for most of its length, in virgin condition. Turtle nesting could be considered to have been operating under reasonably normal circumstances. However, beginning in 1959 and continuing at an ever-increasing rate, much of the beachfront area has been cleared of vegetation and the sand dunes leveled for the construction of houses, motels and public recreation areas. As a result, nesting has not recently been conducted under normal conditions. Natural land reference points for the turtles have been destroyed, buildings and numerous automobiles with confusing bright lights (see Caldwell and Caldwell, *In press*) have been added, and "turtle watching" has become such a summer pastime for visitors to the island that often a turtle will be surrounded by as many as 100 onlookers. The probability is high that the turtle will be interrupted during the early phases of her nesting procedure and that humans will rob the relatively few completed nests.

Consequently, although the sand beaches themselves remain intact, the nesting population has begun to move again—this time to Little Cumberland Island and the northern beaches of Cumberland Island (which to all intents is actually connected to Little Cumberland, being separated by only a narrow watercourse). Aerial surveys made during 1958 and 1959 showed that some nesting took place on Little Cumberland all along, but not to the extent that it is now being done there and on Cumberland. Agent Robert Kilby states that his observations and those of others of the staff of the Georgia Game and Fish Commission in 1960 and 1961 show that the turtles are rapidly abandoning Jekyll Island and that the number of nests on Little Cumberland and Cumberland Islands is increasing.

Cumberland and Little Cumberland Islands are privately owned and under tight security against trespassing. Although there is some construction in the center of Cumberland, the beach areas of both are essentially virgin. It has been proposed that this island be made a National Seaside Park, and thus hopefully the Georgia rookery will be preserved. If the nesting sites should be destroyed on these islands as well, it is hard to say what will happen to the turtles, as the beaches south of those on Cumberland lie on the rapidly developing shores of Florida. There are suitable beaches north of St. Simons Island in Georgia, and some of these are under protection by the federal government. However, to date the trend for the shift of the rookery has been to the south. On the other hand, if Cumberland and Little Cumberland should eventually be lost, the rookery may be swung around to the north of St. Simons Island and become established on beaches which offer more promise of perpetual protection.

The fact that the rookery apparently has been slowly shifting in its point of greatest nesting concentration is significant in that it indicates that offshore physical conditions are not the only criteria for the selection of a rookery site. Conditions on the beach itself, other than ones of such physical factors as sand type, may influence the site of heaviest nesting concentration.

After my departure from the Brunswick area during the early summer of 1960, efforts in the Georgia tagging program were limited almost entirely to the excellent cooperation afforded by the resident game agent. However, due to his many other official duties and lack of sufficient volunteer help, there were many nights or parts of nights when no one familiar with the project was available to pursue it. Gaps in the data, particularly in 1960 and 1961, are thus due more to human factors than to the vagaries of the turtles. The same can be said, to a lesser extent, for the results of work done there in 1958 (Caldwell, *et al.,* 1959).

Reproductive Cycle

An important question left unanswered by the one season's work summarized by Caldwell, *et al.* (1959) was whether each individual lays every year. The following data answer this.

TABLE 5

DATE OF INITIAL TAGGING AND FIRST RECAPTURE AFTER ABSENCES OF TWO OR THREE YEARS OF ATLANTIC LOGGERHEAD SEA TURTLES AT JEKYLL ISLAND, GEORGIA. (ld) DENOTES TURTLE LAID; (dnl) DENOTES TURTLE DID NOT LAY; (nd) DENOTES NO DATA ON NESTING ACTIVITY.

Tag Number	Date Tagged	Date First Long-Term Return
	Two-Year Absence	
G 32	(?) 10 July 1958 (nd)	17 June 1960 (dnl)
G 35 *	11 July 1958 (nd)	16 June 1960 (nd)
G 33 *	11 July 1958 (dnl)	26 June 1960 (nd)
G 102 * †	16 July 1958 (dnl)	18 June 1960 (dnl)
G 4 ‡	1959 (nd)	25 June 1961 (nd)
G 181 **	3 June 1959 (ld)	1 July 1961 (dnl)
G 189 ** ‡	12 June 1959 (dnl)	29 June 1961 (nd)
G 131 **	10 June 1959 (dnl)	22 June 1961 (ld)
G 133	10 June 1959 (dnl)	22 June 1961 (nd)
G 191 **	30 June 1959 (dnl)	17 June 1961 (ld)
G 197 **	17 July 1959 (ld)	5 June 1961 (ld)
	Three-Year Absence	
G 40 ‡	15 July 1958 (ld)	25 June 1961 (ld)
G 46	16 July 1958 (ld)	16 June 1961 (nd)
G 48	16 July 1958 (ld)	16 June 1961 (nd)

* For complete recapture history in 1958, see Caldwell, *et al.* (1959: Table 2).

** For complete recapture history in 1959, see Table 2.

† For complete recapture history in 1960, see Table 3.

‡ For complete recapture history in 1961, see Table 4.

No cases have been recorded of a turtle returning to nest during a season following the one in which it had nested before. The frequency of nesting periods, then, is at a greater interval than every year for the Atlantic loggerhead. Over a period of four years of study at the Jekyll Island rookery, enough tagging returns have now accumulated and enough hours have been logged by competent observers and recorders to show that this absence of yearly nesting by a given turtle is real. Harrison (1956) found this to be the case for western Pacific green turtles, and Carr and Ogren (1960: 14) showed it for western Atlantic green turtles. Harrisson (1956) showed a three-year cycle for the western Pacific green turtles. Carr and Ogren (1960: 14) found a strong three-year cycle, with an undercurrent of a two-year cycle, in western Atlantic green turtles. Harrisson found no such two-year cycle.

The reproductive cycle shown by the Atlantic loggerheads (Table 5) is not clearcut. Of the turtles tagged in 1958, four were recaptured in 1960, after two years, and three were retaken in 1961, after three years. Thus the returns are sufficient only to show that both a two- and a three-year cycle occur. A greater number (seven) of two-year returns were recorded in 1961 from the turtles initially tagged in 1959. The three-year period for the 1959 turtles is not up until the 1962 nesting season. Also in 1962, turtles initially tagged in 1958, and returned in 1960, might be expected back on the beach. The changes discussed in the introduction to this paper will greatly reduce the probability of getting 1962 returns. Thus the significance of a comparison with the number of two-year returns of 1959-tagged turtles will be obscured. A lack of returns will not necessarily mean a lack of three-year nesting or a renesting again after two more years by a 1958-tagged turtle.

Periodicity of In-season Multiple Nesting

Findings reported in Tables 2, 3 and 4 bear out the statement made by Caldwell, *et al.* (1959: 314) that in almost all cases where data are adequate, the intervals between multiple nestings during a given season at Jekyll Island took place at intervals of 12 to 15 days. Only one exception was reported—a return after only six days after laying.

In the last section of this paper I have noted returns to the beach after *laying* of only one or two days. Additional returns after unusual periods of time can be seen in Tables 2, 3 and 4 (see for example turtles numbered G 129, G 189, G 142, G 197, G 158, G 61 and G 4). No explanation is suggested for those returns between one or two days after nesting (discussed later), but after much less time than the usual minimum of 12 days (see Caldwell, *et al.*, 1959: 314). Long returns, as in the case of G 189, G 142, G 158 and G 4, may be the result of an observer-missed normal interval coupled with one of the almost immediate one- or two-day returns. However, they may be a combination of two of the eight- or nine-day returns. The latter is suggested by G 189, which returned after eight days and then not again until after 19 days. The observers may have missed a return midway during this latter period. This turtle was apparently back on a more expected 12-day schedule in 1961, based on one recapture (Table 4).

One entire flotilla of turtles (G 158, G 161, G 165, G 169, G 190, G 162, and G 164, Table 3) returned on a slightly long interval of 15 to 19 days. One of these turtles, G 164, returned once in between, after 10 days, and was back again with the rest after only five more days.

It has been suggested (Caldwell, *et al.*, 1959: 312, 314) that as many as four nestings by some turtles within a given season could be postulated safely, although the tagging results had to be interpolated to suggest this. A similar interpolation of the recovery history of turtles G 127 and G 128 (Table 2) extends this to possibly a five-nesting sequence, based on the time of first and last nesting emergence with approximately two-week intervals in between. On a 12 to 15 day schedule, the season is long enough theoretically to permit six to eight nestings by a turtle arriving early and staying late. If some turtles are on a slightly shorter schedule, as the above results indicate some may be, it is conceivable that as many as a dozen nestings could be accomplished in a season.

Only five turtles were tagged at Jekyll Island in 1961 (Table 1), and there is no recapture history for any of these. However, three turtles that had been tagged at Jekyll Island two or three years previously did return there more than once in 1961 (Table 4). Although the data are limited, they are included in the manner of those presented in Tables 2 and 3 for 1959 and 1960 and show a similar trend of multiple nestings on an approximately two-week schedule.

Deployment Between Emergences During the Season

One of the questions still unanswered is where the nesting turtles go in the interim between nestings during a given season. A satisfactory answer is still needed, but a clue may be presented by the following return.

A turtle that had successfully nested on Jekyll Island on June 19, early in the season and therefore surely destined for additional visits to the nesting beach, was taken in a shrimp trawl a few days later (exact date unknown) in St. Andrews Sound near Satilla Cove. This locality is a protected one in an area bordered by marshes and is behind Jekyll Island. It is unfortunate that this recapture came so soon after the turtle nested, for it only acts as a teaser in that it cannot be said whether the turtle would have remained in the area for the full two-week inter-nesting interval or whether it would have soon moved away either alone or in company with a group, some members of which were still in the process of nesting. It does show, at least, that movement away from the waters near the nesting beach is not immediate.

This turtle very likely was a migrant to the area of the rookery. There is a resident population of loggerheads in the Jekyll Island region. However, as no tagged turtle has ever been reported taken between nesting seasons, despite extensive shrimp and crab trawling (which has produced turtles frequently at all times of the year), it is suggested that the resident population is small or made up mostly of non-breeding individuals. If this is the case, then the nesting turtles must migrate to the rookery from some distant point or series of points. The only recoveries of tagged loggerheads away from a nesting beach or in its close proximity were made far away from the rookery. One was recaptured while the nesting season was still open (Caldwell, Carr and Hellier, 1956: 292), and the other, after traveling a much greater distance, before the next nesting season had begun (Caldwell, Carr and Ogren, 1959: 296).

Group Movements

Carr and Giovannoli (1957: 9) and Caldwell, *et al.* (1959: 309) suggested that, within limits, groups of turtles tagged at the same time, and later recaptured at the same time, indicated the probability of group movements by those turtles between nesting emergences. In those experiments, although many turtles often were tagged at the same time, they were not considered as belonging to the same group if they were recaptured at markedly different times or were not recaptured at all.

In a more recent report, Carr and Ogren (1960: 28) questioned this conclusion regarding groups. They suggested that the clumped returns might only be evidence of a strong homing behavior, although mass travel was not disregarded. Carr and Ogren felt that in the Atlantic green turtle the clumped returns were possibly only artifacts of a combination of (1) physical conditions of the environment which tended to funnel nesting individuals onto the beach at certain points, and (2) several individuals having similar or identical hormone periodicities. The net result, according to their hypothesis, is that two or more turtles from a larger breeding aggregation thus reach the beach at the same time and therefore appear to be acting as a group. Inference was made that a similar phenomenon occurs with the Atlantic loggerheads.

While Carr and Ogren's hypothesis may indeed play a large part in what appears to be group action, I believe that true and possibly permanent grouping, at least to the rookery area, must occur. This is indicated by certain results of the Jekyll Island loggerhead tagging program. Not only is grouping within a given season, as discussed by Caldwell, *et al.* (1959: 309), again strongly suggested by the results of the studies made in 1959 and 1960 (see Tables 2 and 3), but, even more significantly, it is suggested in the over-season returns of two and three years. The over-season evidence, especially as it occurred with only such a small number (probably only about 10 percent of those nesting) of turtles tagged, seems due to much more than chance, or even to physical factors of the environment and especially to hormone periodicities. Such closely related hormonal activity after such a long period of time would suggest genetic relationships and is thus even stronger evidence for true group action. Smith and Daniel (1946: 154) and Carr and Hirth (1961) have indicated that group facilitation operates in escaping the nest, and some group behavior, perhaps in navigation, may well carry through life. Thus, while Carr and Ogren's hypothesis may explain some instances of "grouping" within a given season, the over-season data should be given serious consideration as evidence for real grouping. Atlantic loggerheads move great distances (Caldwell, Carr and Hellier, 1956: 292; Caldwell, Carr and Ogren, 1959: 295). Carr and Ogren (1960: 10) and

Carr and Hirth (1962:35) have summarized similar data in greater numbers for Atlantic green turtles. With a definite geographical goal, such long-range movements might be facilitated by group action in the cooperative seeking of navigational clues.

With regards to over-season grouping, attention is called to Table 5. Turtles numbered G 131 and G 133 appear conclusively to be acting as a pair over a two-year period, having been tagged on the same date in 1959 and recaptured on the same date in 1961. Even stronger evidence for pair interaction is indicated by turtles G 46 and G 48, tagged on the same night in 1958 and recaptured on the same night *three* years later in 1961. That one such closely acting pair was on a two-year cycle, while the other was on a three-year cycle, is further evidence for a possible close genetic relationship by group members; *ie.,* differently-timed scheduling factors, seemingly unrelated to physical factors of the environment, were common to each pair and further increase the probability against chance occurrence of the pairs acting as real groups. Less striking pair interaction is suggested by turtles G 32 and G 35, tagged on possibly successive nights in 1958 and retaken on successive nights after two years, in 1960. Similar long-term "grouping," again at least to the rookery, is suggested for two of Carr and Ogren's green turtles (1960: Table 7). Their turtles numbered 377 and 379 were tagged on the same date in 1956. In 1959, after three years, they were recaptured on successive dates. In a more recent paper, Carr and Hirth (1962: 17) listed two green turtles tagged on the same date in 1957 and recovered on the same date after three years.

Evidence for genetic relationship as it relates to possible group action is shown by the flotilla mentioned above which was on an apparent "long interval" schedule. Such a long interval is unusual, and its being related to a "group" of turtles suggests that the grouping was real and more than coincidental.

Unfortunately, the tagging returns for both the loggerhead and the green turtle are not complete enough to show whether "groups" in phase for two or more emergences in one year were still in phase as a "group" for several emergences two or three years later. The outcome of such findings in later studies will strongly influence the discussion dealing with "groups." For the present, it seems best to suggest that there is evidence that both the earlier hypotheses by Carr and Giovannoli (1957) and by Caldwell, *et al.* (1959) and the later one by Carr and Ogren (1960) may possibly be correct and interacting.

UNUSUAL NESTING BEHAVIOR

The typical patterns of Atlantic loggerhead nest building, oviposition and covering of the nest and eggs have been given in detail in an earlier report (Caldwell, Carr and Ogren, 1959). The majority of the nesting turtles observed on Jekyll Island during the summers of 1959 through 1961 followed these same stereotyped patterns. However, some notable exceptions which were observed are described below.

Caldwell, *et al.* (1959: 314) noted that "a turtle interrupted in her nesting will return either later that night or on successive nights until she has fulfilled her mission." Subsequent observations show that some individuals apparently do not complete their nesting in one visit to the beach, even without molestation. For example, turtle G 199 (Table 2) was recorded as laying eggs on July 5 *and* July 7. Agent Kilby made the following special note of her first emergence: "Laid 20 eggs, did not cover, without [detected] molestation started back to water laying eggs all the way (about 18 more)." Another observer noted simply that she "laid" on July 7. Such interrupted behavior suggests inexperience in nesting.

In other examples of apparent incomplete nesting in one visit to the beach, turtle G 131 (Table 2) laid one night and the following night was back on the beach, but did not lay. Turtle G 71 (Table 3) laid one night and two nights later was back on the beach, although her nesting activity was not recorded by the observer.

Related nesting (laying) behavior was recorded by Agent Kilby for two other individuals and shows that the laying process may be interrupted for a much shorter period of time. Turtle G 72 (Table 3) laid 104 eggs, started to cover, laid one more egg, and then completed her nest in a normal manner. This occurred on June 19, relatively early in the nesting season. In addition to making record of this unusual procedure, Kilby also noted that G 72 was a small individual. Her size, the relatively small number of eggs deposited (see Baldwin and Lofton, 1959: 332), the earliness of the season, and her aberrant behavior all suggest that she was inexperienced.

Another turtle, G 175, also laid in a similar manner even earlier in the season, on June 7, 1960. Her size was not noted, but she laid even fewer eggs (78) in the following sequence: 74 eggs laid; covered with three flipperfuls of sand; 4 eggs laid; completed covering of nest. Inexperience is also suggested by her actions. Lehrman (1956) discussed the fact that certain inexperienced birds and mammals were more retarded in their maternal activities than experienced individuals of the same species. Nesting activities in relation to inexperience were discussed by Lehrman.

Injuries to sea turtles are frequently seen and are often extensive, but seem to heal well and these crippled turtles still try to obey the nesting urge. Those with severe damage to one or both front flippers, or even the loss of most of one, seem to have little difficulty in ascending the beach and in completing their nest. However, those turtles that have lost most of a hind flipper do find difficulty in nesting, as it is these flippers that are most important in nest digging (see Caldwell, Carr and Ogren, 1959). One turtle with such an injury was noted by Agent Kilby to dig four holes of a sort with her one hind flipper. However, these holes apparently were unsatisfactory to her, and after being on the beach for over three hours she proceeded to lay her eggs on the flat beach below the base of the dunes but well away from the edge of the water. Eggs thus deposited would not survive.

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ADDENDUM

After this paper had gone to the printer and was set in type, the 1962 nesting season in south Georgia ended. Due to circumstances discussed in the introduction to this paper, observer-effort was so poor that no turtles tagged in previous years were reported from the nesting beach, and no new individuals were tagged. Therefore no three-year returns were achieved from the 1959 tagging operations, and no turtles tagged in 1958, and returned in 1960, and which might have been expected back again in 1962 on a two-year cycle, were recorded. As no returns from the beach were obtained, the significance of a comparison with the number of two-year returns of 1959-tagged turtles is obscured (see below for a three-year return not on the beach).

That a three-year return was in the making is evidenced by the recapture on about May 15, 1962, of a marked turtle (G 128), see Table 2, by a shrimp trawler working about four miles east (offshore) of the south end of Jekyll Island. Unfortunately, the date of the 1962 return is such that it cannot even be speculated whether the turtle had remained in the area during the three intervening years or whether she was migrating back to the rookery after spending the three years elsewhere. May 15 is almost exactly the time when the nesting season begins at Jekyll Island. This was the only tag return recorded in 1962.

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OBSERVATIONS OF THE FLOCKING HABITS OF GULLS AND TERNS ON THE MISSISSIPPI COAST

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Descriptions and studies of breeding flocks of gulls and terns are well documented in ornithological literature and have provided some important concepts regarding bird behavior. There are, however, relatively few published accounts of the flocking habits of these birds, or of shore birds in general, during the remainder of the year.

The purpose of this paper is to present data concerning flocks of Laughing Gulls (*Larus atricilla*), Royal Terns (*Thalasseus maximas*), Forester's Terns (*Sterna forsteri*), Least Terns (*Sterna antillarum*), and Black Terns (*Chlidonias nigra*) observed on the coast of Mississippi during July and August 1959. In particular an attempt is made to determine whether mixed flocks of gulls and terns are a function of general gregariousness or whether more intricate mechanisms are involved as revealed by patterns of interspecific combinations or ratios within the flocks.

The Gulf Coast Research Laboratory in Ocean Springs, Mississippi, provided facilities for the study. Field work consisted of visiting available beaches, sandbars, and exposed oyster bars in a small motor boat and enumerating the kinds and numbers of birds found on these areas. Although other means of observation were attempted such as walking the beaches and observing from an automobile, the flocks were least disturbed when the observer approached them in a boat. This is perhaps related to the possibility of predation from land animals in contrast to the relative absence of such dangers in the water.

Using the motor boat technique, a total of 18 field trips were made and 128 flocks enumerated. The same flock sites were necessarily visited repeatedly since the range and extent of the field trips were limited by the mode of transportation and the base of operations. Normally the trips took place during the morning, lasted about five hours, and involved accessible areas within five miles of the laboratory. This in turn implies that very likely the same birds were counted on successive field trips but redistributed over different flock sites. Table I illustrates the changing composition of flocks on the same site on successive dates.

TABLE I

FLOCKS OBSERVED ON SANDBAR ON SUCCESSIVE DATES

Date	Laughing Gulls	Royal Terns	Forster's Terns	Least Terns
29 July	1		7	
31 July	3	7	25	
3 Aug	35	20	5	
6 Aug	7	4		
7 Aug	5	20	9	16
9 Aug	21	70	20	
10 Aug	13	5	2	
11 Aug	47	2	1	
14 Aug	110	1	1	

As the study progressed it appeared that the flocks were utilizing two kinds of standing sites; open beaches and oyster bars. Table II indicates the size of the flocks and their distribution. The median presents a more representative figure for flock size than does the mean. Beach flocks were considerably larger than the oyster bar groups partly, at least, because of the limited area of the latter site.

Table III shows the flock compositions by species. In terms of Rand's (1954) classification, Laughing Gulls would constitute the Nucleus Species; Royal Terns and Forster's Terns the Attendant Species; and Least Terns and Black Terns the Accidentals.

Since Laughing Gulls, Royal Terns, and Forster's Terns were found together frequently, it appeared that the associations might have some ecological significance. In order to test this, species were compared in couplets in two by two tables utilizing a presence or absence criterion (Table IV). The null hypothesis for this situation stated that the interspecific composition of the flocks had no significance other than that expected by chance. As seen in Table IV, the species associations were not statistically significant; hence the species composition of the flocks appears to be a function of the numbers of individuals in the area and that for these three species there is no interspecies attraction. As Rand (1954) pointed

TABLE II

SIZE AND DISTRIBUTION OF FLOCKS

	Number of Flocks	Total birds in Flocks	Median Flock Size	Mean Flock Size	Range
All flocks	128	9738	39	76	4 - 472
Beach	87	8230	56	95	4 - 472
Oyster Bar	41	1508	28	37	8 - 184

TABLE III

COMPOSITION OF THE FLOCKS BY SPECIES

	Total Number of Laughing Gulls	Royal Terns	Forster's Terns	Least Terns	Black Terns
All flocks	6558 (67)	1600 (16)	1317 (13)	109 (1)	114 (1)
Beach	5560 (68)	1427 (17)	1010 (12)	91 (1)	107 (1)
Oyster Bar	998 (66)	173 (11)	307 (20)	18 (1)	7 (0.1)

Numbers in parentheses represent per cents

TABLE IV

TWO BY TWO TABLE AND THE RESULTS OF THE SPECIES COMPARISON

Species B

		Present	Absent	
Species A	Present	a	b	a + b
	Absent	c	d	c + d
		a + c	b + d	a + b + c + d = N

Chi-square $$\frac{(ad - bc)^2 n}{(a+b)\ (a+c)\ (c+d)\ (b+d)}$$

Species compared	Chi-square value	
Laughing Gulls—Royal Terns	2.6	$p > 0.10$
Laughing Gulls—Forster's Terns	1.5	$p > 0.20$
Royal Terns—Forster's Terns	0.37	$p > 0.30$

out, mixed flocks such as these are not based on food benefits. Also these aggregates do not form due to a limited habitat preference since there were many miles of beaches and sandbars not utilized by the flocks. It would seem that general gregariousness rather than specific species attraction is the basis for the aggregations noted in this paper.

Observational Notes on Flock Behavior

In the mixed flocks the gulls, Royal Terns and Forster's Terns appeared to be mixed at random on the standing sites. The Least Terns, Black Terns and occasional Black Skimmers, when present, always stayed somewhat apart from the main flock. There was very little interaction between members of a flock until a bird attempted to land among them. The birds which had to make room for the "intruder" then made threatening gestures toward it with their bills and uttered several calls. Based on this type of behavior it seemed that Royal Terns were dominant in the "peck order" as they could displace any of the other species on the standing sites. The Laughing Gulls in turn dominated the other terns. These relations were true of flocks on beaches and bars and birds perched on clusters of pilings.

Frequently immature gulls and terns were observed "posturing", e.g., extending the neck and body in a horizontal plane, and peeping loudly to nearby adults. The adult birds either ignored these birds or moved away if they became persistant. On one occasion an adult gull was observed to respond by feeding the posturing immature gull.

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QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

Editor: Pierce Brodkorb

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QUARTERLY JOURNAL
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Vol. 26 March 1963 No. 1

FRED H. HEATH AND THE DISCOVERY OF ELEMENT 43

George B. Kauffman

The name of Fred Harvey Heath has for many years been linked with the discovery of element 43 at the University of Florida, where he taught chemistry from 1923 to 1952. As little is known concerning this unverified discovery, it is desirable to place on record facts reconstructed from information provided by A. H. Gropp, V. J. Senn, B. J. Otte, and Mrs. F. H. Heath, all of Gainesville, Florida.

While at the University of Washington, sometime between 1917 and 1923, Dr. Heath and J. D. Ross, an electrical engineer, are said to have succeeded in preparing compounds of a hitherto unknown element from ores which they received from British Columbia. They believed this to be element number 43, the long sought eka-manganese whose existence had been predicted by Mendeleev as early as 1872. They submitted their results to the Journal of the American Chemical Society, whose editor, Arthur B. Lamb, requested x-ray spectra as final proof of their discovery. At that time, the equipment needed for this work was not available to them, and consequently their report was not published.

When Heath came to the University of Florida, he began work on an emission spectrograph, but in June of 1925 before he could produce the required information, Walther Noddack and Ida Tacke of the Physico-Technical Testing Office in Berlin, together with Otto Berg of the Werner-Siemens Laboratory, announced their discovery of elements 43 and 75, which they named masurium and rhenium, respectively (Noddack, Tacke, and Berg, 1925). Despite extensive investigation, their discovery of element 43 has never been confirmed and has not been accepted. However, their discovery of element 75, rhenium, has been recognized.

In a meeting held in Amsterdam on September 2-5, 1949, the International Union of Chemistry officially adopted the name technetium for element 43. This action gave approval to the suggestion of Perrier and Segrè, who proposed the name to indicate the fact that in 1937 they had prepared this, the first artificially synthesized element, by bombarding molybdenum with deuterons. Despite numerous previous attempts to find it in nature, the first isolation and identification of naturally occurring technetium has been reported only recently (Kenna and Kuroda, 1961). Since only *ca.* 10^{-9} g. (one-billionth gram) of the element was isolated from 5300 g. of Congo pitchblende and since Heath and Ross had isolated salts in weighable quantities, it seems extremely improbable that the element which Heath and Ross reported was technetium. However, it might possibly have been rhenium, in which case they would still have antedated Noddack, Tacke, and Berg's discovery. On the other hand, since the chemical literature contains many unsubstantiated claims to the discovery of the elusive element 43 (Kenna, 1962), their substance might have been a mixture of elements.

Unfortunately, the author has been unable to obtain any of Heath and Ross' chemical samples or original laboratory notebooks. One of Heath's idiosyncrasies was his apparent disorderliness as far as his office and papers were concerned. The word "apparent" is used advisedly, for while no one else could locate anything in the labyrinth that was Room 102 of Leigh Hall, Heath could instantly produce the most obscure object at a moment's notice. Since he was an inveterate collector and saved everything of a technical and scientific nature, the missing items may someday be made available. Until such a time, the exact nature of Heath and Ross' discovery must remain an enigma.

Heath, who was born in 1883 in Warner, New Hampshire, was doubtless introduced to the chemistry of the rarer elements during his undergraduate years at New Hampshire College, now the University of New Hampshire. Dr. Charles L. Parsons, longtime secretary of the American Chemical Society and specialist on beryllium, was department head, and Dr. Charles James, a world-famed authority on the rare earths, had recently joined the faculty. Heath's B.S. (1905) was followed by graduate work in analytical chemistry at Yale University (Ph.D., 1909) and the University of Marburg, Germany. He held teaching positions at five American universities before coming to the University of Florida in 1923; three years later, he was placed in charge of the general chemistry program there.

In these days of specialization, Heath was unusual in his breadth of interests. In addition to his interesting claim as the discoverer of a new element, he was a prominent expert in the field of war gases. He held the rank of major in the Chemical Warfare Service Reserves, was consultant for the Florida State Defense Council during World War II, and was the co-discoverer of selenium mustard gas (Heath and Semon, 1920). The author of several chemistry and photography texts, he was considered an authority in the fields of geology, astronomy, sponges, phosphorescent materials, fluoborates, and new analytical uses of chromium, vanadium, and molybdenum salts. Throughout his career, he was in demand by many leading industrial firms as a consultant, and during World War II he undertook secret research for the U. S. Navy Submarine Base at Key West.

But over and above his contributions to these many fields, he is remembered by those who knew him as a continually inspiring teacher, exhibiting, to quote his colleagues, "unfailing good humor, unassumed humility, constructive friendliness, and a sincere interest in his associates and the University." His untimely death on January 26, 1952, deprived us of an outstanding educator who combined intellect with humanity.

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Department of Chemistry, Fresno State College, Fresno 26, California.

A SEARCH FOR DECAMETRIC RADIO SIGNALS FROM COMET SEKI (1961f)

N. F. Six, Jr., Alex. G. Smith, T. D. Carr, and W. F. Block

At least two general processes involving comets are theoretically detectable by radio observations. One such process is the refraction of radio waves from more distant sources as these waves traverse the material of the comet. The other process is direct electromagnetic emission from the comets themselves. Optical observations of comets indicate that the electron energies and densities in the tails are too low to give rise to detectable levels of thermal radiation. However, it might be possible to detect the direct emission of non-thermal radiation resulting from plasma effects, or long-wavelength monochromatic radiation of molecular origin (Poloskov, 1957).

History of Radio Observations of Comets

In the spring of 1957 both the Royal Observatory of Belgium and the Ohio State University reported receiving radio signals from Comet Arend-Roland (1956h). The Belgian group, using an azimuthally-mounted 30-foot paraboloid, reported detecting a stable flux exceeding the level of the ordinary fluctuations of the receiver's output when they swept their antenna over the section of sky containing the comet (Coutrez, Hunaerts, and Koeckelenbergh, 1958). The radiation appeared to come from the head of the comet and the maximum flux density received at 600 Mc/s was approximately 8×10^{-23} w/m^2/cps when the object was 0.7 A.U. from the earth. The Belgians concluded that the 600 Mc/s radio flux from the comet may have been monochromatic radiation resulting from transitions between fine structure components of the CH molecule. During perihelion passage of the comet, Kraus (1958) at Ohio State University was monitoring galactic radiation on 27.6 Mc/s with a lobe-sweeping antenna having a fan-shaped beam 12° in right ascension and 60° in declination. From March 11 to May 1, 1957, he detected in a side-lobe of the antenna pattern flux levels which could not be attributed either to the galaxy or to the sun. Kraus concluded that there was an unknown source in the beam producing a blend with the central galactic source, and he suggested that this source might be Comet Arend-Roland. The peak flux density received was 5 x 10^{-22} w/m^2/cps at 27.6 Mc/s. On the other hand, Whitfield and Högbom (1957; 1959, p. 56) at Cambridge were unable to detect any flux from the comet although they employed five different instruments, including two interferometers of large resolving power. These observations, which were made at frequencies of 38 and 81 Mc/s, also failed to disclose any scattering of radio waves from radio stars eclipsed by the comet. The Cambridge workers placed the upper limit of the flux from Comet Arend-Roland at less than 10^{-24} w/m^2/cps at each of their frequencies.

On four nights in early 1960 a group of radio astronomers at Jodrell Bank made scans of Comet Burnham (1959k) at 240, 610, 1393, and 1420 Mc/s, using the great 250-foot radio telescope (Conway, Shuter, and Wild, 1961). They were unable to detect any radiation which could be attributed to the comet. Similarly, a search by another group in July and August of 1961 for 26.3 Mc/s emission from Comet Wilson (1961d) revealed no detectable radiation down to the level of 3 x 10^{-24} w/m^2/cps (Erickson and Brissenden, 1962).

It can be seen that up to the time of the appearance of Comet Seki late in 1961 the evidence for radio effects associated with comets was inconclusive and even somewhat contradictory. It is only natural that the predicted close approach of this new object to within 0.1 A.U. of the earth was regarded by radio astronomers as a particularly favorable opportunity to attempt to resolve this intriguing question.

COMET SEKI

Comet 1961f was discovered by T. Seki on the day of perihelion passage, October 10, as an eighth-magnitude object. As it receded from the sun, the comet passed the descending node of its orbit on November 5 and moved rapidly southward, becoming temporarily invisible from the northern hemisphere. The closest approach to the earth came on November 15, when Comet Seki passed at the unusually small distance of 0.1 A.U. By the 18th of November the comet was again being observed from the northern hemisphere.

Comet Seki was a diffuse, poorly-condensed object, having a very faint fan-shaped tail and no sharp nucleus (Roemer, 1962). Figure 1 is a photograph of the comet taken on October 18 at the Flagstaff Station of the U. S. Naval Observatory with the 40″

reflector. Notice the narrow, faint tail and gaseous head. Another photograph taken by E. Roemer on November 11 showed the head to be at least 4′ in diameter, with a tail extending 22′. The estimates of the total stellar magnitude of the comet shortly after discovery ranged from 5 to 8.

Fig. 1. Comet Seki on October 18, 1961. Official U. S. Navy photograph taken by Dr. Elizabeth Roemer with the 40-inch reflecting telescope at the Flagstaff, Arizona, station of the U. S. Naval Observatory. A 25-minute exposure on Eastman Type 103 A-O emulsion.

The orbital elements of Comet Seki computed by L. E. Cunningham correspond to a long-period elliptical orbit (Meisel, 1962):

$i = 155°.\ 71183$
$\Omega = 246°.\ 67884$
$\omega = 126°.\ 61042$
$q = 0.6812271$ A. U.
$e = 0.9919107$
$T = 770$ years

Time of perihelion passage = October 10.64816 U. T., 1961

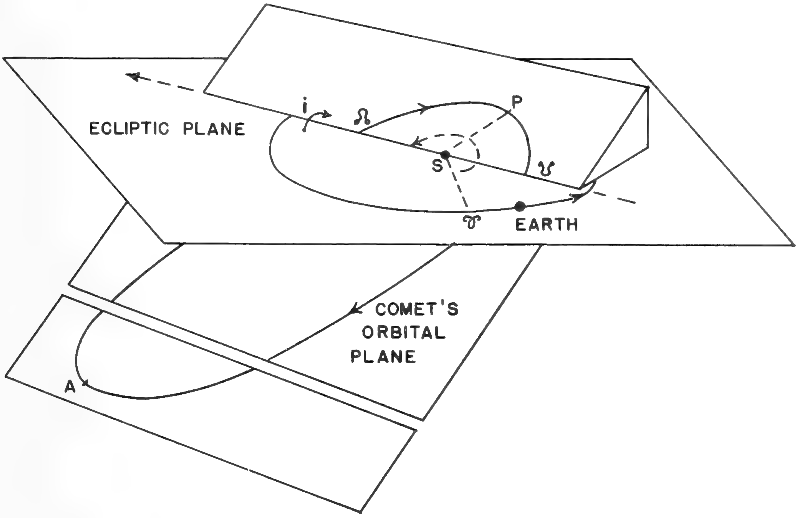

Fig. 2. Elements of the orbit of Comet Seki: i = inclination, ♈ = vernal equinox, ☊ = ascending node, ☋ = descending node, P = perihelion, S = sun, and A = aphelion.

Figure 2 will be of aid in identifying the elements. The angle i is the inclination of the comet's orbital plane to that of the earth; a value of $i > 90°$ indicates that the motion of the comet is retrograde. Ω is the longitude of the ascending node of the comet's orbit measured eastward from the vernal equinox in the plane of the ecliptic; $\Omega = \angle$ ♈ S ☊. The longitude of perihelion, measured in the comet's orbital plane from the ascending node, is designated by $\omega = \angle$ ☊ S P. The letter q represents the perihelion distance SP, while e is the eccentricity of the orbit and T is the comet's period. In Figure 2 the position of the earth is shown for November 15, the date of closest approach of Comet Seki.

THE OBSERVING PROGRAM

Comet Seki was observed at the University of Florida Radio Observatory during the period November 10 through 26, 1961. No observations were obtained on the 15th, 16th, or 17th, since the comet had disappeared briefly below the southern horizon. Fig. 3 shows the position of Comet Seki in the quarter of the celestial sphere extending from the zenith to the southern horizon of the Florida station. The solid lines indicate the motion of the comet from night to night during the period of observation, and the broken lines show the comet's apparent motion that is due to the rotation of the earth on a given night. Azimuth is marked off along the southern horizon, with 0° being due south, and circles of equal altitude are spaced every 10° up to 60°. The numbers 10 through 26 indicate the position of the comet on those dates in November at the designated Eastern Standard Times.

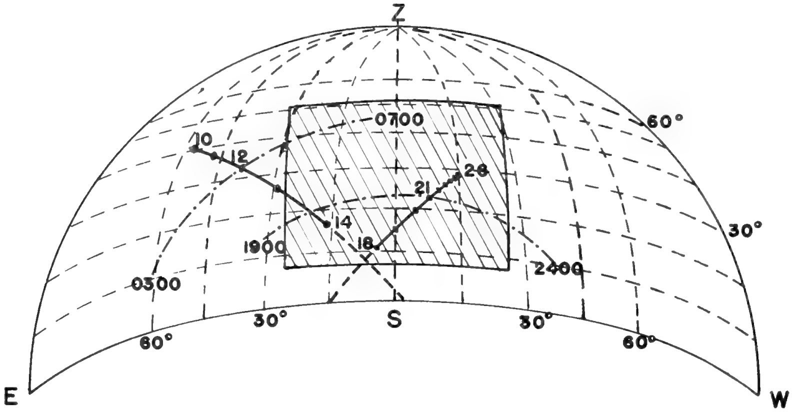

Fig. 3. Alt-azimuth system showing Comet Seki's position in the sky as seen from Gainesville, Florida. Curve 10-14, 0500 EST; curve 18-26, 2100 EST.

The antenna systems used in the study included a 15 Mc/s corner reflector, a 22.2 Mc/s phase-switching interferometer, and three yagis operating at 18, 22.2, and 27.6 Mc/s, respectively. The rotation of the earth carried the comet through the antenna patterns of the corner reflector and the interferometer once each night, while the yagis could be "steered" so as to follow the comet throughout the night.

It will be seen later that signals of possible cometary origin were received only by the 18 Mc/s yagi and the 22.2 Mc/s interferometer. The 18 Mc/s yagi has a beam-width between half-power points of about 45°, and its gain is approximately 12 db over that of a free-space dipole. Each night this antenna was manually scanned a number of times over the position of the comet, a typical scan consisting of sweeping the antenna from 45° east of the comet to 45° west of the comet in one minute's time. During the scans the pen recorder was operated at a chart speed of 1.5 inches per minute, and a stop watch was used to correlate antenna position with time. If Comet Seki had continuously emitted 18 Mc/s radiation, then each sweep of the antenna over the comet's position should have traced out the antenna pattern on the pen recording. It is estimated that the minimum flux detectable with this system was 3×10^{-22} w/m²/cps.

The shaded area in Fig. 3 indicates roughly the section of sky covered by the antenna pattern of the 22.2 Mc/s interferometer from November 13 through 26, when the beam was phased 60° south of the zenith. The rotation of the earth carries a fixed celestial object through one complete fringe of the pattern of the interferometer in a time

$$T = \frac{229.2\ \lambda}{d\ \cos\ \delta}$$

where λ is the wavelength (13.5 meters for 22.2 Mc/s), d is the separation of the two dipole arrays (131 meters), and δ is the declination of the source. Since the comet's motion on the celestial sphere was always less than 2° per hour, the fringe periods of 25 to 38 minutes yielded by this formula were essentially correct. Unfortunately, the strong discrete sources (i.e., "radio stars") Cassiopeia A and Cygnus A were present in side lobes of the antenna pattern during most of the observations, producing their own fringe patterns and thus tending to obscure possible radiation from the comet. In particular, the value of T for Cygnus A was 32 minutes, placing it just in the middle of the range of values expected for Comet Seki. An effort was made to calibrate out the interference from these discrete sources by making comparison runs on the nights of November 16 and 17, when the comet was below the southern horizon at the Florida station. In the absence of interference, the 22.2 Mc/s interferometer should have been capable of detecting a flux of 1 x 10^{-23} w/m^2/cps.

EVALUATION OF THE DATA

The results of an analysis of all of the data obtained during the comet observations from Florida are presented in Table 1. All times in this table are Eastern Standard Time. An "X" means that there was no effective comet watch on the given date with that particular antenna system, and a "0" means that no signal was recognized that might have been of cometary origin. The values of K_p (the geomagnetic planetary 3-hour range index) for November 10 through 16 are those for 0530 Eastern Standard Time; for November 17 through 26, they are for 0130 Eastern Standard Time. The table indicates that the only signals that might have been due to Comet Seki were those received while scanning over the position of the comet with the 18 Mc/s yagi on November 12, 13, and 14, and the 22.2 Mc/s interferometer fringes of November 14, 18, 19, 20, and 21.

An examination of the 18 Mc/s pen recordings of November 12 and 13 revealed that out of 37 scans, only 5 showed suspicious increases in noise level as the beam swept over the position of the comet. The times of these suspicious events are given in Table 1. On November 14 many of the antenna scans produced "bumps" on the record. It was decided that a calibration run should be made on November 16, when the comet had disappeared below the southern horizon. On this date all of the antenna systems were operated as they had been on November 10 through 14. Sweeps were made with the 18 Mc/s yagi at the sidereal times corresponding to the scans on the 14th. A comparison of the calibration record with the scans made on the 14th showed that most of the "bumps" on the November 14 scans were also present on the corresponding scans of the calibration record. This indicates that most of the noise level increases on the 14th were due to background radiation. However, a few of the "bumps" on the November 14 record were missing on the calibration scans. Figure 4 shows the record of such a scan made on November 14 at approximately 0500 EST. Time increases from right to left; hence, the antenna was swept from east to west over the comet's position. The center of the maximum lies about 20° west of the comet.

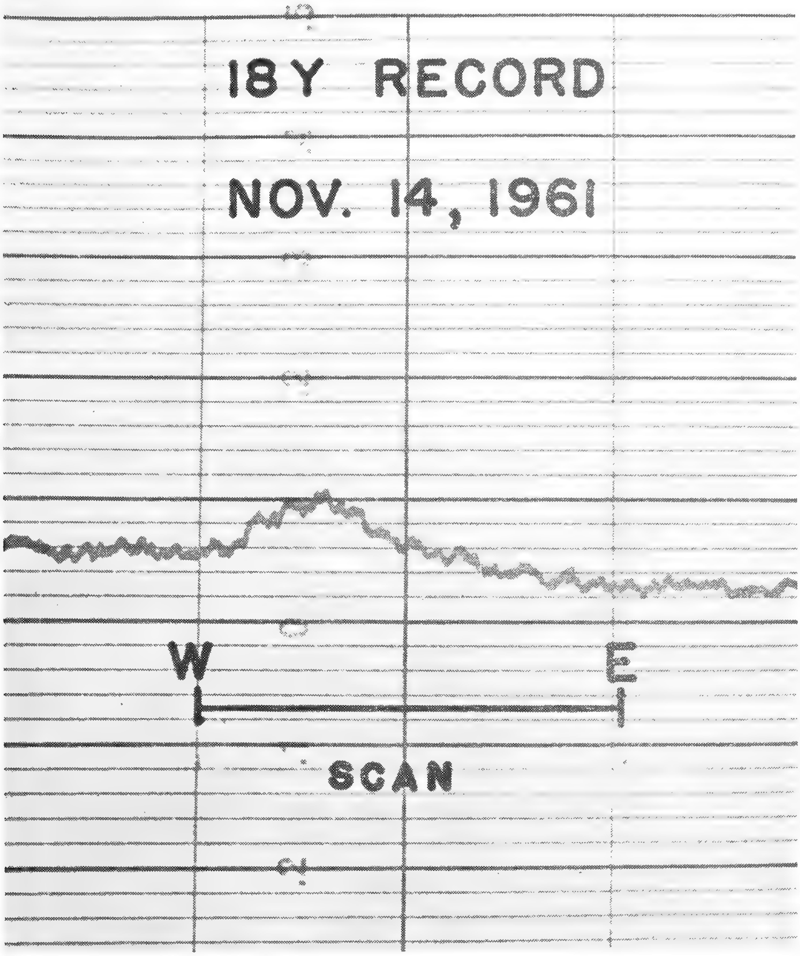

Fig. 4. 18 Mc/s scan of Comet Seki.

The 22.2 Mc/s interferometer records of November 14, 18, and 19 were found to warrant careful scrutiny. (The weak fringes detected on the 12th were considered unreliable because of the antenna phasing error.) Figure 5 shows a comparison of the interferometer record made on November 14th with the corresponding section of the calibration record made on November 16th. The upper record suggests fringes with spacings of 23, 24, 32, and 28 minutes. The main fringe at 0620 EST occurred when the comet was due south, i.e., centered in the interferometer pattern.

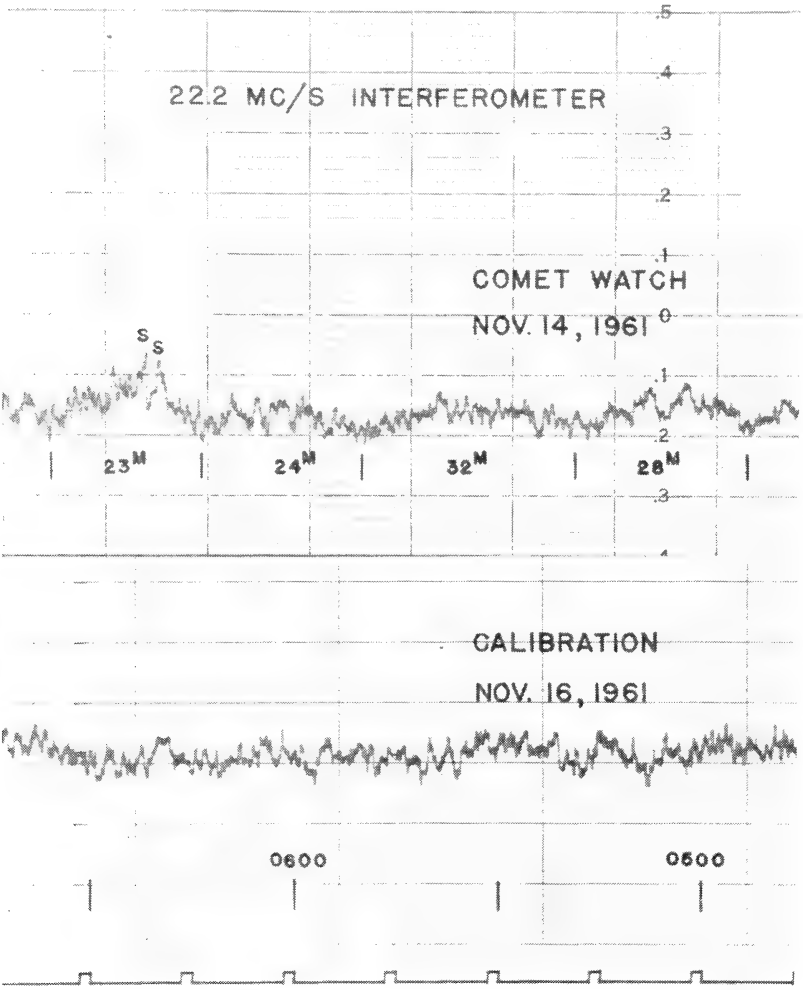

Fig. 5. 22.2 Mc/s interferometer records made on November 14 and 16, 1961.

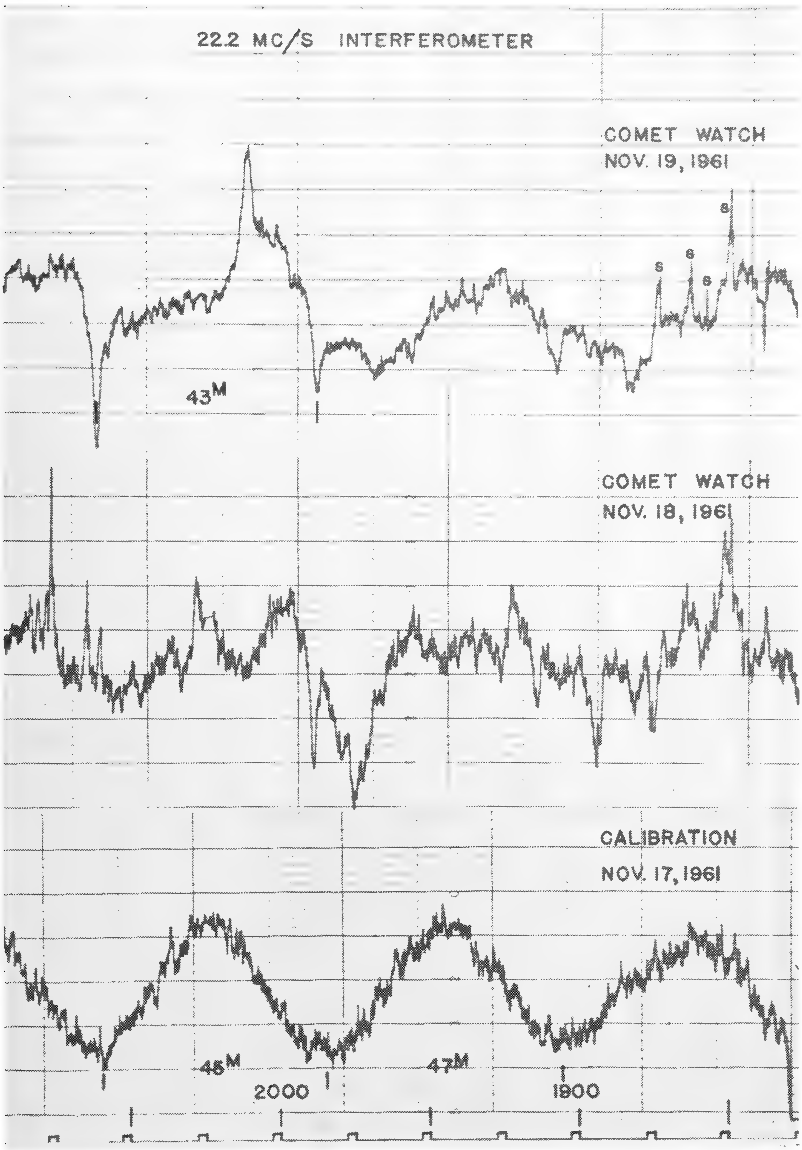

Fig. 6. 22.2 Mc/s interferometer records made on November 17, 18, and 19, 1961. EST is indicated at the bottom of the record.

Radio station interference on this record is identified by "s". The record made on November 16, when the comet had passed below the Gainesville horizon, shows no such fringes. The theoretical fringe spacing for radiation coming from the declination of Comet Seki (—41°) on November 14, 1961, is 32.5 minutes.

Figure 6 shows a comparison of the interferometer records made during the comet watches of November 18 and 19 with the calibration run of November 17. The records of the 18th and 19th show strong signals superimposed on the regular fringes produced by Cassiopeia A. The calibration run of the 17th, when the comet had dropped below the horizon, shows no such deflections—only the smooth fringes due to Cassiopeia A, which produces a 22 Mc/s flux density of about 4.6 x 10^{-22} w/m^2/cps (Wells, 1958). Notice that the fringe period of Cassiopeia A on the calibration record (about 45^m) is very nearly the same as the signal period on the 19th (43^m). Comet Seki's declination on the 19th (—49°) would have corresponded to a fringe period of 37.^{m}4.

It is not likely that the unexplained deflections on the two upper records of Figure 6 were produced by emission from Jupiter. On November 18 Jupiter crossed the meridian at 1700 EST, and by 1830 the giant planet was almost out of the antenna beam. Since Jupiter was at a declination of —20°, radiation from the planet would have produced a fringe spacing of only 26^m. It is conceivable that equipment trouble or some form of interference produced these strong deflections. Another possibility is that they represent scintillations of the radiation from Cassiopeia A produced by marked irregularities in the ionosphere. The periods of the fluctuations on the 18th and 19th correspond to a source declination about equal to that of Cassiopeia A. This is also true of the deflections on the record taken November 20 (not shown). It is interesting, however, that these deflections appeared just when the comet again became visible over the southern horizon.

The column of K_p values was included in Table 1 because there is evidence that solar stimulation might be a source of comet radiation (Biermann, 1951). Being a measure of disturbances in the earth's magnetic field, K_p is also an indirect index of solar activity, for the magnetic effects are attributed to charged particles spewed into space from the sun. On the K_p scale, 0 means very quiet, while 9 indicates an extremely disturbed condition. It has also been discovered that the rate of scintillation of radio stars increases under magnetically disturbed conditions (Booker, 1958). On the calibration nights (November 16 and 17) K_p was quite low. On November 18 and 19, when deflections were observed superimposed on the fringes produced by Cassiopeia A, the K_p values were relatively higher. Since the periods observed did not correspond to the declination of the comet, it is reasonable to suppose that these deflections were in fact scintillations of Cassiopeia A.

If Comet Seki had emitted *sporadic* 22.2 Mc/s radiation in pulses of more than one second's duration, then one might expect to find Jupiter-type bursts on the interferometer records. No such pulses were found among the comet data. However, the interferometer is somewhat limited in detecting short pulses of radiation, since the noise level is quite high with small time constants of the size necessary to record such bursts.

Additional observations of Comet Seki were made at the University of Florida's southern hemisphere station at Maipú, Chile, where the comet passed almost directly overhead. The dates of these observations were November 11 through 14, and November 20. The equipment used included a 15 Mc/s broadside array, an 18 Mc/s interferometer, 18 and 20 Mc/s broadside arrays, a 22.2 Mc/s polarimeter, and a 27.6 Mc/s corner reflector. The results of the southern hemisphere observations were completely negative.

CONCLUSIONS

The interferometer records obtained during November, 1961, suggest that if Comet Seki was a *continuous* source of 22 Mc/s radiation during its close approach to the earth, it must have produced a flux density of less than 10^{-23} $w/m^2/cps$. The record most suggestive of possible high-level *sporadic* activity is that of November 14, which showed a fringe period very close to the theoretical period for radiation from a source at the declination of Comet Seki on that date. A calibration run made on November 16 at the corresponding sidereal time showed no fringes (Fig. 5). Strong, sporadic deflections superimposed on the Cassiopeia A fringes of November 18 and 19 are believed to have been due to ionospheric scintillations, rather than to the comet.

Certain deflections present in the 18 Mc/s scans over the position of the comet were not reproduced when calibration runs were made with the comet below the horizon. However, it is

TABLE 1

OBSERVATIONS OF COMET SEKI FROM FLORIDA

Date	22.2 Mc/s interferometer	18 Mc/s yagi	15 Mc/s corner reflector	22.2 Mc/s yagi	27 Mc/s yagi	K_p
Nov. 10	X	X	X	X	0	1
11	0	0**	X	X	0	0+
12	Weak fringes *	3 possible "events": 0523, 0526, 0612	X	X	0	2+
13	0	2 possible "events": 0532, 0544	0	X	0	1−
14	Weak fringes 0515 - 0638	First series of scans (0335) and second (0400) show "bump" 10° east of comet; first scan of fourth series (0500) shows rise in level 20° west of comet	0	X	0	2
15	X	X	X	X	X	0+
16	No fringes+	Calibration	Calibration	X	Calibration	0+
17	Calibration	X	X	X	X	2+
18	Signal superimposed on fringe of Cass. A	0	0	0	0	5
19	Deflections superimposed on Cass. A fringes; appear to have same period as Cass. A	0	0	0	0	4+

TABLE 1 (cont.)

OBSERVATIONS OF COMET SEKI FROM FLORIDA

Date	22.2 Mc/s interferometer	18 Mc/s yagi	15 Mc/s corner reflector	22.2 Mc/s yagi	27 Mc/s yagi	K_p
Nov. 20	Same as 19th	0	0	0	0	0+
21	A few deflections on Cass. A fringes	0	0	0	0	3
22	Only Cass. A fringes	0	0	0	0	2
23	Only Cass. A fringes	0	0	0	0	0
24	Only Cass. A fringes	0	0	0	X	1—
25	Only Cass. A fringes	0	0	0	X	1—
26	Only Cass. A fringes	0	0	0	X	0

* It was later discovered that on this date the two sections of the interferometer were phased for different zenith angles. The east array was phased 30° south, while the west array was phased 45° south.

** The pen recorder speed was too slow to resolve the antenna scans.

+ Calibration run. The comet was below the southern horizon.

disappointing that these deflections did not in general correspond with the exact position of the comet.

Evidently the question of radiofrequency emission from comets is one that still remains to be resolved. Since the past few years have been unusually productive of comets, radio astronomers may before long be presented with new opportunities to investigate this challenging problem.

ACKNOWLEDGMENTS

The writers are most grateful for support provided for these experiments by the National Science Foundation, the Office of Naval Research, and the U. S. Army Research Office (Durham). The southern hemisphere station is operated in cooperation with the University of Chile, under the direction of Dr. Federico Rutllant; Heins Bollhagen, Jorge May, and Jorge Levy served as observers.

APPENDIX

Abbreviations used: A. U. = astronomical unit (mean distance of the earth from the sun)
cps = cycles per second
m = meter
Mc/s = megacycles per second
w = watt

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Quart. Jour. Florida Acad. Sci. 26(1) 1963

REMARKS ON SEABALLS FROM FLORIDA AND HAWAII

F. C. W. Olson

Recently the writer gave a brief description of a seaball from Escambia County, Florida (Olson, 1957). Shortly thereafter, in September 1957, he and Mary Ann Olson found a quite similar one on the shore of St. Andrew Bay, Panama City, Florida, at the foot of Grant Avenue. This one had the same football shape but was only about 4 inches in length. Further, the density of plant material was so much less that it seemed reasonable to assume that the formative process had just begun. In the hope of finding other seaballs in the process of formation, a thorough search of the general shore area was made. Many rather large patches of plant stems and other debris were noticed in the waves washing on the shore, but no further seaballs, incipient or fully formed, were found.

An entirely different type of seaball was kindly sent to the writer by Dr. George D. Grice, Jr., in May 1959. This was found

Fig. 1. Seaball from Kauai Island, Hawaii. Official U. S. Navy Photograph.

along with hundreds of others on the north shore of Kauai Island, Hawaii. As can be seen in the figure, it is almost spherical in shape and is formed of a dense mass of bagasse, the remains of sugar cane after it has been through the presses. The weight of the thoroughly dried ball was 39 grams, and its diameter was about 9.2 centimeters. Its density was thus 0.1 $\mathrm{gm\ cm^{-3}}$ which compares with 0.3, the approximate density of hay or straw bales. Thus the seaball is only one-third as compact as a bale of hay. The source of the bagasse is believed to be one of two sugar mills at Waimea and Koloa on the south side of Kauai. The material was dumped from piers and apparently travelled some 40 miles in the littoral drift before reaching the estuary of the Kalihiwai River on the north side of the island where the balls were found.

On cutting both the Bay County and Kauai seaballs there was indication that each core was composed of a small bundle of parallel fibers, but the parallelism was not striking. From this rather weak evidence one can conjecture that the balls are formed by wave action which first builds up a wad of parallel fibers. Conditions must be such that the wad be compact and adherent. Following this, the wave action must impart a rolling motion to build up a spherical bundle. If this conjecture be valid, requiring two successive kinds of wave action, it might account for the comparative rarity of sea balls.

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HYDROLOGY AND PLANKTON OF COASTAL WATERS AT NAPLES, FLORIDA

Alexander Dragovich

In characterizing a marine environment ecologically, studies of aquatic conditions (Harvey, 1957; Rochford, 1951) and plankton as indicator organisms (Cleve, 1900; Russell, 1939) are extremely important.

The object of this work was to make concurrent studies of plankton occurrence and hydrology as well as to determine the influence of precipitation on them. Occurrence of the red-tide organism, *Gymnodinium breve* Davis (1948), was of particular interest in this study, since the Florida red tide is a natural fish-killing phenomenon in the coastal waters of southwest Florida. Monthly variations in temperature, salinity, total phosphate phosphorus, inorganic phosphate phosphorus, nitrate-nitrite nitrogen, substances which react to tests for arabinose and tyrosine, and characteristic plankton forms were investigated. A second objective was to observe the influence of precipitation upon the hydrology and plankton.

In recent years, the chemical and biological properties of Gulf waters of the west coast of Florida have been studied by various authors (Gunter *et al.*, 1948; Lasker and Smith, 1954; Ketchum and Keen, 1948; King, 1950; Graham *et al.*, 1954; Graham, 1954; Collier, 1958a; Curl, 1959a, 1959b; Finucane and Dragovich, 1959; Pomeroy, 1960; Dragovich *et al.*, 1961), but very little simultaneous hydrological and planktonic information is available for southwestern Florida waters.

The data on which this study is based have been published elsewhere (Dragovich, 1961).

Materials and Methods

All water samples were collected from the surface at Naples Pier, Naples, Florida, latitude 26° 07.9′, longitude 81° 48.5′. Sample collection procedure, plankton counting technique, and chemical methods of analysis were those described by Dragovich (1961). Organisms were enumerated in the living state. All Florida identifications and distributions not otherwise ascribed are by the au-

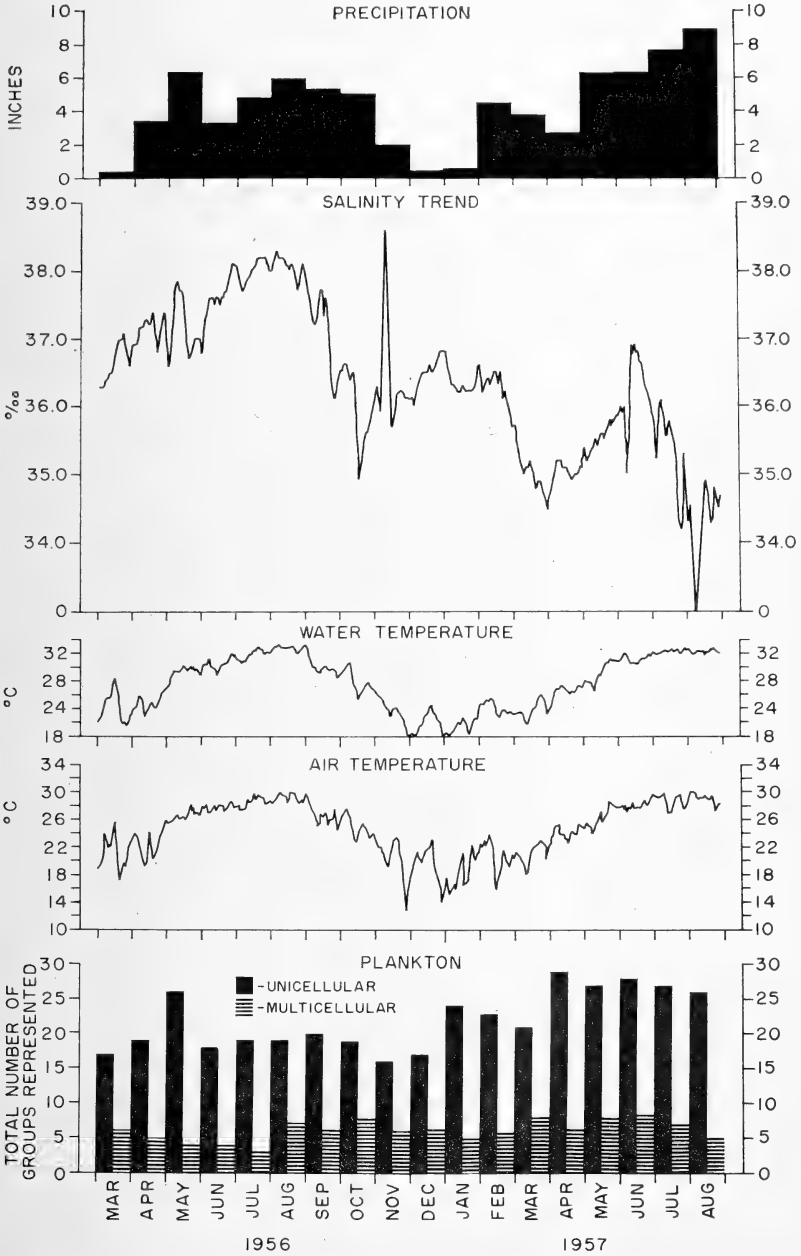

Fig. 1. Precipitation, salinity, water temperature, air temperature, and plankton for the surface water at Naples, Florida, March 1956-August 1957.

thor. Notes on species and distributions in other Gulf of Mexico waters not otherwise ascribed are from unpublished records of the Biological Laboratory of the Bureau of Commercial Fisheries at Galveston, Texas. When another source is also cited, these unpublished data will be indicated by (BCF).

HYDROLOGICAL OBSERVATIONS

The maximum (31.9° C.) water temperature was recorded in August 1956 and the minimum (17.0° C.) in November 1956 and January 1957. The monthly mean temperatures varied from 19.5° C. in January 1956 to 30.8° C. in August 1956. A relatively sharp rise occurred from April to May 1956 and a sharp decline from October to November 1956 (figure 1). Unusual spells of warm weather were recorded during March-April 1956 and from December 1956 through February 1957. During the remaining portion of this investigation, the seasonal temperature changes were gradual. The air temperature varied from 7.5° C., in January 1957, to 30.8° C., in July 1956. The monthly distribution of water temperature was essentially that of the air temperature (figure 1).

The monthly salinity means varied from 34.4 o/oo in August 1957 to 38.0 o/oo in August 1956. From March 1956 to August 1956 a gradual increase in salinity was noted. From August 1956 to August 1957 there was a generally declining trend.

The year 1956 was characterized by relatively little precipitation (38.1 inches), whereas the year 1957 had heavy rainfalls (58.4 inches). The 20-year mean precipitation for the Naples area is 51.50 inches. Precipitation values in figure 2 are the means of monthly rainfall recorded at weather centers in Naples, Miles City Tower, Everglades, and Fort Myers. Fort Myers, Everglades, and Miles City Tower are located within a 38-mile radius to the north, south, and east of Naples, respectively. All four of these weather centers are within the drainage basin of Everglades swamps, which drain their waters into the Gulf of Mexico.

The concentrations of total phosphorus in 69 water samples collected over a period of 17 months varied from 0.2 to 17.4 microgram atoms per liter (μg.at./l) with a mean of 1.5 μg.at./l (Dragovich, 1961). The highest concentrations during 1956 were observed in March and April. From April 1956 to May 1957 the concentrations remained below 2.0 μg.at./l. Unusually high values

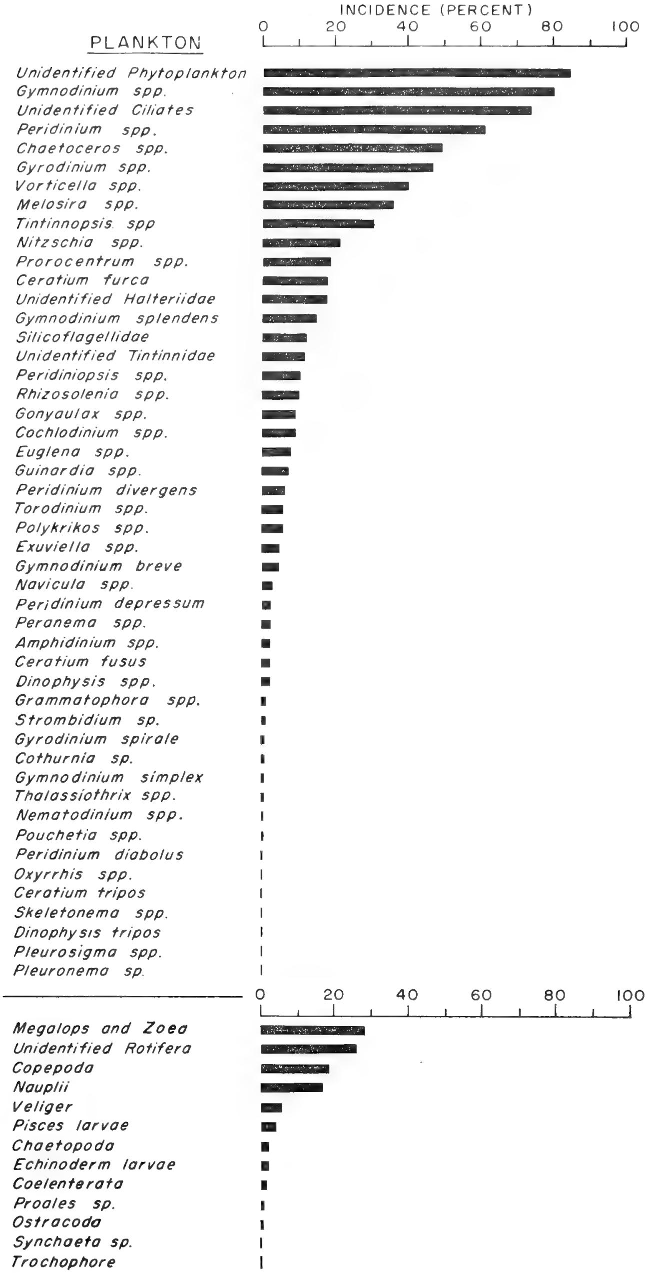

Fig. 2. Incidence of plankton at Naples, Florida, March 1956-August 1957.

(17.4 and 12.7 μg.at./l) were recorded in May and June 1957. During July, the concentrations remained below 2.0 μg.at./l.

The frequency distribution of total phosphate phosphorus concentrations shows that the majority of values (69.6 per cent) ranged from 0.2 to 1.0 μg.at./l. In 20.3 per cent of observations the values ranged from 1.1 to 2.0 μg.at./l, but the range 2.1 to 17.4 μg.at./l was recorded in only 10.1 per cent of the samples.

Concentrations of inorganic phosphate phosphorus in 73 samples varied from 0.0 to 3.2 μg.at./l with a mean of 0.6 μg.at./l. With the exception of May and June 1957, the monthly distribution pattern of inorganic phosphate phosphorus was similar to that of the total phosphate phosphorus. The frequency distribution of values showed a range of 0.1 to 0.6 μg.at./l in 68.5 per cent of the samples; 0.7 to 1.0 μg.at./l in 19.2 per cent; and 1.1 to 3.2 μg.at./l in 12.3 per cent.

Concentrations of nitrate-nitrite nitrogen in 66 water samples collected in a period from May 1956 to July 1957 ranged from 0.0 to 4.4 μg.at./l, with a mean of 0.7 μg.at./l. The monthly distribution of nitrate-nitrite nitrogen was very irregular. Highest concentrations were observed during November 1956 and March 1957. The distribution of nitrate-nitrite nitrogen values shows that the majority of concentrations (62.1 per cent) varied from 0.0 to 0.6 μg.at./l. A range of 0.7 to 2.0 μg.at./l was observed in 33.3 per cent of the samples. High values (2.1 to 4.4 μg.at./l) were recorded in only 4.5 per cent of the samples collected during November 1956 and March 1957. The minimal nitrate-nitrite nitrogen values of 0.0 μg.at./l were recorded in 6.1 per cent of samples and occurred during July, August, and October 1956.

Concentrations of carbohydrates producing a positive arabinose test in 73 samples varied from 0.0 to 4.1 milligrams per liter (mg/l) with a mean of 1.2 mg/l, and total tyrosine in 71 water samples varied from 0.0 to 10.5 mg/l, with a mean of 1.1 mg/l. These carbohydrate and protein substances will be referred to hereafter simply as carbohydrates and proteins.

The monthly mean values of carbohydrates and proteins were irregular. The concentrations of carbohydrates during 1956, with the exception of some values in March, April, and December, exceeded those of proteins. In 1957, extremely high concentrations of proteins were observed during February, March, and July, at which time proteins greatly exceeded carbohydrates. The concentrations of carbohydrates were generally lower during 1957 than during 1956. The frequency distribution of carbohydrates and proteins showed that the majority (66.2 per cent) of protein concentrations varied from 0.0 to 0.6 mg/l, and the majority (63.0 per cent) of carbohydrate concentrations ranged from 0.7 to 2.0 mg/l.

PLANKTON OBSERVATIONS

The study included 48 unicellular and 13 multicellular taxa of plankton (Dragovich, 1961). The unicellular taxa consisted of 10 genera of diatoms, 26 genera of dinoflagellates (11 of which were identified to species), a group of silicoflagellates, a group of unidentified phytoplankton (5-12 μ in size), 2 euglenoid genera, 6 ciliate genera, 1 ciliate family, and 1 unidentified group of ciliates.

Diatoms were represented by five centrate genera: *Chaetoceros* Ehrenberg, *Guinardia* Perag, *Melosira* Agardh, *Rhizosolenia* (Ehrenberg, Brightwell) Perag, and *Skeletonema* Greville; and five pennate genera: *Thalassiothrix* Cleve and Grunow, *Navicula* Bory, *Nitzschia* Hassal, *Pleurosigma* W. Smith, and *Grammatophora* Ehrenberg. All genera consisted of several species. No species identification was made.

Chaetoceros, Melosira, and *Nitzschia* were the principal diatom genera observed, occurring every month during this investigation.

Chaetoceros, the most frequently occurring group of diatoms, was present in 49 per cent of all observations (figure 2). Although *Chaetoceros* spp. appeared throughout the observation period, their

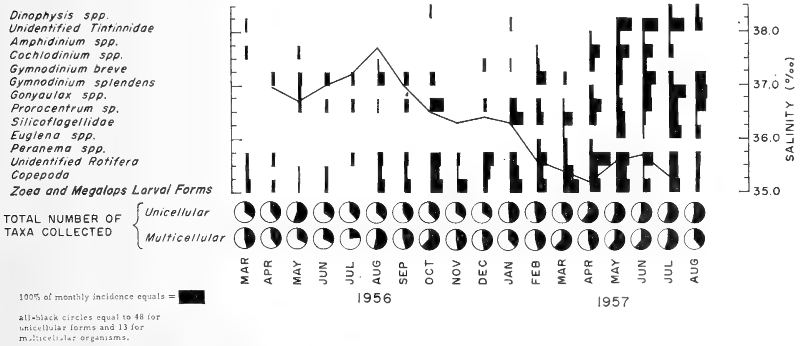

Fig. 3. Monthly incidence of selected planktonic groups, total number of taxa collected, and the salinity trend at Naples, Florida. Salinity trend represented by a three-item moving average of monthly salinity means.

presence in large numbers was noted only from May through September 1956.

Melosira and *Nitzschia*, the second and third most frequently observed groups of diatoms, showed similar monthly occurrence.

Rhizosolenia and *Guinardia* were present during most months, and blooms of these two groups were recorded during May 1956. A larger *Rhizosolenia*, resembling *R. styliformis* Brightwell, was on the whole, much scarcer than a smaller species.

Skeletonema and *Pleurosigma* had very limited occurrence. *Pleurosigma* occurred in small numbers. *Skeletonema* was predominant during April 1957.

Grammatophora appeared only during spring and summer months of 1957, occurring most frequently in April.

Navicula appeared during 9 months but never in high numbers.

Thalassiothrix was observed only in June and July of 1956 in small numbers.

The data indicate an influx of diatoms in May, June, August, and September of 1956. High concentrations of diatoms were observed in 1956, but 1957 was characterized more frequently by low concentrations.

Among dinoflagellates, the principal groups of organisms were *Gymnodinium* Stein, *Peridinium* Ehrenberg, and *Gyrodinium* Kofoid and Swezy (figure 2).

Gymnodinium spp. ranged from 5 to 40 μ. The smallest resembled *G. vitiligo* Ballantine and *G. veneficum* Ballantine; the largest resembled *G. heterostriatum* Kofoid and Swezy. *Gymnodinium* spp. occurred during every month; their abundance was consistently high from January through August 1957 at periods of reduced salinity and high precipitation.

The three gymnodinians identified to species are *G. splendens* Lebour, *G. simplex* Lohmann, and *G. breve* Davis.

G. splendens. Neritic and estuarine species. Common off west coast of Florida; off Galveston coast, Texas; and off Plymouth Sound, England (Lebour, 1925). Occurred during 13 months of the observation period. Monthly incidence higher during comparable months of 1957 than of 1956, except for April. Absence noted during November, December 1956 and January 1957, the period of lowest temperatures (figure 1).

G. simplex. Neritic and estuarine species. Common off west coast of Florida and Galveston, Texas. Observed in Adriatic Sea

(Ercegović, 1936), Plymouth Sound and at Kiel (Lebour, 1925). Appeared at Naples in January and April 1957 at the period of lower salinity and cooler temperatures *G. simplex* occurred in unusually large numbers (up to 10,000 per ml).

G. breve. Neritic and estuarine species. Observed in an area from Tarpon Springs, Florida, to Ten Thousand Islands off Everglades, and extending 40 miles offshore (Finucane and Dragovich, 1959; Dragovich *et al.,* 1961). Recorded from lagoons near Galveston, Texas. At Naples, present only in low concentrations. Occurred during August and December 1956 and first half of 1957.

Peridinium spp. made up the second most frequently occurring group of dinoflagellates. Frequency of occurrence was considerably higher during 1957 than in comparable months of 1956. Three peridinians were identified to species, *P. divergens* Ehrenberg, *P. depressum* Bailey, and *P. diabolus* Cleve. The identification of *P. diabolus* is questionable.

P. divergens. Neritic species. Observed in Norwegian and Danish seas, English Channel, Adriatic Sea, Bosporus, California (Lebour, 1925), and off Australian coast (Wood, 1954). Common in waters of west coast of Florida; present at Naples in higher numbers only during June 1956 and July 1957. Highest incidence observed during July and August 1957 during a period of low salinities.

P. depressum. Oceanic species. Common in North Sea, Atlantic Ocean, Indian Ocean, and Mediterranean Sea (Lebour, 1925). Observed in Adriatic Sea (Ercegović, 1936), off the east coast of New Zealand (Cassie, 1960), and off the west coast of Florida (BCF; Curl, 1959b). Recorded at Naples during May and September 1956; and June, July, and August 1957. Highest frequency of occurrence recorded during July 1957 at a period of low salinities and great heterogeneity in phytoplankton species composition.

P. diabolus. Oceanic species. Observed in Atlantic, Mediterranean, Plymouth Sound (Lebour, 1925), and off east coast of Australia (Wood, 1954). Occurred at Naples only in small numbers during March and May 1956.

Gyrodinium spp. comprised one of the principal dinoflagellate groups recorded during this investigation. Although found in every month, they occurred more frequently in the samples during 1957 than in comparable months of 1956, except for April.

G. spirale Berg, was the only gyrodinian identified to species.

Known for world wide distribution (Lebour, 1925). Present only during April and May 1956 in minimal numbers.

The genus *Ceratium* Schrank was represented by *C. furca* Ehrenberg, *C. tripos* O. F. Muller, and *C. fusus* Ehrenberg.

C. furca. Neritic species. Observed in northern temperate Atlantic to English Channel, Baltic Sea (Lebour, 1925), Norwegian Sea (Hasle and Nordli, 1951), South Pacific (Cassie, 1960), North Sea (Lucas, 1942), and off the west coast of Florida (BCF; King, 1950; and Curl, 1959b). Occurred during every month of the investigation with the exception of July 1956. Frequency of occurrence higher during 1957 than in comparable months of 1956, appearing in high numbers only during December.

C. tripos. Oceanic species. Observed in North Sea (Lucas, 1942), Norwegian Sea (Hasle and Nordli, 1951), English Channel (Lebour, 1925), South Pacific (Cassie, 1960), and off west coast of Florida. Present at Naples only during August 1957 in small numbers.

C. fusus. Oceanic species. Observed in all oceans (Curl, 1959b). Fairly common in coastal waters of west Florida; occurred at Naples only in small numbers during June, August, and September 1956.

Prorocentrum sp., resembling *P. micans* Ehrenberg, was present during 15 months of this investigation, occurring more frequently in samples during 1957 than in comparable months of 1956. During August 1957, *Prorocentrum* sp. was present in large numbers. The actual count of organisms during these blooms was 100 to 1,000 cells per ml. These blooms occurred in the period of lowest salinities accompanied by high temperatures and high organic phosphate phosphorus content. *Prorocentrum* sp. is common in the coastal waters of west Florida and in East Lagoon, Galveston, Texas.

The genus *Exuviella* Cienkowski was represented by several species, which are listed under *Exuviella* spp. Most of the organisms resembled *E. compressa* (Bailey) Ostenfeld. *Exuviella* spp. were present in small numbers, occurring during 8 months of the observation period. They were recorded most frequently during December 1956 and January 1957. *Exuviella* spp. are common in coastal waters from Tarpon Springs to Cape Sable, Florida.

Peridiniopsis Lemmermann. *Peridiniopsis* spp. occurred through the observation period, but never in high numbers.

Torodinium Kofoid and Swezy. *Torodinium* spp. were never present in high numbers, but they appeared in the samples during 10 months of the observation period, including January through June of 1957.

Gonyaulax Diesing. *Gonyaulax* spp. were recorded only once during 1956. In 1957, their presence was noted from April until the end of the investigation, a period of reduced salinities. Their highest concentrations were attained in June 1957.

Cochlodinium Schutt. *Conchlodinium* spp. were scarce during 1956. In 1957, they were more frequently observed, occurring during February, April, May, June, and July.

Polykrikos Butschli. *Polykrikos* spp. had a monthly distribution similar to that of *Conchlodinium* spp.

Amphidinium Claparede and Lachmann. *Amphidinium* spp. occurred only from April through July 1957, the period of relatively low salinities, in small numbers.

Dinophysis Ehrenberg. *Dinophysis* spp. occurred in small numbers in October 1956 and July 1957 during the periods of salinity decline. Blooms of *Dinophysis* spp. were recorded in August 1957, when salinity was low.

Dinophysis tripos Gourret. Oceanic form. Observed in Norwegian Sea, Greenland Sea, Indian Ocean, Mediterranean (Lebour, 1925), Australian region (Wood, 1954), and in the coastal waters off west Florida. Rare at Naples, appearing only during October 1956.

Oxyrrhis Dujardin. This genus was represented by one species, which resembled *O. marina* Dujardin, and was very scarce.

Nematodinium Kofoid and Swezy and *Pouchetia* Schutt (emended by Kofoid and Swezy) was represented by a few species. They occurred only during the spring months of 1956 in small numbers.

Two euglenoid groups of organisms and a chrysomonad group, belonging to the family Silicoflagellidae, were also observed at Naples. *Euglena* and *Peranema* first appeared during the spring months of 1957, which were characterized by the onset of the rainy season and a salinity decline. *Peranema* spp. were present in samples from February through April. *Euglena* spp. were observed in March and from May until the end of the observation period. The highest numbers of *Euglena* spp. were recorded during June and July.

After a complete absence during 1956, blooms of silicoflagellates, resembling *Distephanus speculum* (Ehrenberg) Haeck, appeared in January 1957. Thereafter, although the numerical prominence of these silicoflagellates never attained blooming proportions, they were present in the samples until the end of the observation period.

Unidentified phytoplankton, 5-12 μ in size, were very numerous during every month of this investigation. Most of these cells were generally translucent, yellowish green, somewhat round in shape, and occasionally flagellated. This was the most common group of organisms observed during this study, occurring in 85.2 per cent of observations (figure 2). Despite their minute size, they appear to be a prominent constituent of the plankton.

The most frequently occurring group of ciliates is listed as unidentified species. This assemblage of various species ranged in length from 5 to 80 μ. The smallest organism resembled *Mesodinium pulex* Claparede and Lachmann, while the largest resembled members of the families Frontonidae and Euplotidae. Unidentified ciliates were recorded during every month of the observation period. Consistently high numerical representation was recorded from September 1956 until April 1957 when other ciliates were also prominent.

Vorticella Fromental was the second most frequently observed group of ciliates. Its absence in samples was noted only during June 1956. The highest frequency of occurrence was attained in January. *Vorticella* spp. were most common from July 1956 to May 1957. The shallow investigation area provides an excellent environment for telotrochs and sessile vorticellids.

Tintinnopsis Stein was the third most frequently occurring group of ciliates (figure 2). This genus was present during 14 months of this investigation. Blooms of *Tintinnopsis* spp. were observed during December 1956 and January 1957. These organisms were most common from October 1956 to April 1957. The remaining members of the family were listed as unidentified Tintinnidae. With the exception of March 1956, their presence was observed exclusively during 1957. Their maximum incidence in samples was attained during May 1957.

Ranking fourth in frequency of occurrence among ciliates were the Halteriidae. This group of ciliates occurred more frequently during the comparable months of 1956 than 1957. Blooms were observed during November 1956, and January and March 1957. *Strombidium* Claparédè and Lachmann sp. was the only further identified member of the Halteriidae.

Strombidium sp. occurred in small numbers and was present during the winter and spring months of 1957.

Cothurnia Ehrenberg and *Pleuronema* Dujardin were present only during 1956 in small numbers.

Multicellular plankton, or zooplankton, consisted of copepods, rotifers, ostracods, chaetopods, coelenterates and larval stages of crustaceans, mollusks, annelids, echinoderms, and fishes.

Copepods were very common in samples but never present in high numbers. Their absence was noted only during April and July of 1956. Their maximum frequency of occurrence was observed in March 1957.

Ostracods appeared only during June 1957 and were present in high numbers.

Rotifers, consisting of a variety of species, were listed as unidentified rotifers. They appeared to be a significant segment of multicellular plankton (figure 2), occurring in 26.2 per cent of the samples. With the exception of August, they were noted more frequently during 1957 than in comparable months of 1956. *Synchaeta* Ehrenberg and *Proales* Ehrenberg were listed separately. *Synchaeta* sp. appeared in small numbers and only during August 1956. *Proales* sp. was the only rotifer to attain dense population during this investigation.

Free-swimming coelenterate medusae and echinoderm larvae were very irregular in occurrence, appearing only in small numbers.

Chaetopods, resembling *Dinophilus* Schmidt, were recorded during March, April, and May 1957, a period of high form diversity in other plankton.

Crustacean larvae made up the most commonly observed larval group. Zoea and megalops larval stages were absent only during June and July of 1956. Their frequency of occurrence was greater during the spring months of 1957 than in those of 1956. The temporal occurrence of nauplii was continuous.

Veliger larvae, present during 11 months, never occurred in high numbers. Their frequency of occurrence was greater during 1957 than in comparable months of 1956.

Trochophore larvae were present only during September 1956 in small numbers.

Fish larvae occurred very irregularly during 11 months, always in small numbers.

TABLE 1

SURFACE CONCENTRATIONS OF PHOSPHATE PHOSPHORUS IN MARINE WATERS

Locality	PO_4-P Minimum	(μg. at./l) Maximum	Mean	Source of Information
South Atlantic Coast of the United States (April 1954)	0.0	1.8	0.3	Anderson and Gehringer (1958)
South Atlantic Coast of the United States (June, July 1954)	0.1	2.4	0.7	Anderson and Gehringer (1959a)
South Atlantic Coast of the United States (September 1954)	0.0	1.4	0.0	Anderson and Gehringer (1959b)
Gulf of Mexico	0.0	5.3	0.2	Collier (1958b)
English Channel	0.03	0.74		Harvey (1957)
Calicut-West Coast of India	0.13	1.68		Subrahmanyan (1959)
Florida West Coast	0.0	2.5	0.3	Finucane and Dragovich (1959)
Florida West Coast	0.0	9.4	1.2	Dragovich, Finucane, and May (1961)
Naples, West Coast of Florida	0.0	3.2	0.6	Present investigation

DISCUSSION

The particular collection and examination method used in the present study permitted the detection of small, fragile forms, including *Gymnodinium breve,* which does not readily survive collection by plankton net or brass water sampling bottle.

King (1950), in his plankton studies of coastal waters of west Florida, observed six diatom genera (*Skeletonema, Navicula, Nitzschia Rhizosolenia, Chaetoceros,* and *Thalassiothrix*) and eight dinoflagellate genera (*Gymnodinium, Gonyaulax, Peridinium, Prorocentrum, Cochlodinium, Polykrikos, Ceratium,* and *Dinophysis*), which we also noted. The same author reported that water samples from river, bay, and coastal areas off Boca Grande, Florida, usually yielded large numbers of *Gymnodinium simplex* when cultured in the laboratory. The present work shows that this organism also occurred in extremely high numbers at Naples. In regard to tintinnids, copepods, ostracods, rotifers, and mollusk larvae, King's observations were in general agreement with our findings. On the other hand, he found much better representation of copepods and diatoms than the fragile phytoplankton forms. He collected plankton with both reversing water bottle and plankton net, preserving the samples in formalin.

For his phytoplankton study of Apalachee Bay and the northeastern Gulf of Mexico, Curl (1959b) detected a greater variety of diatoms than was observed in the present study, but only one nonthecated dinoflagellate. He usually preserved one liter of water with neutralized formalin and concentrated samples in a Forest plankton centrifuge. Ciliates and euglenoid organisms were not mentioned in his report.

The difference between our results and those of Curl and King may be attributed largely to differences in methods of collection and treatment of samples. In regard to detection of non-thecated dinoflagellates, ciliates, and euglenoids, examination of living organisms has advantages over preserved samples. However, this type of sampling method seems not to have any advantage in collection of large multicellular plankton.

Since the author's identifications of most of the plankton were carried out only to family, genus, or listed as unidentified, the plankton probably consisted of a much larger number of species than we list. This should stimulate those who wish to engage in taxonomic plankton studies of the west coast of Florida.

TABLE 2

INCIDENCE OF PLANKTON BY TEMPERATURE INTERVALS

Temperature Range (°C.) Number of Observations	17.0–23.5 126	23.6–28.4 120	28.5–31.9 120*
UNICELLULAR PLANKTON:			
Amphidinium spp.	0	5	2
Cochlodinium spp.	5	18	10
Gymnodinium breve	3	9	5
G. simplex	2	1	0
G. splendens	9	18	29
G. spp.	89	105	104
Gyrodinium spirale	1	3	0
G. spp.	46	74	53
Torodinium spp.	8	10	5
Polykrikos spp.	7	3	11
Nematodinium spp.	1	0	1
Pouchetia spp.	0	2	0
Oxyrrhis spp.	1	0	0
Ceratium furca	31	18	18
C. fusus	0	3	4
C. tripos	0	0	1
Gonyaulax spp.	1	7	26
Peridiniopsis spp.	7	10	23
Peridinium depressum	2	1	4
P. diabolus	1	1	0
P. divergens	2	5	17
P. spp.	70	74	80
Dinophysis tripos	0	1	0
D. spp.	0	1	6
Exuviella spp.	9	5	4
Prorocentrum sp.	13	32	24
Silicoflagellidae	20	15	11
Euglena spp.	0	6	25
Peranema spp.	4	4	0
Melosira spp.	40	54	38
Skeletonema spp.	0	1	0
Chaetoceros spp.	39	58	86
Guinardia spp.	4	18	6
Rhizosolenia spp.	2	28	9
Thalassiothrix spp.	0	1	2
Navicula spp.	3	6	1
Pleurosigma spp.	1	0	0
Nitzschia spp.	17	30	31

TABLE 2 (cont.)

INCIDENCE OF PLANKTON BY TEMPERATURE INTERVALS

Temperature Range (°C.) Number of Observations	17.0–23.5 126	23.6–28.4 120	28.5–31.9 120*
UNICELLULAR PLANKTON: (Cont.):			
Grammatophora spp.	1	4	1
Unidentified Phytoplankton	118	120	85
Strombidium sp.	3	3	0
Unidentified Halteriidae	26	28	12
Tintinnopsis spp.	58	42	13
Unidentified Tintinnidae	3	9	31
Vorticella spp.	62	52	33
Cothurnia sp.	1	3	0
Pleuronema sp.	0	1	0
Unidentified ciliates	100	104	68
Coelenterata	1	0	5
Proales sp.	0	1	2
Synchaeta sp.	0	0	1
Unidentified Rotifera	27	42	27
Echinoderm larvae	2	3	2
Veliger	8	11	2
Chatetopoda	0	7	0
Trochophore	1	0	0
Copepoda	27	24	18
Ostracoda	0	1	1
Nauplii	25	26	12
Megalops and Zoea	49	35	21
Pisces larvae	5	5	4
BROAD PLANKTON GROUPS:			
Dinoflagellates	308	406	427
Silicoflagellates *Peranema* spp.	24	19	11
Euglena spp.	0	6	25
Diatoms	107	200	174
Unidentified phytoplankton	118	120	85
Ciliates	253	242	157
Multicellular plankton	145	155	95

* Number of observations in regard to *Gymnodinium breve* was 125.

Scatter diagrams indicate no correlation between the broad plankton groups (dinoflagellates, diatoms, ciliates, unidentified phytoplankton, silicoflagellates, euglenoids, and zooplankton) and hydrological parameters (temperature, salinity, inorganic phosphate phosphorus, total phosphate phosphorus, nitrate-nitrite nitrogen, carbohydrates, and proteins).

The subtropical annual temperature range of 17.0 to 31.9° C. observed at Naples is comparable to that of Tampa Bay (Dragovich *et al.*, 1961) and to the Apalachee Bay waters of northern Florida (Curl, 1959a). A close parallel between the air and the water temperatures was noted (figure 1). Rapid changes in water temperature occurred during the winter and early spring months but were less pronounced than in Texas bays (Collier and Hedgpeth, 1950) or Tampa Bay (Dragovich *et al.*, 1961). In order to compare the occurrence of plankton constituents with the temperature, the entire temperature data were subdivided into three categories, each of which included about one-third of the total number of observations (table 2). Dinoflagellates, *Euglena* spp., and diatoms occurred more frequently at the higher end of the Naples water temperature range, and the unidentified phytoplankton, ciliates, silicoflagellates, *Peranema* spp., and multicellular plankton were more frequent at the lower end.

Pronounced salinity differences between the relatively dry year of 1956 and the relatively wet year of 1957 were observed. However, the monthly salinity distribution does not show an inverse relationship to the precipitation. This was particularly noticed during November, December, and January. The absence of this relationship may indicate that the waters at Naples are influenced more by the coastal water circulation than by direct fresh-water runoff. The values for Naples show deviation both above and below 35.0o/oo, which may be assumed to be a representative salinity value for the open Gulf. However, the frequency distribution of salinity values showed that in only 6.6 per cent of the observations were the salinities below 35.0o/oo, while in 93.4 per cent of observations they ranged from 35.0o/oo-38.6o/oo, indicating that coastal waters off Naples are marine. The salinity range observed at Naples can be classified as euryhaline (30.0o/oo-40.0o/oo). The temporal salinity distribution indicates that change is more characteristic than steady state for this area. Such changes are typical of coastal waters.

The plankton occurrence was compared with salinities in a manner analogous to the temperature-plankton comparison (table 3). All broad plankton groups occurred with greater frequency at the lower end of the Naples salinity range, with the exception of diatoms and unidentified phytoplankton. A number of taxa, notably several dinoflagellates (including *G. breve*), Tintinnidae, silicoflagellates, and euglenoids, were observed only, or most frequently, in this range.

Higher incidence of certain plankton forms and higher taxonomic diversity of the plankton as a whole occurred during the lower salinity months of 1957 (fig. 3). Abundance of phytoplankton during periods of salinity decline has also been observed in other areas (Bigelow, 1926; Gaarder and Gran, 1927). Dissolved nutrients in land drainage (Wilson and Collier, 1955) and external metabolites (Lucas, 1955; Wilson, 1951; Wilson and Armstrong, 1952) are factors which are thought to be responsible for the greater prominence of plankton at the periods of lower salinity. Thus, salinity reduction *per se* may not have been the decisive factor in proliferation of plankton. However, the salinity tolerances of coastal planktonic organisms observed during this study may have enabled them to take advantage of the availability of nutrients during periods of reduced salinity (Braarud and Rossavik, 1951).

The Florida red-tide organism was never observed to bloom during the period of this study, although the data of Dragovich *et al.* (1961) indicate that *G. breve* occurred in blooming proportions during October and November 1957, in coastal waters less than 8 miles off Naples Pier. The occurrence of *G. breve* was more frequent during 1957 than in comparable months of 1956 (figure 3). In the absence of *G. breve* blooms, the present results do not give evidence of a planktonic succession that may be associated with the development of the Florida red tide. This observation is in agreement with that made by Gunter *et al.* (1948).

The temporal distribution of total phosphorus was characterized by great fluctuations in March and April 1956, and May and June of 1957 (Dragovich, 1961). Possible explanations for the high total phosphorus levels noted are (1) proximity to land drainage outlets, in which high phosphorus concentrations exist, and (2) stirring of the bottom sediment by wind (Harvey, 1957). The absence of an inverse salinity-phosphorus relationship favors the latter possibility. The mean total phosphorus value observed at Naples

TABLE 3

INCIDENCE OF PLANKTON BY SALINITY INTERVALS

Salinity Range (o/oo) Number of Observations	32.4–36.0 121*	36.1–36.9 121	37.0–38.6 115
UNICELLULAR PLANKTON:			
Amphidinium spp.	5	1	0
Cochlodinium spp.	20	9	2
Gymnodinium breve	9	4	1
G. simplex	1	2	0
G. splendens	19	20	16
G. spp.	107	99	84
Gyrodinium spirale	0	0	4
G. spp.	42	52	71
Torodinium spp.	9	7	5
Polykrikos spp.	12	7	2
Nematodinium spp.	0	1	1
Pouchetia spp.	0	1	1
Oxyrrhis spp.	0	0	1
Ceratium furca	28	27	12
C. fusus	4	2	1
C. tripos	1	0	0
Gonyaulax spp.	25	6	1
Peridiniopsis spp.	13	10	15
Peridinium depressum	4	3	1
P. diabolus	0	1	1
P. divergens	9	5	10
P. spp.	107	74	41
Dinophysis tripos	0	1	0
D. spp.	7	0	0
Exuviella spp.	5	9	4
Prorocentrum sp.	35	24	8
Silicoflagellidae	28	16	0
Euglena spp.	23	5	0
Peranema spp.	4	3	0
Melosira spp.	34	48	44
Skeletonema spp.	1	0	0
Chaetoceros spp.	58	57	65
Guinardia spp.	9	8	10
Rhizosolenia spp.	15	5	14
Thalassiothrix spp.	0	0	2
Navicula spp.	1	6	3
Pleurosigma spp.	1	0	0

TABLE 3 (cont.)

INCIDENCE OF PLANKTON BY SALINITY INTERVALS

Salinity Range (o/oo) Number of Observations	32.4–36.0 121*	36.1–36.9 121	37.0–38.6 115
UNICELLULAR PLANKTON (Cont.):			
Nitzschia spp.	23	22	30
Grammatophora spp.	5	1	0
Unidentified phytoplankton	83	113	117
Strombidium sp.	4	2	0
Unidentified Halteriidae	40	19	6
Tintinnopsis spp.	45	43	20
Unidentified Tintinnidae	31	7	3
Vorticella spp.	42	60	40
Cothurnia sp.	0	1	3
Pleuronema sp.	0	0	1
Unidentified ciliates	89	93	82
MULTICELLULAR PLANKTON:			
Coelenterata	1	0	4
Proales sp.	1	1	1
Synchaeta sp.	0	0	1
Unidentified Rotifera	46	35	9
Echinoderm larvae	4	2	1
Veliger	10	7	3
Chaetopoda	4	0	0
Trochophore	0	1	0
Copepoda	33	25	6
Ostracoda	0	1	0
Nauplii	23	23	17
Megalops and Zoea	51	34	14
Pisces larvae	8	4	3
BROAD PLANKTON GROUPS:			
Dinoflagellates	462	365	282
Silicoflagellates *Euglena* spp. *Peranema* spp.	55	24	0
Diatoms	147	147	168
Unidentified phytoplankton	83	113	117
Ciliates	251	225	155
Multicellular plankton	181	133	59

* Number of observations in regard to *Gymnodinium breve* was 126.

Pier was two to three times higher than the corresponding values (0.6 μg.at./l) recorded at the 4-fathom contour off Naples (Finucane and Dragovich, 1959).

The highest inorganic phosphate phosphorus values occurred during March, April, November, and December 1956. The seasonal cycle in inorganic phosphate phosphorus observed in northern latitudes (Harvey, 1957) was not evident. The concentrations of phosphate phosphorus from various marine areas shown in table 1 are comparable to that for Naples. The maximum values observed at Naples exceed all other corresponding values, except those for two other Gulf of Mexico studies.

Concentrations of organic phosphorus were determined by subtracting the inorganic from total phosphate phosphorus, as determined in simultaneously collected samples. Organic phosphorus averaged 45.5 per cent of the total. The concentrations of organic phosphorus varied considerably from sample to sample and showed no consistent change in regard to the inorganic phosphate phosphorus. High values for inorganic and organic phosphorus may also have resulted from the lack of sample filtration.

The temporal distribution of nitrate-nitrite nitrogen was very irregular. The nitrate-nitrite nitrogen data indicate that the levels observed at Naples are very low if compared to certain marine areas such as the English Channel (Cooper, 1937), Sea of Calcutta (Panikkar and Jayaraman, 1953), Gulf of Maine (Rakestraw, 1936), or Barents Sea (Kreps and Verjbinskaya, 1930). Low levels of nitrate-nitrite in the coastal waters of west Florida were also observed by Finucane and Dragovich (1959) and Dragovich *et al.* (1961). Complete depletion of nitrate-nitrites during July, August, and October 1956 may be ascribed to phytoplankton utilization. Nevertheless, scatter diagrams for various groups of phytoplankton and nitrate-nitrite nitrogen show no relationship.

The existence of other chemical factors in the sea, which affect phytoplankton metabolism, has been postulated by various authors (Lucas, 1955; Wilson, 1951; Wilson and Armstrong, 1952; Collier *et al.*, 1953). The concentrations of carbohydrates and proteins in this study showed an erratic distribution. Collier (1958a) postulated that highly uneven distribution of carbohydrates and proteins might be related to the uneven distribution of marine microorganisms (Barnes and Marshall, 1951; Bainbridge, 1953), but scatter diagrams for various groups of plankton and carbohydrates and proteins showed no relationship.

This ecological investigation has characterized the shallow coastal waters at Naples as a subtropical, marine environment subject to considerable variation in precipitation and in several ecologically important factors. Dinoflagellates, unidentified phytoplankton, and ciliates were the most prominent representatives of unicellular plankton, and copepods and crustacean larvae were the most frequently observed multicellular plankton. The incidence and population density of *G. breve* were very low. Further taxonomic and quantative plankton work might show more definite relationships between the hydrological conditions and the resident biota.

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SUMMARY

During the course of this investigation, temperature, salinity, total phosphate phosphorus, inorganic phosphate phosphorus, nitrate-nitrite nitrogen, substances which react to the test of arabinose and tyrosine, and plankton composition were determined weekly in the coastal surface waters of Naples, Florida. The temperature variations were characterized by relatively sharp changes from April to May and from October to November. During the remaining months, the temperature changes were gradual. A striking effect of air temperature on water temperature was noted. Marked salinity differences were observed between the summer months of 1956 and 1957.

Phosphate levels were two to three times higher than in the adjacent offshore waters at the 5-fathom curve. Unusually high concentrations of total phosphate phosphorus were noted in May and June 1957, during heavy rainfalls. Nitrate-nitrite nitrogen levels at Naples were low compared with those of other marine areas of the world. The seasonal occurrence of organic substances, which react to the test of arabinose and tyrosine, was very erratic.

The plankton composition consisted of 48 unicellular and 13 multicellular taxa. The unicellular taxa or phytoplankton were represented by 10 genera of diatoms, 26 genera of dinoflagellates

(11 of which were identified to species), a group of unidentified phytoplankton (5-12 μ in size), 2 euglenoid genera, 6 ciliate genera, 1 ciliate family, and a group of unidentified ciliates. Copepods, rotifers, ostracods, chaetopods, coelenterates and larval stages of crustaceans, mollusks, annelids, echinoderms, and fishes constituted the multicellular plankton or zooplankton.

The incidence of plankton was considerably higher during the spring and summer months of 1957 than during the corresponding periods of 1956. This difference is associated with a disparity in rainfall and salinity during the spring and summer months of 1956 and 1957. There was no correlation observed between the various groups of plankton and hydrological parameters.

The particular collection and examination method employed during this investigation seems to have certain advantages over collecting by net and examining preserved samples.

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AN UNUSUAL MIOCENE PELECYPOD BURROW

H. K. Brooks, Arnold Ross, and H. C. Eppert, Jr.

During recent field work in southern Florida the authors collected a large number of macroscopic invertebrates, predominantly *Balanus* and *Ostrea*, from a State Road Department borrow pit near Nocatee, De Soto County. The fossiliferous deposits at this pit represent an arenaceous facies of the Tamiami formation of late Miocene age. What was at first considered an unusual cluster of barnacles proved, upon preparation, to be the burrow linings of a boring pelecypod. No attempt is here made to assign this fossil to genus in the absence of shells. Microscopic examination of the external surface of the calcitic burrow linings indicates that the molluscs probably bored into a dense colony of a tubiculous annelid (*Serpula*), which has since been leached and eroded away (see fig. 1, top).

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The Department of Geology and the Florida State Museum, University of Florida, provided equipment and facilities to further studies in invertebrate paleontology.

Occurrence

The specimen was collected from a State Road Department borrow pit (N. E. ¼ S. E. ¼ Sec. 24, T. 38 S., R. 24 E., Arcadia Quadrangle) along Florida Highway 760, approximately 1.6 miles east of the junction of U. S. Highway 17 and Florida Highway 760 at Nocatee, De Soto County, Florida.

Sediment samples from the fossil bearing horizon in the quarry consist of light gray to greenish-gray calcareous and argillaceous sand. The quartz particles are poorly sorted, angular, and range in size from coarse to very fine, with fine size particles predominating. Insoluble residues of a 50 gm. sample digested in 20 per cent hydrochloric acid for 24 hours amounted to 70.8 per cent of the sample, of which 37.6 per cent had a particle size of less than 62 microns. Round, smooth, brownish-black phosphate grains constitute only a minor fraction of the sediment.

The areal extent and stratigraphy of the deposits from which the cluster of burrows was collected have been discussed by Berg-

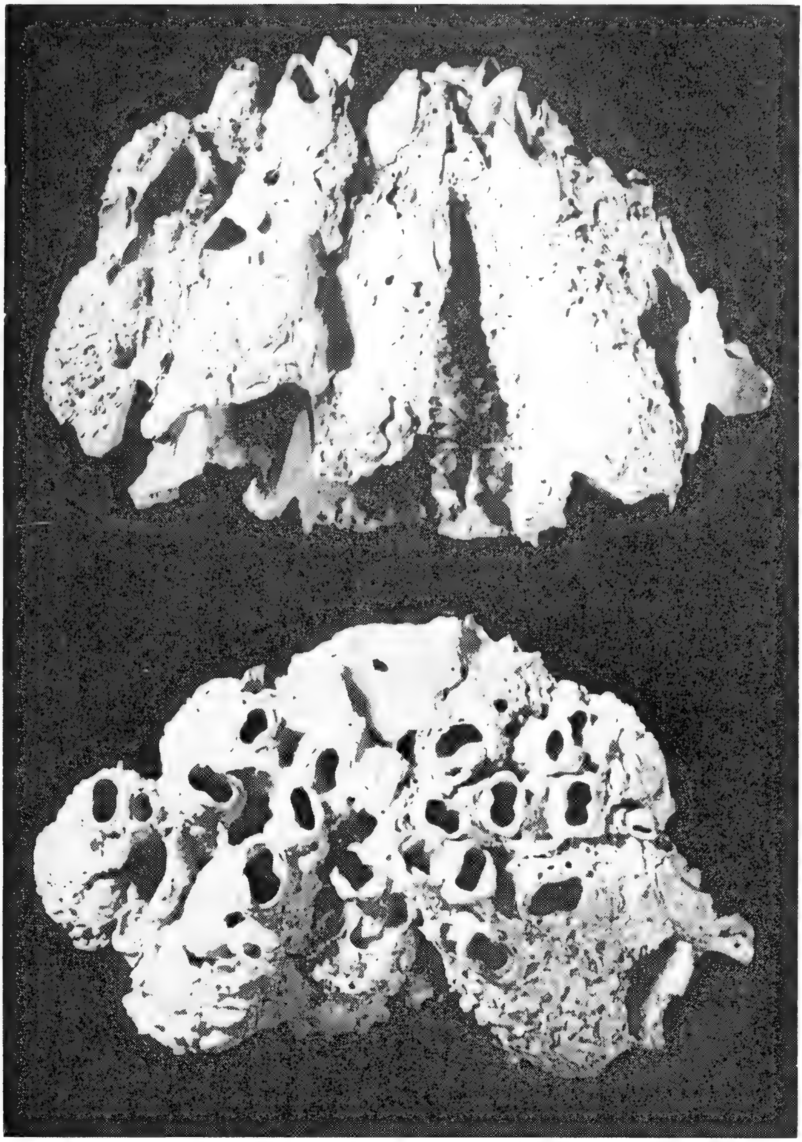

Fig. 1. Lateral (top) and siphonal (bottom) views of the pelecypod burrow linings. Hypotype, Florida State Museum No. 1318. Actual width of specimen, 11 cm.

endahl (1956). The Arcadia marl, described by Dall (1892), is a light colored, phosphatic, calcareous sand outcropping about 6 miles north of Arcadia, De Soto County, and was considered, by Dall, to be of early Pliocene age. Dall also reported exposures of an oyster marl along the Peace River at Shell Point, approximately 3 miles north of Arcadia. Similar outcrops were reported from the vicinity of Nocatee and Zolfo Springs. Bergendahl dated the Arcadia and "oyster" marls of Dall as being of late Miocene age. These fossiliferous sands and marls overlie the middle Miocene Hawthorn formation, and are here considered a lithofacies of the Tamiami formation which, as defined by Parker (1951), includes all of the upper Miocene strata in southern Florida. Specimens of *Ecphora quadricostata umbilicata* (Wagner) in the Florida State Museum collections at the University of Florida from near Fort Myers and from near Buckingham in Lee County serve to confirm the upper Miocene dating of the Tamiami formation proposed by Parker.

Bergendahl stated that these deposits are indicative of a shallow marine environment. The foraminiferal assemblage, identified from these deposits by the authors (*Anomalina io, Bolivina* cf. *B. advena, Bulimina* cf. *B. elongata, Cibicidella* cf. *C. variabilis, Discorbis* cf. *D. consobrina, Discorbis* cf. *D. vilardeboana, Lagena clavata, Nonionina* cf. *N. depressula, Textularia candeiana,* and *T. gramen*), however, indicates a bathymetric range of approximately 15 to 20 fathoms or less. The presence of *Balanus* and *Ostrea* cannot be considered discordant because this depth range is well within the maximum for these genera. The comminuted barnacle-oyster marl at Nocatee suggests a deep epineritic shelf environment with moderate to strong turbulence. The environmental conditions, based upon the foraminiferal assemblage, do not indicate "shallow" water as postulated by Bergendahl.

MORPHOLOGY

The external surface of the fossil burrow linings, as preserved, consists of impressions of closely packed worm tubules and of barnacle shells which were incorporated into the mass of worm tubules as the *Serpula* colony grew. The fossil clams lined their siphonal canals and the posterior portion of the burrows with successive layers of calcareous material, evidence for which may be seen where pieces of the canal openings have been broken away.

The linings are probably secreted by the walls of the siphon and the mantle (Yonge, 1955).

Only the morphological features of the posterior portion of the living chambers are preserved, the anterior portion being broken and leached away, with one exception. A young, second generation individual subsequently bored along the side of the pre-existing chambers. From this individual it can be seen that the living chamber was elongate-expanding and flagon-shaped, whereas the remaining incomplete burrows are funicular in shape. The internal surface of the shell chamber is smooth and circular to subcircular in cross section. The siphonal canals are moderately short and somewhat constricted in the middle, suggesting a figure 8 in cross section (see fig. 1, bottom).

The numerous borings are closely packed together and are separated only by thin walls. Because of this proximity, the siphonal canal openings are not directly above the shell chamber. The external openings are appreciably narrower than the living chamber itself, the size of which is adjusted to the growth of the animal, so that the burrowers are confined to this elongate-expanding domicile for life.

Measurements of a representative mature individual are as follows: diameter of shell chamber, 22.5 x 22.0 mm.; length of shell chamber, 45.2 mm.; length of siphonal canal, 29.1 mm.; diameter of siphonal opening, 2.9 x 5.6 mm.

REMARKS

Representatives of the genera *Gastrochaena, Spengleria,* and *Rocellaria* of the family Gastrochaenidae, *Pholas, Barnea, Martesia, Diplothyra,* and *Pholadidea* of the family Pholadidae, *Petricola* and *Rupellaria* of the family Petricolidae and *Botula* and *Lithophaga* of the family Mytilidae, as well as many other genera, are known to burrow in shells, wood, coral, or unconsolidated and lithifield sediments. There is an extensive literature dealing with the mode of burrow excavation in these groups (Turner, 1954). Few studies, however, have been directed toward the morphology of this type of mollusc burrow; thus generic identification of this fossil is not warranted.

The rate of growth of the clam, and the size and shape of the burrow, depend largely upon the hardness of the substratum and the amount of crowding. Furthermore, siphonal sinuosities are also a function of crowding and type of substratum, and in the case of coralliophilic species a function of the coral's growth pattern. When all of these and many other variables are taken into account, a pattern will no doubt emerge which will permit recognition of suprageneric taxa based on distinctive characteristics of the burrows and burrow linings.

Yonge (1955) noted that the posterior portion of the burrows and the siphonal canals of several species are lined with calcareous material. However, not all of the above mentioned boring molluscs secrete such a lining (e.g., species of *Lithophaga* and *Barnea*). Also, it should be noted that the Mytilidae have poorly developed siphons. Therefore it is improbable that the fossil burrows reported here belong to a species of this family.

Gardner (1943) questionably assigned a burrowing mollusc from the Miocene Yorktown formation of Virginia to the genus *Coralliophaga* of the family Trapeziidae. A comparison of the present specimen with the illustrations given by Gardner (pl. 9, figs. 2 and 6) indicates that there is a great similarity. Although it cannot at this time be ascertained if different species are represented, neither specimen can be assigned to the genus *Coralliophaga,* as this mollusc lives in the burrows made by other boring clams.

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Quart. Jour. Florida Acad. Sci. 26(1) 1963

A NEW PLEISTOCENE GREBE FROM FLORIDA

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THE Pleistocene record of the grebes includes nine of the world's 17 living species, but that epoch is currently represented by only one extinct species of the family Podicipedidae (Brodkorb, 1963b). Among the more than 5000 avian fossils thus far catalogued from Reddick, Florida, is a single carpometacarpus that represents a second, hitherto undescribed, extinct grebe from the Pleistocene.

Two living species of grebes also occur in Pleistocene deposits of Florida. The pied-billed grebe, *Podilymbus podiceps* (Linnaeus), has been recorded at Seminole Field in St. Petersburg and from the Itchtucknee River (Wetmore, 1931), at Haile (Brodkorb, 1953), Reddick (Brodkorb, 1957), Arredondo (Brodkorb, 1959), Rock Spring (Woolfenden, 1959), Vero Beach (Weigel, 1963), and the Santa Fe River (Brodkorb, 1963a). Previously unreported Pleistocene sites for this species include Jenny's Spring, Hornsby Spring, Lake Monroe, Catalina Lake in St. Petersburg, and Bradenton. The horned grebe, *Podiceps auritus* (Linnaeus), occurs at Seminole Field (Wetmore, 1931) and Rock Spring (Woolfenden, 1959), but the specimen attributed to this species from the Itchtucknee River (Wetmore, 1931) represents a large individual of *Podilymbus podiceps.*

The carpometacarpus of *Podiceps* differs from that of *Podilymbus* in several characters. In *Podiceps* the excavation proximal to the pisiform process occupies a large, elongated area that undercuts the pisiform process distally and extends proximally to the rim of the trochlea (in *Podilymbus* the excavation is short and round, and lies entirely proximal to the pisiform process and well distal to the rim of the trochlea). Metacarpal one is nearly parallel with the shaft of metacarpal two (in *Podilymbus* metacarpal one is rotated proximally toward the internal side). The outer trochlea is relatively short, so that the intertrochlear notch is weakly developed (in *Podilymbus* the outer trochlea is lengthened proximally to form a more pronounced intertrochlear notch). The pisiform process is strongly developed (in *Podilymbus* it is much less produced).

As the new species from Reddick agrees with *Podiceps* in the characters outlined above, it is described as

Podiceps dixi, new species

Fig. 1

Holotype. Proximal portion of right carpometacarpus, Brodkorb no. 1113, at University of Florida. From Middle Pleistocene Reddick beds, at Dixie Lime Products Company mine, 1 mile south of Reddick, Marion County, Florida, in SW corner of NW ¼, section 14, Township 13 South, Range 21 East. Collected by H. James Gut, 1950.

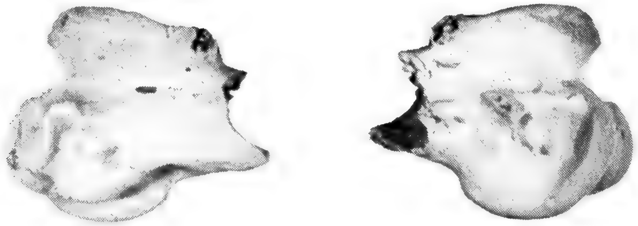

Fig. 1. *Podiceps dixi,* n. sp. Holotype carpometacarpus (actual length, 8.6 mm.).

Diagnosis. Resembles living *Podiceps auritus* (Linnaeus) but somewhat larger; metacarpal one lengthened proximally nearly to level of proximal end of inner trochlea.

Measurements. Comparative measurements of the type, various living species of *Podiceps,* and the Pleistocene *P. parvus* (Shufeldt) are given below.

Height through process of metacarpal one and inner trochlea, 7.3 mm. (5.9 in *P. caspicus;* 6.7-7.0 in *P. auritus;* 9.3 in *P. cristatus;* 9.4 in *P. grisegena*). Height through process of metacarpal one and outer trochlea, 6.3 (5.0 in *P. caspicus;* 5.8-6.0 in *P. auritus;* 8.0 in *P. cristatus;* 8.4 in *P. grisegena*). Length of metacarpal one, 5.6 (4.4 in *P. caspicus;* 5.0-5.2 in *P. auritus;* 6.4 in *P. cristatus;* 7.0 in *P. parvus;* 7.0-7.8 in *P. grisegena*). Width through trochleae, 3.1 (2.9 in *P. caspicus;* 2.8-3.1 in *P. auritus;* 4.1 in *P. cristatus;* 4.3 in *P. grisegena*). Width of metacarpal two, 3.0 (1.8 in *P. caspicus;* 2.0-2.6 in *P. auritus;* 3.0 in *P. cristatus;* 3.1 in *P. parvus;* 3.0-3.3 in *P. grisegena*). Height through pollical facet and metacarpal two, 5.0 (3.6 in *P. caspicus;* 4.2-4.3 in *P. auritus;* 5.5 in *P. cristatus;* 5.8 in *P. grisegena*).

Compared with the extinct fossil species of *Podiceps,* the new species is larger than *P. pisanus* (Portis) from the Middle Pliocene of Italy and *P. subparvus* (L. Miller and Bowman) from the Middle Pliocene of California. It is smaller than *P. oligoceanus* (Shufeldt) from the Middle Pleistocene of Oregon and older deposits in California.

Acknowledgments. This study was aided by the National Science Foundation through grant number G-19595. The photographs are by Robert W. McFarlane and Carol Zunker.

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THE NEARCTIC SPECIES OF *COPELATUS* ERICHSON (Coleoptera: Dytiscidae)

Frank N. Young

The Nearctic water beetles of the genus *Copelatus* Erichson are readily recognized by the characteristic grooves or striae on the elytra, the approximate coxal lines, and the form of the metasternal wings. All are referable to the typical subgenus. In southern Mexico, Central and South America, the Antilles, and Hawaii, however, non-striate species occur, which are presently referred to the subgenus *Liopterus* Dejean or *Leiopterus* Stephens. Some of these forms probably represent convergent stocks, but as a whole the genus is remarkably homogeneous despite its enormous size (J. Balfour-Browne, 1939).

Zoogeography

The genus is largely tropical with over 200 species described from Africa, Asia, Australia, and the Neotropical region. The Nearctic species represent extensions of South American groups that have apparently moved northward at various times in the past and in some cases have undergone isolation and subsequent differentiation.

Copelatus glyphicus (Say) and *C. punctulatus* Aubé probably reached the eastern forested areas before the Pleistocene. These are the only Nearctic species that occur commonly in habitats where the genus *Hydroporus* is also well-represented. Morphologically similar species occur in the Antilles and South America, but closely related forms are not found in Central America or Mexico.

C. caelatipennis princeps, new subspecies, probably reached the southern United States during the Pleistocene by way of the Antilles. It is closely related to the Central American-Mexican *fragilis* Sharp and the Cuban *angustatus* Chevrolat, but its range now is completely isolated from that of *fragilis* and overlaps with that of *angustatus* only in southern Florida where the two seem to have come together only in recent years. All three of these forms are part of a Neotropical complex centering around *C. caelatipennis* Aubé. The members of this complex are characterized by the remarkable modification of the male aedeagus, which in lateral view assumes the appearance of a bird's head.

C. chevrolati Aubé probably represents a Pleistocene extension from Central America and Mexico which has now extended from Florida into the Bahamas. The 8 discal elytral striae separate the species from the 10-striate species, but progressive reduction of striae is indicated in the Central American *C. prolongatus* Sharp and in some local populations now included in *C. distinctus* Aubé. *C. chevrolati* is divisable into two subspecies on the basis of coloration and the presence or absence of a short apical sutural stria. These may, in fact, represent distinct species evolved during two separate isolations, one in the southeastern United States, the other in northern Mexico. In the eastern population the occurrence of occasional specimens without the sutural stria suggests, however, that *renovatus* Guignot is a derivative of the southeastern United States population and has extended westward and southward in relatively recent times. If the converse is true, that is if the occurrence of individuals without the sutural stria indicates introgression of *renovatus* into the southeastern population, one would expect the frequency of *renovatus*-like individuals to decrease from northwest to southeast. The present evidence indicates, however, that individuals lacking the sutural stria are less common in western Florida than in the Peninsula.

C. distinctus Aubé (*C. impressicollis* Sharp and of authors) is a montane species of Central America and Mexico, but it also occurs in a number of isolated mountain ranges in the southwestern United States. These isolated populations may indicate a more extensive distribution in the past. All of the United States specimens seen are rather similar, but Mexican populations show considerable variation.

C. debilis Sharp is widely distributed in Central America and Mexico and reaches the United States in extreme southern Texas. The related *C. blatchleyi* Young is now known only from Key West, Florida, but it is undoubtedly Antillean in origin and only erratic on the Florida Keys. *C. cubaensis* Schaeffer has recently been found in southern Florida, where it may have been introduced in recent years.

In southern Mexico, where the Nearctic and Neotropical faunas overlap or interdigitate, a number of species of *Copelatus* may intrude into the Nearctic region. Genitalia of a few of these are figured, but the species are not included in the key, because as far as I know none has actually been recorded from the Nearctic area. For the most part they are species of strictly Neotropical affinities, whose the range is largely in the Neotropical region.

In the Neotropics, *Copelatus* seems to replace ecologically *Hydroporus* and related genera. Various species have radiated into a wide variety of habitats, ranging from swift mountain streams to water held in epiphytic plants.

The Nearctic species *C. glyphicus* and *C. punctulatus* are associated with flocculent organic debris, largely in seepages, and burrow much as do some species of *Hydroporus*.

The members of the *C. caelatipennis* complex belong to the pioneer water beetles, which quickly occupy temporary ponds and other situations and are usually rare in permanent waters. *C. c. chevrolati* also belongs to the pioneer group, but it frequently occurs in more permanent situations. *C. c. renovatus* is a typical member of the desert group which occurs in streams, tanks, temporary puddles, and similar ephemeral situations in the west. It is particularly common in streams but disappears in the presence of organic or other pollution.

In the Nearctic *C. distinctus* occurs in pools and streams usually at higher elevations, but in contrast *C. debilis* occurs in both permanent and temporary situations in the humid lowlands. In Central America *C. debilis* and *distinctus* (*impressicollis*) apparently occur at higher elevations.

The habitats of *C. blatchleyi* and *C. cubaensis* are poorly known, but both of these species probably occur in temporary fresh-water pools associated with wooded areas such as the Florida hammocks.

KEY TO NEARCTIC SPECIES OF *Copelatus*

1. Each elytron with a submarginal stria and with 10 discal striae, the alternate striae more or less abbreviated at the apex (Group 12 of Sharp, 1882a, in part) 2

1′. Each elytron with less than 10 distinct discal striae 7

2(1). Body form narrow, relatively convex; bases of elytra usually crossed by a distinct pale fascia contrasting with the ground color of pronotum and rest of elytra; front tibia of male strongly bent at base and with a notch below the knee; male aedeagus strongly modified, resembling in lateral view a bird's head (fig. 5 *caelatipennis* complex) 3

2′. Body form broader, sometimes flattened; dorsum usually uniformly colored, only rarely with a very vague fascia across bases of elytra;

male aedeagus simply curved with or without recurved teeth on margin 5

3(2). Pronotum in both sexes with fine short strioles or scratch-like impressions rather uniformly distributed over entire surface; females often with short strioles on basal third of elytra; elytral striae regularly impressed, the first and second (counting from suture) nearly as long as the others; elytra reddish brown to piceous with a narrow testaceous or reddish-brown fascia at base which is nearly uniform in width and not expanded in scutellar region; length 3.9 to 5.0+ mm; width 1.8 to 2.4 mm . . . . *caelatipennis princeps*, new subspecies

3′. Pronotum in both sexes usually without strioles on the disk; strioles if present more numerous on pronotum of female, and restricted to the sides; first elytral stria often shorter than others; elytral fascia expanded in scutellar area 4

4(3′). Color generally reddish brown; body narrow rather attenuate behind; elytral punctation fine, irregular; pronotum usually without strioles in either sex, but if present restricted to the sides leaving the disk smooth; length about 4.3 to 4.8; width 1.9 to 2.2 mm . . . . . . *caelatipennis angustatus* Chevrolat, new combination

4′. Color generally dark reddish brown to piceous; body form less broad, not strikingly attenuate behind; elytral punctation very fine; pronotum often without strioles in either sex, but sometimes with strioles at side in both males and females; length about 4.2 to 4.7; width 1.9 to 2.3 mm. . . *caelatipennis fragilis* Sharp, new combination

5(2′). Pronotum without strioles in male, nearly smooth; only a few strioles at the sides in the females; size generally smaller, length 4.2 to 5 mm 6

5′. Pronotum in both sexes with fine strioles at the sides; strioles usually more numerous in females but not extending over the disk; elytral striae sometimes irregular, interrupted, the first and often the second also conspicuously shorter than the others; color generally dark piceous or brown, the margins of pronotum and elytra sometimes lighter and contrasting with darker discal areas; size larger, length 5.8 to 6.3; width 2.8 to 3.0 mm. . . . . . . *distinctus* Aubé *

6(5). Elytra conspicuously punctate on intervals between striae; body form narrower, less depressed; color generally reddish-brown above and below; aedeagus of male stout, not strongly curved to sides; parameres broad (fig. 2); length 4.3 to 5.0; width 2.0 to 2.5 mm . . . . *punctulatus* Aubé

**Copelatus posticatus* (Fabricius), *C. terminalis* Sharp, and *C. integer* Sharp, which may extend into the Nearctic region in Mexico, will key to this point. They can readily be distinguished from *distinctus* by the broader body form, the coarser pronotal strioles extending onto the disk in both sexes, and by the distinctive male genitalia (figs. 9-11).

6′. Elytra inconspicuously punctate on intervals between striae; body form broad, subdepressed; color variable, but usually dark brown to piceous beneath when fully hardened; aedeagus of male slender, strongly curved to side; parameres relatively slender (fig. 1); length 4.2 to 5.0; width 2.1 to 2.6 mm. . . . *glyphicus* (Say)

7(1′). Each elytron with a submarginal stria and 5 to 6 discal striae; base of elytra with lighter transverse fascia 9

7. Each elytron with a submarginal stria and 8 to 9 discal striae; color nearly uniform on dorsum, no conspicuous fascia 8

8(7′). Each elytron with 8 distinct discal striae and usually a short ninth stria near the suture toward the apex; color generally dark brown to piceous when fully hardened; male genitalia relatively simple, apparently indistinguishable from the following (fig. 4) . . . . *chevrolati chevrolati* Aubé

8′. Each elytron with eight distinct discal striae but lacking a short sutural stria; color generally light brown or pale castaneous when fully hardened; male genitalia much as in typical *chevrolati* (fig. 4) . . . . *chevrolati renovatus* Guignot

9(7). Each elytron with submarginal and 5 discal striae; form elongate, narrow; size small rarely over 4 mm. in length; color yellowish brown to dark brown, the elytral fascia usually conspicuous; dorsal punctation fine and inconspicuous; male genitalia distinctive (fig. 6); length about 3.7 to 4.1; width 1.8 to 1.9+ mm. . . . *debilis* Sharp

9′. Each elytron with submarginal and either 5 or 6 discal striae; form broader less elongate; length usually over 4.5 mm . . . 10

10(9′). Each elytron with submarginal and 5 discal striae; form broad, convex; elytra usually darker in color than disk of pronotum, the basal light fascia narrow; dorsal punctation fine but more conspicuous than in *debilis*; male genitalia distinctive (fig. 7); length 4.5 to 4.7+; width 2.3 to 2.5+ mm. . . . . . . *blatchleyi* Young

10′. Each elytron with submarginal and 6 discal striae; form broad, but less convex; elytra lighter in color than disk of pronotum, the basal light fascia broad and conspicuous; dorsal punctation moderately coarse and close; male genitalia distinctive (fig. 8); length about 5.0 to 5.3; width 2.4 to 2.5+ mm. . . . *cubaensis* Schaeffer

Copelatus punctulatus Aubé (1838, p. 381)

Copelatus glyphicus (Say); Young, 1954; p. 106 (in part)

Extremely similar to *C. glyphicus* Say, but narrower and more convex in body form with the punctation of the dorsum coarser and deeper, particularly on the elytra. The male genitalia are distinctive (fig. 2). The color is usually more reddish brown, especially on the venter, than in *glyphicus,* but the latter is variable and some individuals are scarcely distinguishable on color alone.

This species has long been considered a synonym of *C. glyphicus,* but specimens fit the original description so precisely that I believe they will prove to be identical with the type.

Aubé described *C. punctulatus* from a single specimen in the Dejean collection, received from North America without definite locality. The rarity of the species is puzzling, but I suspect that it will prove to be widely distributed along the Gulf coastal area and northward. Its occurrence seems to be associated with seepage situations in deciduous woodland. Such situations must have once been very numerous throughout the eastern United States, but they have become increasingly rare even in areas where forest fragments still persist. Early collectors might thus have had a better opportunity of obtaining such forest species than have recent workers. *Hydroporus oblitus* Aubé may represent a parallel case; specimens agreeing with the type (in BMNH)* are exceedingly rare in collections, the common forms in open seepages representing other species.

Specimens Examined. ALABAMA.——Mobile Co., Mobile, iii.19.1932, H. Dietrich (1, CU). FLORIDA.——Haw Creek, 11.6, Hubbard & Schwarz (1, USNM). Alachua Co., near Paradise, iii.5.1946 (1, UMMZ); San Felasco Hammock west of Gainesville, viii.1.1959-viii.26.1961 (8, UMMZ). Clay Co., 6 mi. northwest Keystone Heights, x.15.1938, F. N. Young (2, CU, ex Chamberlain coll.) Columbia Co., near Lake City, ii.4.1938 (1, UMMZ): near Lulu, xii.30.1947 (1, UMMZ). Manatee Co., Onesco, iii.24.1954, G. E. Ball (1, CU). Polk Co., Lakeland, ii.21.1918, W. S. Blatchley (1, Purdue University, Blatchley coll.) Volusia Co., Enterprise, 11/23, "debris lake shore", ex Leng coll. (1, CAS). GEORGIA.——Charlton Co., Billy's Island, Okefenokee Swamp, vi.1912, J. C. Bradley (4, CU; 2, USNM). NEW JERSEY.——Bergen Co., Hillsdale, IX.1941, Quiresfeld (1, CAS).

I have also seen one doubtful female specimen from MICHIGAN.——Chippewa Co., Whitefish Point, vii.27.1914, A. W. Andrews (UMMZ). In size and coloration it closely resembles the Florida-Alabama-Georgia specimens, but the shape does not match exactly, and the punctation is finer.

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* British Museum (Natural History), London. Other abbreviations used subsequently are: University of Michigan Museum of Zoology (UMMZ); American Museum of Natural History (AMNH); Museum of Comparative Zoology (MCZ); United States National Museum (USNM); California Academy of Sciences (CAS); Chicago Natural History Museum (CNHM); Snow Museum, University of Kansas (SM); Ohio State University (OSU); Illinois Natural History Survey (INHS); Cornell University (CU); Florida State Collection (FSC). Unless otherwise indicated specimens were collected by the writer and are in the UMMZ.

Copelatus glyphicus (Say, 1823, p. 99)

This is the commonest Nearctic species of the genus. There is considerable variation in color, shape, and size, but the male genitalia (fig. 1) and the punctation are relatively constant. Newly emerged (teneral) specimens often appear flattened and very pale in color. Older specimens tend to be darker and more convex. There also seems to be some regional variation in shape, but I cannot find any characters to justify the separation of subspecies.

I have examined specimens from all of the United States east of the Mississippi River except West Virginia. I have also seen material from Minnesota, Iowa, Missouri, Arkansas, Louisiana, Oklahoma, Kansas, Texas, and Ontario. The range may be defined as from New England through southern Canada to Minnesota, south to Texas and east to Florida. In Texas, *C. glyphicus* occurs as far west as Jeff Davis County, but in Florida it is restricted to the northern portion of the state. It has also been recorded from Cuba and Guadeloupe, but these records are old and probably apply to other species.

Copelatus caelatipennis Aubé (1838, p. 382)

The exact identity of *C. caelatipennis* Aubé is still a matter of surmise. The species was described from the Antilles and Brazil (Aubé 1838, p. 382), and it is possible that Chevrolat (1863, p. 201) was mistaken in separating *C. angustatus* as distinct. A comparison of the Latin and French descriptions of *C. distinctus, punctulatus,* and other species described in the same work with *caelatipennis* convinces me, however, that Aubé did not have specimens

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Fig. 1. *Copelatus glyphicus* (Say). Washtenaw Co., Michigan, UMMZ; ventral view of aedeagus, lateral view of aedeagus, right paramere. Cross hatched, line, or stippled areas represent membranes difficult to represent by lines.

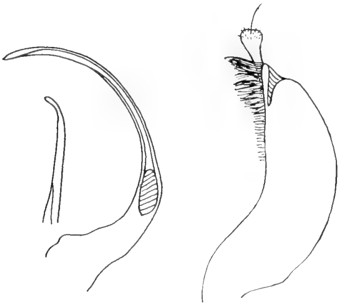
Fig. 2. *C. punctulatus* Aubé. Alachua Co., Florida, UMMZ; same views as fig. 1.

Fig. 3. *C. distinctus* Aubé. Sierra del Tigre, Sonora, Mexico, UMMZ; same views as fig. 1.

Fig. 4. *C. chevrolati chevrolati* Aubé. Alachua Co., Florida, UMMZ; same views as fig. 1.

Fig. 5. *C. caelatipennis princeps* new subspecies. Holotype, Miami, Dade Co., Florida, UMMZ; lateral view of aedeagus, right paramere.

Fig. 6. *C. debilis* Sharp. Rio Ramos, Nuevo Leon, Mexico, UMMZ; same view as fig. 5.



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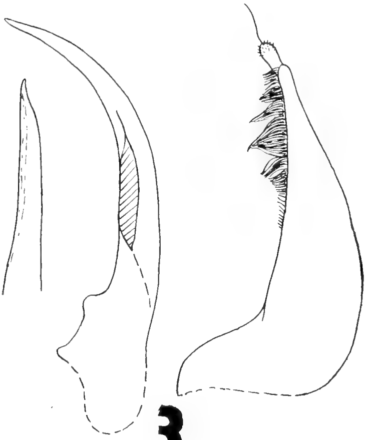

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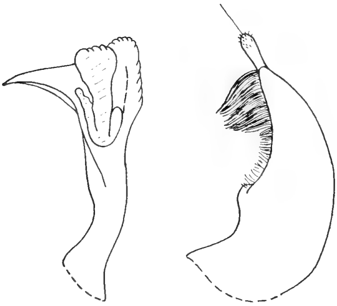

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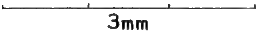

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from Florida before him. Sharp (1882a; p. 591) assigns to *caelatipennis* specimens from Brazil (1 ♂, 1 ♀, Santa Rita, Aug. Sept. 1850, Sahlberg in BMNH) in which both the male and the female have small strioles on the pronotum, although the original description does not mention strioles. Such strioles are clearly described by Aubé, however, in *C. distinctus* from Mexico (1838, p. 375). Sharp's "*caelatipennis*" is therefore probably distinct, and may require a new name when the South American forms are better known. The genitalia of Sharp's male specimen are, as far as I can tell, identical with those of *C. fragilis, angustatus,* and *princeps.*

Jamaican specimens previously determined by me as *C. caelatipennis* (St. Andrews, Swallow Field, Nov. 5, 1951, G. B. Thompson (1 ♂ Institute of Jamaica; 1 ♂ UMMZ); St. Catherine, Bushy Park-Amity Hall, Feb. 9, 1947, G. B. Thompson (1 ♀ Institute of Jamaica) are similar to Sharp's specimens. The male genitalia are apparently indistinguishable from *princeps, fragilis,* and *angustatus,* but the coloration, punctation, and degree of impression of the elytral striae is different.

A female specimen from São Paulo, Brazil, determined by Régimbart as *C. caelatipennis* (loaned to me some years ago by Frederico Lane, Museu Paulista), is also similar to Sharp's specimens and has the pronotal strioles extending over the disk. Another female of similar appearance is in the USNM (Pernambuco, Bonita Province, Brazil, Feb. 24, 1883).

South American specimens in which the pronotal strioles are restricted to the sides of the pronotum or are lacking and in which the elytral striae are only moderately impressed may represent typical *caelatipennis.* Such specimens are however, apparently very rare and I have seen only a few: Amazon River, Arary to Manaos, Brazil, Sept. 20-21, 1930, Holt, Blake, and Augustini Coltre (1 ♀, USNM); Prov. of Salta, Argentina, 1927-28, G. L. Harrington (1 ♀ USNM); 9 mi. S. Santa Rosa, El Oro, Ecuador, i.23.1955, E. I. Schlinger and E. S. Ross (1 ♂, 1 ♀ CAS).

Copelatus caelatipennis princeps, new subspecies

Copelatus caelatipennis Schaeffer (not Aubé), 1908, p. 17; Leng and Mutchler 1918, p. 87; Blatchley 1919, p. 313; Young 1953a, p. 5 (?); Young 1954, p. 107 (?).

Diagnosis. A small *Copelatus* with distinct submarginal and 10 discal elytral striae (Group 12 of Sharp, 1882a) very similar to

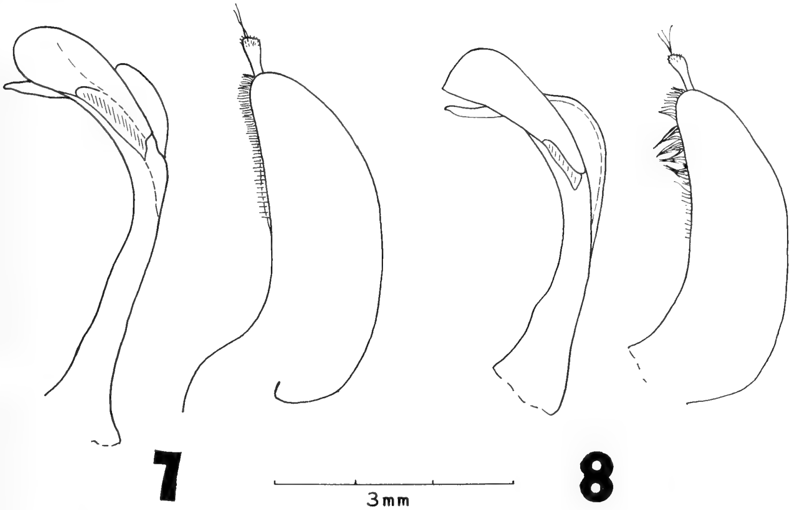

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Fig. 7. *Copelatus blatchleyi* Young. Paratype, Key West, Monroe Co., Florida, UMMZ; lateral view of aedeagus, right paramere.

Fig. 8. *C. cubaensis* Schaeffer. Miami, Dade Co., Florida, UMMZ; same view as fig. 7.

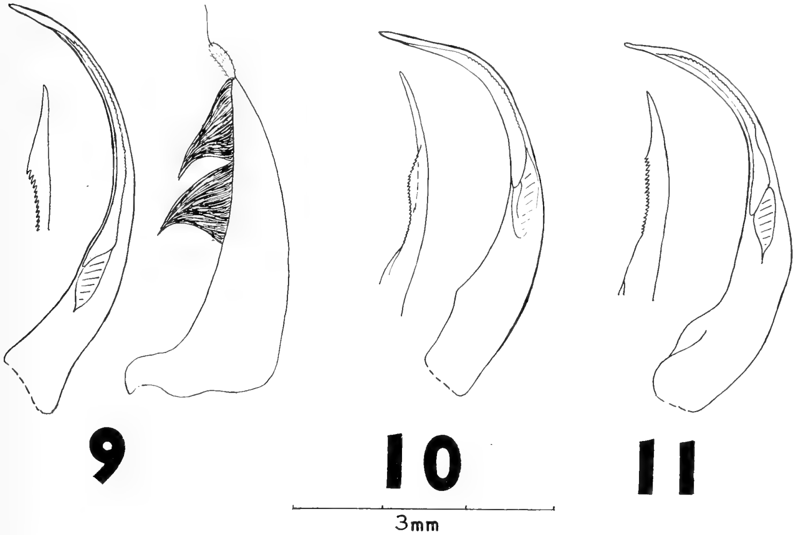

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Fig. 9. *Copelatus posticatus* (Fabricius). Atteye, Haiti, USNM; ventral view of aedeagus, lateral view of aedeagus, right paramere. The teeth (fixed spines) of aedeagus are represented semi-diagramatically; actual numbers may not correspond, although extent is represented accurately.

Fig. 10. *C. terminalis* Sharp. 25 km. south of Tepic, Nayarit, Mexico, ex CAS, UMMZ; ventral and lateral view of aedeagus.

Fig. 11. *C. integer* Sharp. Alhajuelo, Panama, USNM; same views as fig. 10.

typical *caelatipennis, angustatus* Chevrolat, and *fragilis* Sharp, but differing from all of these in the generally reddish brown color with reduced elytral fascia, the more distinctly impressed elytral striae and more evident microreticulation of the dorsum, and in the strioles or strigae of the pronotum which extend across the disk in the male and female and in the latter sometimes occur on the bases of the elytra. The geographically proximate subspecies, *fragilis* and *angustatus* differ from *princeps* in their less deeply impressed elytral striae, shorter submarginal stria, more distinct (*angustatus*) or less distinct (*fragilis*) elytral punctation, and in the consistent absence of small strioles on the disk of the pronotum in both sexes.

Holotype Male. Elongate, oval, attenuate behind and somewhat depressed. Total length, 4.47 mm; width at base of pronotum, 1.89 mm; width at apex of pronotum, 1.39 mm; length of pronotum at midline, 0.69 mm; length of elytron, 3.35 mm (elytra slightly separated in drying, exposing the wings). *Head:* light yellowish brown; microreticulate, the meshes moderately impressed making the surface appear matte; punctation fine, regular on disk; coarser punctures and other features much as in other members of the group. *Pronotum:* darker brown on the disk than the head but lighter than head toward the anterior lateral margins; microsculpture much as on head; finer punctures largely obscured by small strioles running roughly parallel to the longitudinal axis of the body and extending over the entire disk and at the base almost to the lateral margin; coarser punctures much as in other members of the group. *Elytra:* moderately dark reddish brown, darker than pronotal disk, except for a narrow light yellow brown transverse band or fascia at the base which extends from margin to scutellum and ends just back of the anterior ends of the discal striae; basal fascia not expanded in scutellar region as in *fragilis, angustatus,* and most South American specimens examined, interrupted at the humeri by narrow longitudinal dark spots which probably indicate some difference in sclerotization; microsculpture well-impressed, giving surface a distinctly matte appearance with a feeble iridescence in some lights; finer punctures coarser than those of head and more irregularly distributed (coarser and more deeply impressed than in *fragilis;* finer and more regularly distributed than in *angustatus*); only a few indistinct strioles among the punctures near the base; coarser punctures along margins as usual in group; submarginal stria distinct running from basal ⅓ or elytron to beyond apical ⅕ (not usually extending much anterior of basal ½ of elytron in *fragilis* and *angustatus*); discal striae rather deeply impressed the intervals between them convex; all 10 striae reaching well-forward on the elytron, the first (counting from the suture) only slightly less advanced then the others (often shorter in *fragilis* and *angustatus*); 1st, 3rd, 5th, 7th, and 9th striae extending farther posteriorly as usual, the intermediate striae shorter (1st stria extends farthest posteriorly; 10th stria is most abbreviated but this varies in series). *Venter:* legs, hypo- and epipleurae yellowish brown; other ventral structures irregularly darker, reddish brown; anterior tibiae bent below knee, notched, and broadened distally as usual in group; basal segments of anterior and intermediate tarsi distinctly widened with pallettes beneath; other ventral structures and sculpture apparently similar to other members of the group.

Allotype Female. Similar to male in sculpture and color; body form slightly more convex and more regularly ovate with greatest width of elytra near middle of body; pronotal strioles slightly longer individually than in male but similarly distributed over nearly the entire surface; a few distinct strioles on elytra near scutellum and humeri; general color slightly lighter above and beneath. Total length, and other measurements almost identical with those of holotype, except that base of the pronotum is slightly narrower, 1.84 mm.

Variation. There seems to be remarkably little variation in most of the population in the southeastern United States. Some males have the microreticulation less impressed, but this may be due to their teneral condition. Some females and a few males have small strioles on the base of the head, and in some females strioles occur over the basal third of the elytra, a condition which I have not observed in any Antillean or South American members of the group. The color variation seems largely to be due to the degree of hardening of the integument. The majority of mature specimens have a generally reddish-brown appearance, and few are darker than the holotype. The dargest specimen I have seen is from Jones Co., Georgia. It has the elytra dark reddish brown almost piceous, but the pronotum is lighter.

Examination of nearly 1000 specimens of *princeps* convinces me that the population is remarkably constant in regard to at least the following characteristics:

> (1) Strioles or small grooves on pronotum extend rather uniformly over the disk of the pronotum in both sexes. (2) The first and second elytral striae are extended at the base to nearly the same extent as the other striae, not abbreviated in the basal portion. (3) The elytral punctation on the spaces between the striae is fine, irregularly distributed, and rather shallowly impressed. (4) The microreticulation of the elytra (the fine sculpture between the punctations composed of very fine net-like impressions) is strongly impressed often giving a matte appearance to the elytra. (5) The body is moderately convex and not much attenuate behind. (6) The basic coloration is generally light reddish brown without strong contrast between the pronotum and elytra. There is more variation in this last regard than in other characteristics because of the difference in age of specimens at the time of capture. Fully hardened specimens are, however, relatively constant with only a very few being darker than the majority. The age of the specimen after preservation seems to be of no importance; some collected in the 19th Century being indistinguishable from those collected in the summer of 1962. (7) The light fascia at the base of the elytra is narrow, usually not in very strong contrast with the basic color of the elytra and not expanded in the scutellar region.

All of these characters contrast with those shown by *C. c. angustatus*. For example, Cuban specimens lack strioles on the elytral disk; the first and second elytral striae are abbreviated at base; punctation of elytral interspaces is coarser, more regular, and rather deeply impressed; microreticulations are reduced, not strongly impressed, so that the surface is usually very strongly shining; body form is less convex, attenuate behind; basic coloration is dark reddish brown; and the elytral fascia is distinct and expanded in the scutellar region.

Evidence for Interbreeding with C. c. angustatus. Determination of the genetic basis of these characters is difficult because of the techniques needed for rearing the insects and the difficulties of importing living specimens for crossbreeding. Apparently, however, a natural experiment has been performed for us in recent years. The many specimens from southern Florida, both from my own collecting and several museums, show no individual resembling *angustatus* before 1959. In the last few years, however, the

Plant Industry Division of the Florida State Department of Agriculture has made extensive collections in that region using ultraviolet or blacklight traps. In these collections the majority of specimens of *Copelatus* of the *caelatipennis* complex agree in all characters with *princeps.* In at least ten specimens, however, characters of *angustatus* appear. These are from traps operated by P. E. Briggs in Miami (Dade County) on Sept. 13, Oct. 12, and Nov. 3, 1960; and in West Palm Beach (Palm Beach County) on July 23, 1959, by M. L. Messac. In these specimens the characters of *angustatus* and *princeps* are intermixed in the series.

A similar mixing is exident to a degree in specimens from the Bahamas. One Bahamian female from North Bimini, about 35 miles east of Miami, is apparently identical with Florida specimens. Others from Long Island, about 175 miles southeast of Miami and closer to Cuba, are more similar to *angustatus.* One male from Miami is almost identical with Cuban examples, except for a reduction of the elytral punctation. Other specimens show varying combinations of the characters of the two forms. One female is aberrant, being nearly uniformly dark brown with the elytral fascia narrow and indistinct. This condition has not been observed in any other United States or Antillean material.

It seems evident that interbreeding between two distinct populations has occurred. The supposed hybrids show combinations of the characters of the parent races and in at least one instance characters not found in either of the parents. These variations suggest that a second generation may have been produced, and no absolute sterility barriers are present. The more robust forms of some of the individuals may indicate heterosis or hybrid vigor.

The apparent recency of the appearance of *angustatus*-like beetles in southern Florida suggests that these may have been artificially introduced in boats, water containers, or other materials brought in by the large number of human migrants. Another Cuban water beetle, *Copelatus cubaensis* Schaeffer, was also found in Florida for the first time in two of the collections in which the supposed hybrids were found.

A question arises as to whether *princeps* should be considered a subspecies of *angustatus* or whether both should be placed as subspecies of *caelatipennis.* The close resemblance in the male genitalia in most of the complex convinces me that the so-called species are closely related and probably interbreed wherever they come into contact with one another. I therefore feel that the older name, *caelatipennis,* should be used even though we are not presently certain as to its exact identity.

Habitat and Geographical Distribution. The name *princeps* is given to this subspecies in recognition of its pioneer role in invading newly formed aquatic situations. It is among the first water beetles to appear in new ditches, ponds, and pools. In Butts County, Georgia, I found it along with *Laccophilus proximus* Say in the shallow, vegetationless pools on exposed granite rocks. This is probably one of the most transient natural habitats in eastern North America. It occurs also in canals and other situations of a more permanent nature, but usually only in clear, unpolluted water. This is one of the characteristic water beetles of the Everglades region of Florida, but it is sporadic or erratic to the north and west.

This subspecies ranges over the Atlantic and Gulf coastal plains and immediate adjacent areas, including the Bahama Islands. It probably extends into Texas (Schaeffer 1908) but must be rare there. Conversely, *C. c. fragilis* does not reach Texas, and the most northern record on the eastern side of Mexico is from Mante in Tamaulipas, south of the tropic of Cancer, Dec. 19, 1940 (1♀, UMMZ).

Holotype Male. FLORIDA.—Dade County, South prong Miami River, ix.11.1939, F. N. Young (UMMZ). *Allotype female:* same data as holotype (UMMZ). *Paratopotypes:* 53, same locality as holotype, ix.9-ix.11.1939 (UMMZ to be distributed to various museums and individuals).

Additional paratypes are designated as follows: BAHAMAS.——North Bimini Island, vii.27.1951, C. & P. Vaurie (1, AMNH). ALABAMA.——Houston Co., Chattahoochee State Park, vi.6.1954 (1, UMMZ). Mobile Co., Mobile, viii.1.1901, vi.13.1913, ix.15.1921, i.12.1924, iii.18.1925, and no dates, H. P. Löding (6, Alabama Museum of Natural History; 5, USNM). Mobile, vi.5-6, 1927, P. J. Darlington, Jr. (3, MCZ). Noccalula, vi.18.1931, H. P. Loding (2, Alabama Museum of Natural History). FLORIDA.——"Fla." (1, AMNH). Alachua Co., vii.27.1954, viii.6.1955, at light, H. V. Weems, Jr. (2, FSC). Archer, iii.1921, W. S. Blatchley (2, Blatchley coll., Purdue University). Near Arredondo, xi.29.1947 (1, UMMZ). Brooker, iv.3.1960, R. E. Woodruff (1, FSC). Near Fort Clark, vii.18.1962 (3, UMMZ). Gainesville, x.29.1932, T. H. Hubbell (1, UMMZ); viii.27.1954, viii.6.1955, at light, H. V. Weems, Jr. (2, FSC); viii.1-7.1956, L. A. Hetrick (12, FSC; 12, UMMZ); v.2-3, vii.4-7.1957, blacklight trap, L. A. Hetrick (14, FSC; 12, UMMZ); vi.28.1958, blacklight trap, R. E. Woodruff (7, FSC), iv.4, v.26, v.28, vi.1, vi.9, vi.25.1959, at light, H. V. Weems, Jr. (18, FSC; 3, UMMZ); vii.1.1959, swimming pool,

R. E. Woodruff (5, FSC); vi.19.1960, cypress swamp, R. E. Woodruff (1, FSC); vi.12.1961, blacklight trap, H. A. Denmark (5, FSC; 6 UMMZ). Near Gainesville, iii.5.1934 (1, UMMZ); ix.15, x.10, x.24.1937 (13, UMMZ); xii.9.1936 (1, UMMZ); i.6.1949 (19, UMMZ); v.14.1948 (2, UMMZ); viii.18.1959 (3, UMMZ); viii.21-23.1961 (3, UMMZ). West of Gainesville San Felasco Hammock, vii.21.1960 (3, UMMZ). Near High Springs, x.14.1947 (3, UMMZ). Bradford Co., near Melrose, viii.17.1959 (4, UMMZ). Brevard Co., Merritt's Island, at light, H. V. Weems, Jr. (2, FSC). Broward Co., near Davie vii.27.1939, ix.9.1950 (5, N. Sanfilippo, Genova; 20, UMMZ). Ft. Lauderdale, blacklight trap, vii.2, ix.1.1960, G. F. Spencer (12, FSC). Calhoun Co., near Altha, vi.9.1938 (1, UMMZ). Charlotte Co., Punta Gorda, x.20, xi.9.1960, blacklight trap, H. M. Faircloth (2, FSC). Clay Co., near Keystone Heights, x.15.1938 (4, K. F. Chamberlain coll., New York State Museum). Green Cove Springs, vii.27, viii.1.1942, R. C. Barnes (2, CAS). Collier Co., near Everglades, viii.15.1959 (1, UMMZ). Immokalee, iv.20-27.1960, blacklight trap, H. M. Faircloth (9, FSC). Columbia Co., east of Lake City, vi.12.1937 (1, UMMZ). Dade Co., Homestead, vi.1929, P. J. Darlington, Jr. (3, H. Howden coll.); v.28.1956, blacklight trap, D. O. Wolfenbarger (6, FSC). Matheson Hammock Park, viii.28.1939 (2, UMMZ). Miami, viii.20, viii.26, ix.4.1937, vi.26.1938, viii.25.1939 (26, UMMZ: 2, USNM); v.16, vii.27.1960, iv.27.1961 blacklight trap, P. E. Briggs (4, FSC). Dixie Co., Suwannee Springs, viii.2-3. 1939, D. E. Hardy (3, SM). Duval Co., Atlantic Beach, ix.7.1942, R. C. Barnes (1, CAS). Jacksonville, no dates (2, AMNH; 3, CAS; 9, USNM); vi.10, R. L. Blickle (1, OSU); vii.25.1932, in swimming pool (biting people?), G. H. Bradley (1, USNM); vi.23, viii.15, viii.18, ix.15, x.10.1942, R. C. Barnes (5, CAS); vii.1943, G. S. Hensill (6, CAS). Mayport, x.12.1960, blacklight trap, L. M. Taylor (6, FSC). Escambia Co., Pensacola, vii.12, viii.30.1961, blacklight trap, T. W. Boyd (2, FSC). Franklin Co., near Alligator Harbor, viii.17.1955 (7, UMMZ). West of Carrabelle, vi.6.1938 (3, UMMZ). Dog Island off Carrabelle, iv.16.1947 (7, UMMZ). Near St. Teresa, vi.6.1938 (2, UMMZ). Gadsden Co., Glen Julia Springs, vi.6-13.1954, viii.14-15.1955 (13, UMMZ). Glades Co., near Lake Okeechobee, viii.2.1959 (2, UMMZ). Hendry Co., Clewiston, iv.6.1944, at light, J. G. Needham (5, CU). Near Clewiston, vii.1.1962 (5, UMMZ). LaBelle, vii.16.1939, R. H. Beamer (1, SM). Near Moore Haven, viii.2.1959 (5, UMMZ). Highlands Co., Brighton, vi.10.1929, P. J. Darlington, Jr. (1, H. Howden, coll.) Near Brighton, viii.2.1959 (3, UMMZ). Highlands Hammock State Park, v.13.1939 (1, UMMZ). Lake Letta, vi.27, viii.16, viii.22, xi.2.1961, vi.25, vii.19, vii.30.1962, blacklight trap, T. W. Morris (111, FSC; 35, UMMZ). Lake Placid, iii.-iv., iv.2.1945, iv.19.1950, J. G. Needham (14, CU); iii.30.1961, A. & H. Dietrich (1, CU). Sebring, vi.30, ix.7, ix.10.1942, at light, C. Parsons (6, CAS); v.23, vi.7.1961, blacklight trap, T. Morris (12, FSC). Hillsborough Co., Tampa, 24.4, F. C. Bowditch, coll. (1, MCZ). Jackson Co., near Marianna, vi.14.1954 (1, UMMZ). Lee Co., Ft. Myers, ii.21.1918, W. S. Blatchley (1, Blatchley coll., Purdue University); ix.7.1961, blacklight trap, H. M. Faircloth (31, FSC; 25, UMMZ). Levy Co., near Cedar Key, vii.27.1959 (1, UMMZ). Northeast of Lebanon Station, vii.11.1960 (2, UMMZ). Liberty Co., south of Bristol, vi.12.1954 (1, UMMZ). Near Sumatra, vi.12.1954

(8, UMMZ). Marion Co., Ocala, vi.22.1962, blacklight trap, T. R. Atkins (30, FSC; 17, UMMZ). Monroe Co., v.1.1953, N. J. & E. L. Sleeper (1, OSU). Big Pine Key, vi.8.1960, at light, R. E. Woodruff (1, FSC). Nassau Co., Callahan, viii.24.1959 (1, UMMZ). Hilliard, vii.28.1934, R. H. Beamer (1, SM). Okaloosa Co., near Crestview, x.17.1941 (1, UMMZ). Okeechobee Co., near Basinger, viii.17.1961 (2, UMMZ). Okeechobee, iii.18.1943, W. Proctor (1, AMNH; 5, CU). Orange Co., Orlando, vi.26.1945, J. H. Robinson (1, CAS). Winter Park, i.12, i.15, i.20.1929, J. G. Gehring (1, CU; 3, MCZ). Osceola Co., near Deer Park, iv.1.1939 (2, UMMZ). Palm Beach Co., west of Lantana, viii.17.1961 (1, UMMZ). Near Okeelanta, viii.2.1959 (20, UMMZ). West Palm Beach, v.10.1962, blacklight trap, R. A. Long (2, FSC). Pinellas Co., Dunedin, iv.1.1920, W. S. Blatchley (1, Blatchley coll., Purdue University). iii.6.1925, W. S. Blatchley (2, CU); iv.2.1929 (2, CU). Polk Co., north of Haines City, viii.18.1952 (1, UMMZ). Lakeland, xi.10.1911 (2, AMNH); iv.27.1941, E. C. Williams, Jr. (2, CNHM). Winter Haven, viii.9.1960, blacklight trap, J. Hayward (3, FSC). Putnam Co., near Interlachen, x.2.1937 (1, UMMZ). North of Palatka, x.2.1937 (1, UMMZ). Southwest of Palatka, iii.31.1939 (1, UMMZ). St. Johns Co., Hastings, x.25.1926, M. D. Leonard (1, CU); viii.16.1950, P. J. Spangler, Jr. (4, USNM). Trout Creek near Orangedale, iv.23.1938 (1, UMMZ). Santa Rosa Co., vi.24.1959, blacklight trap, M. Lutrick (1, FSC). Sarasota Co., Myakka River State Park, iv.6, vi.3-4.1954, at light, H. V. Weems, Jr. (4, FSC; 2, UMMZ). Seminole Co., Sanford, (1, AMNH). viii.1.1929, J. G. Gehring (1, MCZ); viii.5, x.19, x.28.1929, xi.1, xi.8.1961, blacklight trap, G. W. Dessin (70, FSC). Taylor Co., (15, AMNH; 12, USNM). Perry, viii.18.1955 (9, UMMZ). Volusia Co., Edgewater, ii.25, ii.28.1939, C. A. Frost (2, CAS; 4, CU; 1, H. Howden, coll.). New Smyrna, v.17, v.19, v.28, vi.10, M. Wright (8, OSU). Port Orange, Andreas Bolter coll. (1, INHS). Wakulla Co., near Ward, vi.5.1938 (10, UMMZ). GEORGIA.—— "Geo." (1, SM). Appling Co., Little Satilla River near Bristol, viii.28.1961 (1, UMMZ). Baker Co., west of Newton, x.29.1938 (1, UMMZ). East of Elmodel, vi.29.1962 (1, UMMZ). Brantley Co., near Hoboken, viii.24.1959 (2, UMMZ). Butts Co., near Worthville, vi.28.1962 (1, UMMZ). Near Jackson, vi.28.1962, pools on exposed granite rocks (1, UMMZ). Charlton Co., Billy's Island Okefenokee Swamp, vi.1912, J. C. Bradley (1, CU). Okefenokee Swamp, vii.27.1939, J. Beamer (2, SM). Chatham Co., near Savannah, viii.16.1950 (1, UMMZ). Colquitt Co., x.28.1938 (1, UMMZ). Decatur Co., Mosquito Creek near Faceville, vi.11.1954 (2, UMMZ). Spring Creek, vii.16-29.1912, J. C. Bradley (1, CU). Emanuel Co., near Lexsy, viii.24.1959 (2, UMMZ). Hart Co., near Nuberg, ix.1.1949, ix.20.1950, viii.25-26.1959 (36, UMMZ). Jones Co., Clinton, vi.28.1962 (1, UMMZ). Lee Co., Kinchafoonee Creek, vi.29.1962 (1, UMMZ). Lowndes Co., near Hahira, x.28.1938 (1, UMMZ). Valdosta, vi.9.1936, T. H. Hubbell (2, UMMZ). Mitchell Co., near Vada, vi.5.1954 (3, UMMZ). Pierce Co., Blackshear, viii.17.1950, P. J. Spangler (11, USNM). Satilla River near Hoboken, viii.28.1961 (1, UMMZ). Sumter Co., northeast of Americus, vi.28.1962 (1, UMMZ). Wilcox Co., Abbeville, vii.13.1960 (4, UMMZ). LOUISIANA.——Acadia Par., Rayne, vi.10. 1917 (1, CU). Vermilion Par., Gueydan, vi.15.1925, E. Kalmbach (1, USNM).

NEW JERSEY.——"New Jersey" (1, AMNH). NORTH CAROLINA.——Cabarrus Co., near Concord viii.27.1959 (1, UMMZ). Columbus Co., vi.19. 1952, at light (1, USNM). Wake Co., Raleigh, viii.15, ix.1, ix.2.1952, at light, W. M. Knisch (6, USNM). SOUTH CAROLINA.——"S. C." (1, MCZ). Beaufort Co., Beaufort, G. D. Bradford coll. (10, AMNH).

Copelatus caelatipennis angustatus Chevrolat (1863; p. 201), new combination

This subspecies has already been characterized under the description of *princeps.* Specimens show some variation in color, degree of elytral punctation, and other characters, but seem in general to represent a fairly uniform population in Cuba. The few specimens I have seen from other parts of the Antilles are doubtfully identical.

The specimens from southern Florida showing characteristics of *angustatus* must, I think, be considered intergrades with *princeps,* as already indicated. Specimens from the more remote islands of the Bahamas, however, may be identical with Cuban material, although they appear to be less strongly punctate.

Copelatus caelatipennis fragilis Sharp (1882b, p. 40), new combination

The types of *fragilis* (Paso Antonio, Guatemala, 400 ft., Champion in BMNH) are more slender and more finely punctate than either *angustatus* or *princeps.* Specimens from Costa Rica (USNM) and eastern Mexico (UMMZ) are also similar to the types. Material from Nayarit (CAS) and Sinaloa (CAS, CU), however, is somewhat less like typical *fragilis* and more like what I consider the typical South American form. Neither typical *fragilis* nor the western Mexican form seem to come into contact with *princeps,* from which both are easily distinguished by the characters given in the key.

Copelatus distinctus Aubé

Copelatus distinctus Aubé, 1838, p. 375; Sharp 1882a: 590; Sharp 1882b: 40.
Copelatus impressicollis Sharp, 1882a, p. 589; Sharp, 1882b, p. 40; Schaeffer, 1908, p. 16; Leech, 1948, p. 405

As indicated by Sharp (1882b,p. 40) *C. distinctus* as now defined occurs in Central America, Mexico, and the southwestern United States. I believe that it will eventually prove to form an *Arten-*

kreis of isolated montane species. Some of the variants from Mexico (Jalisco in CAS) show reduction and fragmentation of the elytral striae in the male, although the 10-striate condition is maintained in the females I have seen associated with them. As usual in *Copelatus,* it is difficult to find differences in male genitalia.

In the United States the species occurs abundantly in some mountain ranges, for example, the Huachucas in Arizona, the Chisos in Texas, and the Sierra del Tigre in Sonora. It seems to be rare in lowland or desert areas in Texas, New Mexico, Arizona, and Mexico, and I suspect that it is characteristic of montain areas of moderate elevation. Aubé's type female of *distinctus* is without more definite locality than Mexico. Sharp's types of *impressicollis* from Guatemala (Guatemala City, 1879, Champion, in BMNH) do not match exactly any specimens I have seen either from the United States or Mexico. Mexican specimens in the British museum, placed by Sharp as *distinctus,* more closely resemble Texas-Arizona-Sonora material, and for the present I believe the latter should be referred to *distinctus* rather than *impressicollis.*

Copelatus chevrolati Aubé (1838, p. 389)

With its subspecies *renovatus* Guignot (1952b, p. 170), this is the commonest and the most widely distributed of the Nearctic species.

I have seen numerous specimens of the typical form from Alabama, Georgia, Florida, and South Carolina. It is recorded from Bimini in the Bahamas (Young, 1953) and has also been taken at Nassau, New Providence, iv.11.1953 (3); Eleuthera Island, New Portsmouth iii.28.1953 (1); Long Island, Deadman's Cay, iii.11.1953 (3), all collected by E. B. Hayden (in AMNH).

Older records indicate the extension of typical *chevrolati* northward to Michigan, but I am now doubtful of this and believe that it is confined to the Atlantic and Gulf coastal plain area and the Bahamas.

C. chevrolati renovatus occurs very widely in the southwestern United States and in Mexico. I have examined specimens from Arizona, Arkansas, California, Kansas, Louisiana, New Mexico, Oklahoma, Texas, Sonora, Baja California, Sinaloa, Tamaulipas, and Nuevo Leon. It doubtless also occurs in Coahuila and Chihuahua.

Although specimens lacking the short sutural stria of typical *chevrolati* occur in Florida, most of them are indistinguishable from typical *chevrolati* on other characters. As previously mentioned, further work is required to determine whether *renovatus* and *chevrolati* represent interbreeding subspecies or whether they represent distinct populations occupying separate ranges.

Copelatus debilis Sharp (1882a, p. 579)

This distinctive little species is common in Mexico and Central America and extends into southern Texas. I have seen material comparable to the male type (Nicaragua, Chontales, T. Belt in BMNH) and the cotypes (Guatemala, San Geronimo, Champion in BMNH) from British Honduras, Costa Rica, Guatemala, Panama Canal Zone, Mexico, and the United States. From Mexico, I have seen specimens from Hidalgo (SM), Morelos (CU), Nayarit (CAS), Nuevo Leon (UMMZ), San Luis Potosi (UMMZ), Sinaloa (CAS), and Tamaulipas (CNHM, BMNH, USNM, UMMZ).

Lech (1948a) records *debilis* from Brownsville, Texas (CAS). I have seen specimens from Brownsville, Texas: "On garlic from Mexico", 36-36282 (1, USNM); v.25.1934, J. N. Knull (2, OSU; 1 UMMZ); xi.42, E. S. Ross (1, CAS).

A female from Durango, Mexico, "JLY. 1896", Dr. E. Palmer (USNM), may represent a new species.

Copelatus blatchleyi Young (1953b, p. 24)

The types (Key West, Monroe Co., Florida, iii.3.1919, W. S. Blatchley) are the only known specimens of this species.

Copelatus cubaensis Schaeffer (1908, p. 18)

This interesting species is now apparently established in Florida: (Dade Co., Miami, ix.13.1960 at blacklight trap, P. E. Briggs (1 FSC); x.12.1960, at blacklight trap, P. E. Briggs (1 ♂ FSC; 1 ♂, 1 ♀ UMMZ). The structure of the male genitalia (fig. 8) is of the same general type as *blatchleyi* and *debilis* confirming my suspicion (Young, 1953b) that *cubaensis* is closely related to *blatchleyi* although with a different number of elytral striae. The type is a female from Cayamas, Cuba (USNM No. 11545), probably collected by E. A. Schwarz.

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EFFECTS OF PHOSPHORUS-32 ON THE COTTON RAT

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ONE of the useful applications of radioisotopes in ecology is in tagging animals so that their movements can be traced with portable radiation detectors. Griffin (1952) and Pendleton (1956) have discussed various aspects of this technique.

Among vertebrates, radioactive marking has thus far been used most extensively in studies of mammals. Several types of rings or bands utilizing Co^{60}, Ag^{110}, I^{131}, and Sb^{124} as radiation sources have been used for tagging moles, shrews, bats, and mice (Godfrey, 1953, 1954a, 1954b, 1955; Gifford and Griffin, 1960; Linn and Shillito, 1960; Punt and van Nieuwenhoven, 1957). Kaye (1960, 1961) and Johanningsmeier and Goodnight (1962) marked mice with internal tags employing Au^{198} and I^{131} as radiation sources. In addition to their use as inert tags, radioisotopes have been employed in a manner that results in their incorporation into the metabolic systems of the marked individual. Jenkins (1954) marked a lemming (*Lemmus*) with radioactive phosphorus given in the food. Miller (1957) studied the home range of a meadow mouse (*Microtus pennsylvanicus*) by injecting P^{32} into the abdominal cavity and then tracing the movements of the animal through radioactive excretory products deposited on dropping boards. Similarly, Birkenholz (1962) obtained data on movements of round-tailed muskrats (*Neofiber alleni*) by scanning feeding pads with a geiger counter for the presence of radioactive feces from individuals previously live-trapped and injected with P^{32}.

In any system of marking animals for field studies, the possible effect of the marking method on the activities of the animals must be taken into consideration. Although workers who have marked wild mammals with radioisotopes have given consideration to the type and strength of radiation necessary to detect tagged individuals under the conditions of the study, relatively little attention has been given to the possible effects of radiation from the tag source on the behavior of the marked animals.

Our objectives in the present study were (1) to test the relative effectiveness of different doses of P^{32} in labeling the feces of the cotton rat (*Sigmodon hispidus*) as a preliminary to field studies and (2) to obtain some indication of the influence, if any, of the radiation levels on the animals. The criteria selected for evaluating radiation effects were general behavior and appearance, trends in body weight, and patterns of food and water consumption.

MATERIALS AND METHODS

Twenty-four cotton rats live-trapped in the vicinity of Gainesville, Alachua County, Florida, were used. The group consisted of 12 males and 12 females, ranging in weight from 71 to 166 g (mean, 119.2 g). The animals were individually housed in metal cages equipped with wire mesh bottoms and pans. Food (Purina rat chow) and water were provided *ad libitum*.

After a minimum acclimation period of two weeks in the laboratory, the animals were divided into four groups of six individuals each. Each group had an approximately equal weight distribution and sex ratio. Three groups were given intraperitoneal injections of different amounts of P^{32} in unbuffered solution; the fourth group served as controls. The treated rats received doses of isotope equivalent to 10 (Group I), 2 (Group II) and 0.5 (Group III) $\mu c/g$ of body weight. The controls (Group IV) received injections of distilled water on the same fluid volume/body weight basis as the treated individuals.

The radioactivity of feces of treated animals was measured daily. A sample of ten fresh pellets was randomly selected from the pan beneath the cage of each animal, and the activity (counts/minute) of each pellet was determined separately with a Geiger counter. The tube face was positioned one inch from the pellet when a reading was made.

Observations were made each day on the general appearance and behavior of the animals during a 14-day period before and 30-day period after treatment. Food and water consumption were measured daily in all groups for two weeks prior to treatment and for 30 days after treatment. The amount of food consumed each day was calculated by subtracting the weight of uneaten food from the known weight given the previous day. Water intake was measured by means of calibrated water bottles fitted with drinking tubes. A bottle and tube in an empty cage were used to correct for evaporative losses.

Weights of all animals were recorded at the beginning of the experiment. Rats dying during the course of the study were weighed and autopsied. At the end of the 30-day interval following treatment, the surviving animals were sacrificed, weighed, and autopsied. Weights of adrenal glands and spleens were obtained after preservation in 10 percent formalin. The organs were blotted to remove excess moisture and weighed on an analytical balance to 0.1 mg.

RESULTS

P^{32} elimination in feces: Figure 1 shows the relationship between dosage of P^{32} and the level of radioactivity of feces at 9, 18, and 24 hours post injection and thereafter at daily intervals through 21 days. The points plotted are averages of the highest counts in the fecal samples of each animal in the group and thus represent maximum activity.

The data on P^{32} elimination indicate that the level of activity of the feces reflects the strength of the dose given. However, the ranges of activity in the three groups overlapped broadly, and considerable variation in the activity of pellets occurred within and between samples from individuals of the same group. The extent of this variation was correlated with dosage, being most pronounced in Group I, intermediate in Group II, and least in Group III.

The level of activity of at least some of the fecal pellets of each animal in all groups was still sufficiently above the background level to be detectable at the end of 21 days. The carcasses of animals in all groups were still highly radioactive and could be easily recorded at a distance of several feet with a Geiger counter at the end of 30 days.

General health: Mortality occurred only in Group I. All but one of the animals in this group died within the 30-day period following injection. Mean survival time was 12.8 days, with individuals dying from 5 to 21 days after injection. The lone survivor appeared to be normal in all respects when sacrificed at the close of the study. The animals that died showed no obvious effects of radiation until shortly before death, when they began to huddle in a corner of the cage with the pelage ruffled. The cotton rats in Groups II and III exhibited no outward changes in appearance or behavior as the result of treatment.

On the basis of gross examination at autopsy, only individuals in Group I showed signs that could be attributed to possible radiation damage. One specimen had a small cyst about ¼ in. in di-

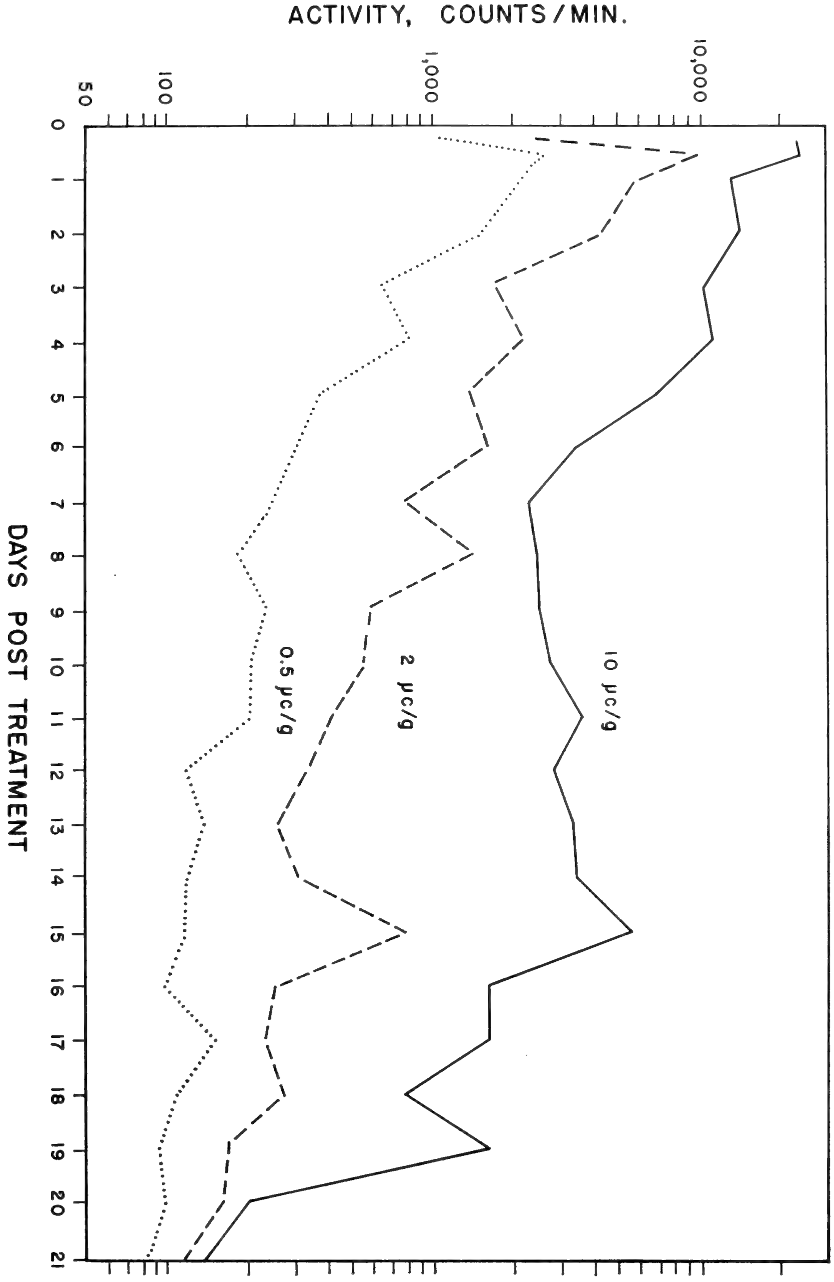

Fig. 1. Radioactivity over a 3-week period of fecal pellets of cotton rats receiving intraperitoneal injections of P^{32} equivalent to 10, 2, and 0.5 $\mu c/g$ of body weight.

ameter on the caecum. Another had a large ulcerated area on the stomach, and its prostate glands and seminal vesicles were distinctly abnormal in appearance. A third animal had conspicuous lesions on the liver.

A reduction in spleen weight appeared to be correlated with the amount of isotope received. Mean relative weights of spleens, expressed as mg of spleen/g of body weight, were: Group I, 1.469; Group II, 1.583; Group III, 1.614; and Group IV, 1.658. Mean relative weights of adrenal glands were: Group I, 0.368; Group II, 0.366; Group III, 0.463; and Group IV, 0.387.

Body weight: Differences in trends of body weight between treated and control groups were apparent. Every control animal except one gained weight during the course of the experiment, the animals averaging 17 percent heavier at the end of the 30-day period following treatment. In treated groups, the extent of weight change was correlated with dosage. Only the surviving animal in Group I gained weight during the test. When sacrificed it weighed 7 percent more than its initial weight. The remaining individuals in this group had lost an average of 13 percent of their initial weight by the time of death. The mean loss of weight for the group as a whole was 9 percent. The rats in Groups II and III gained weight, but to a lesser extent than controls, averaging 10 and 11 percent heavier, respectively, at the end of the experiment.

Food consumption: The mean daily food consumption of the six control individuals over a 42-day period of measurement was 15.8 g, or 0.14 g/g body weight.

To provide a basis for a comparison of the effect of dosage on food consumption patterns, the mean daily food intake for three-day periods was calculated for each group over the 30-day post treatment interval and then expressed as a percentage of the mean consumption per day for that group during the six-day period immediately preceding injection. All treated groups took less food after injection than before (Figure 2). In contrast, the food intake of controls increased markedly during the same period. The cotton rats receiving the heaviest dose of isotope exhibited the greatest reduction in food consumption. Although the differences were not pronounced, the rats in Group II tended to consume less food than those in Group III. All the Group I fatalities drastically reduced their food intake or stopped feeding entirely from one to five days prior to death.

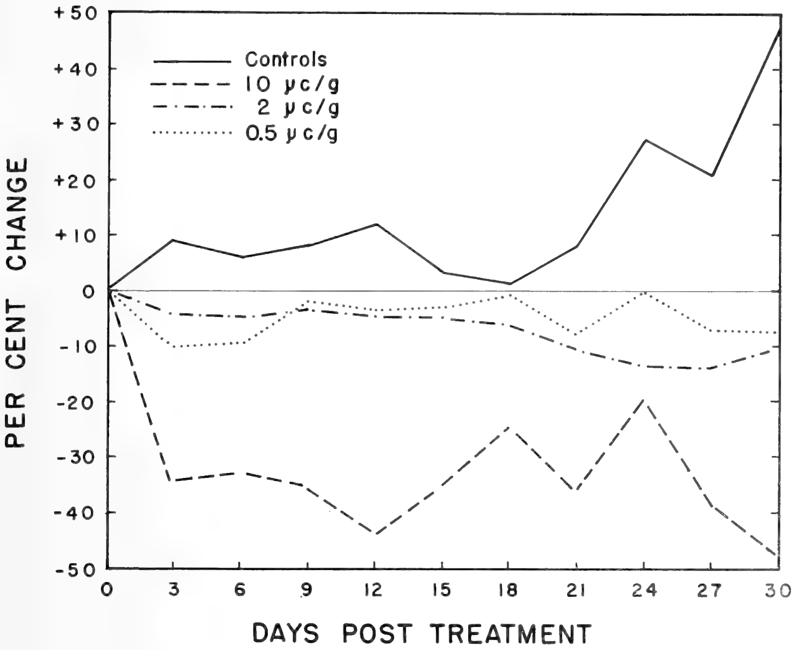

Fig. 2. Effect of different doses of P^{32} on food consumption of cotton rats. Average daily food consumption over 3-day periods is plotted as a percentage of mean daily food intake for the 6-day interval immediately preceding treatment.

Water intake: Over an interval of 42 days, control animals drank an average of 24.4 ml of water per day, or 0.22 ml/g body weight.

Data on water consumption presented in Figure 3 are expressed in the same way as those for food. The trends in water consumption of Group I following treatment agree generally with those for food, with the exception that the decline in drinking occurred more gradually than that of feeding. Although the food intake of Groups II and III declined following injection, their water consumption tended to increase. It is not known whether the difference in water intake between these groups from about 6 to 15 days after treatment is attributable to the different levels of radiation involved. Except for an initial depression following injection with water, the trend of fluid intake of controls conformed closely to that of food consumption. It appears, therefore, that treated individuals had higher water requirements relative to food intake than controls.

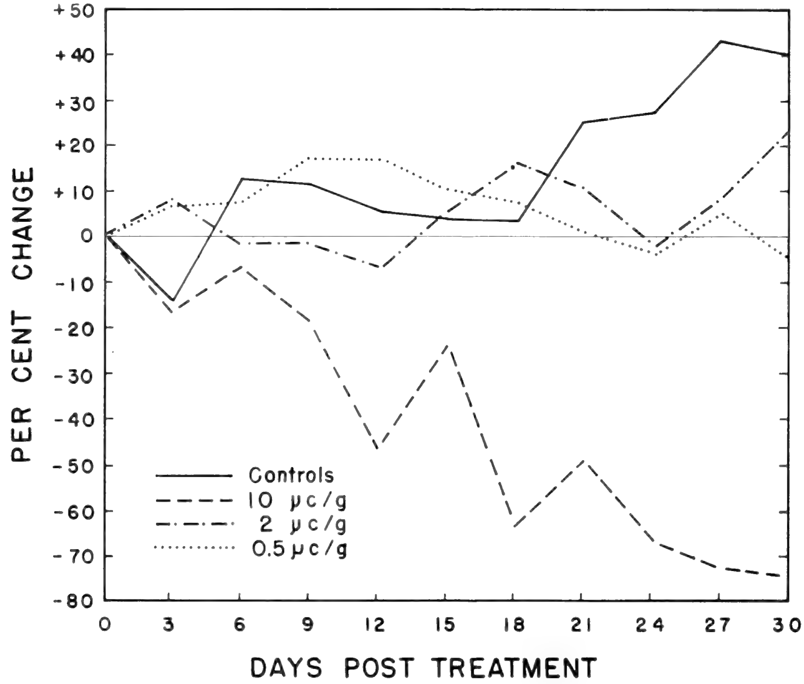

Fig. 3. Effect of different doses of P^{32} on water consumption of cotton rats. The data are expressed in the same way as those for food consumption in Figure 2.

Daily variation in water consumption in all groups was greater than that of food consumption. Group I rats that died drank little or nothing from one to seven days preceding death.

DISCUSSION

The effects of radiation on the physiology and behavior of a mammal marked with radioisotopes could conceivably influence a number of ecologically significant aspects of its biology, as, for example, activity cycles, food and water requirements, pattern of movements, exposure to predation, susceptibility to parasites and disease, reproduction, and social interactions. As yet, however, workers who have used radioisotope marking techniques in studies of wild mammals have given little consideration to the extent to which the data obtained on tagged individuals may have been biased by such effects. Godfrey (1954a, 1954b), Punt and van Nieuwenhoven (1957), and Gifford and Griffin (1960) have reported that they were unable to observe any harmful effects of radiation on tagged individuals in their studies. In these instances, however, the marked animals were apparently not closely studied for radiation effects; and it is possible that the level of radiation involved, though not high enough to produce obvious effects, was still sufficient to cause behavioral or physiological disturbances that might have biased data obtained from the marked individuals.

The LD_{50}/ 30-day dose of P^{32} for the cotton rat is approximately 4.3 $\mu c/g$ body weight (Hankins, 1954). This value is similar to that, about 4.5 $\mu c/g$, for the laboratory mouse and rat (Koletsky and Christie, 1951; Mewissen and Comar, 1959). The heaviest dose used in this study was, therefore, over twice the LD_{50} level, but the other two were only 0.4 and 0.1 of this value. Based on the changes in weight and patterns of food and water consumption following treatment, each of these doses had some influence on the animals, and the response of weight and food and water intake are in turn probably symptomatic of a variety of physiological and behavioral changes. Although only rats in Group I showed gross behavioral changes, and then only when close to death, we strongly suspect that with more critical observations and testing behavioral changes would have been demonstrated in the animals receiving even the lowest dose. The magnitude of the effects of radiation on weight, feeding, and drinking in Group I suggest that field data on home range or other parameters derived from animals marked with a similar dose would not be representative of the unmarked population. Whether or not the effects of the lower dosages would produce significant biases under field conditions is problematical, but the possibility cannot be ignored. Even the relatively slight modification of food and water intake occurring in the animals of Group III might reflect somewhat altered activity patterns which under field conditions might influence the animal's movements or other activities.

In view of the foregoing, it is possible that doses of P^{32} that have previously been used in actual field studies may have been too high to give reliable results. Jenkins (1954) marked a lemming with 250 μc. Assuming an average body weight of about 50 g in this mammal, the dosage was equal to approximately 5 $\mu c/g$ body weight. Miller (1957) used nearly the same dose (200 μc with a 41 g animal) in studying the home range of a single meadow mouse. She suggested that an even higher dose, perhaps 400 μc, would have given better results. Assuming that the LD_{50} of P^{32} for these rodents is close to that for *Sigmodon* and the laboratory mouse and rat, it seems doubtful that individuals marked with a dose approximating the LD_{50} would behave normally. This criticism can be extended to at least certain studies in which other marking procedures or types of radiation have been used. For example, Kaye (1960, 1961) used gamma emitting tags with a strength of up to 4500 μc to trace the movements of harvest mice.

There is clearly a need for further studies on the effects of different radioisotope marking methods on wild mammals before ecological information obtained with this technique can be fully evaluated. In addition to laboratory investigations designed to obtain more detailed information on the less conspicuous effects of lower doses of radiation on behavior or aspects of physiology that may have particular ecological significance, it would seem desirable to test the effects of various types of radioactive marking under natural conditions. This could perhaps be done by marking some animals in a given population with the types or strengths of radioactive tags to be tested and others by conventional methods to serve as controls. The population could then be studied by livetrapping procedures and the relationship of type of mark used to trap response, home range size, longevity, parasite loads, weight, or other aspects of life history or ecology determined.

SUMMARY

Three groups of cotton rats (*Sigmodon hispidus*) were given intraperitoneal injections of P^{32} equal to 10, 2, and 0.5 $\mu c/$ g of body weight in order to obtain data on the rate of isotope elimination in feces and the effects of the different levels of radiation involved on behavior and appearance, weight, and food and water consumption patterns. A fourth group served as controls. Elimination of the isotope in the feces was roughly proportional to dosage. Mortality occurred only in the 10 $\mu c/g$ group, but trends in body weights of all treated groups differed from those of controls. Rats receiving the heaviest dose exhibited a pronounced

reduction in food consumption following injection. The food intake of the intermediate and low dosage groups declined to a lesser extent, while that of controls increased markedly. Water consumption in cotton rats receiving 10 μc/g body wt. was markedly reduced following treatment but declined more gradually than food intake. Animals given 2 and 0.5 μc doses exhibited a tendency toward greater water consumption after injection than before, despite a reduction in the amount of food taken. It is concluded that the changes in weight and feeding and drinking patterns following administration of P^{32} observed in this study were probably symptomatic of physiological and behavioral effects that under field conditions might have a significant influence on activity, home range, or other aspects of life history or ecology being studied.

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EFFECT OF RATION, BREED, AND GRADE ON SUCCINOXIDASE IN CATTLE

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A. Z. Palmer, and G. K. Davis

In the evaluation of many cattle feeding experiments it would be helpful to have chemical studies to supplement growth and performance data. Dietary factors affect the activity of various enzymes, and knowledge of such effects increases our understanding of the nutrition of animals. Shirley *et al.* (1959) found that two-year old heifers fed about half the National Research Council recommended level of protein for 6 months had a significant increase in succinoxidase activity in the muscle and a marked increase in xanthine oxidase activity in the liver.

The object of the present study was to determine upon slaughter the succinoxidase activity of heart and gracilis muscle of heifers fed four levels of dietary protein and energy while on winter pasture for 148 days, and thereafter full-fed for 140 days in dry lot. The heifers were also evaluated for variation between Standard and Good grades, and among various degrees of Brahman to British cattle crossbreeding.

Acknowledgment

This study was financed in part by a grant-in-aid from the National Heart Institute, P.H.S. (H-1318).

Experimental

Forty-eight Brahman-British (mostly Shorthorn) crossbred heifers, about 8 months old, were divided equally into four dietary groups and wintered for 148 days on fair quality Bahia grass pastures, with supplemental feeding as shown in Table 1. The four lots of heifers were fed in dry lot for 140 days a ration of the composition shown in Table 1.

The heifers were slaughtered at the end of the 140-day dry lot feeding period; they were then about 18 months of age. Samples of left ventricle and gracilis muscle were removed within 10 minutes and frozen in a deep-freeze at minus 8° C. Succinoxidase activity was determined within one week after slaughter by the manometric method of Schneider and Potter (1943). Differences in data that might be due to treatments were analyzed for significance according to Snedecor (1956).

TABLE 1

DIETARY TREATMENTS

During 148 days of wintering on Bahiagrass pasture; each group included 12 heifers:

	Group 1	Group 2	Group 3	Group 4
Cottonseed meal (41% protein), lbs/heifer/day	1.00	1.25	1.49	1.72
Citrus pulp, lbs/heifer/day	0.86	1.36	3.91	7.24

During 140 days in the feed lot; all heifers fed the following ration:

Cottonseed hulls	20.6 per cent
Cottonseed meal, 41% protein	20.7
Dried citrus pulp	42.6
Corn meal	10.0
Alfalfa pellets	5.0
Complete mineral	1.0
TOTAL	99.9 per cent*

* Plus an average of 2.22 lbs. of Pangolagrass hay per heifer per day.

RESULTS AND DISCUSSION

In Figure 1 are shown the average gains per day for the four groups of heifers during 148 days on pasture. The increased supplementation increased the gains from approximately 0.3 to 1.4 pounds per day between the groups receiving the lowest and highest levels of protein and energy. On the other hand the gains per day in the feed lot were reversed (see Figure 1). The gains in the feed lot ranged from approximately 2.1 for ration 1 to less than 1.7 lb. per day for ration 4 animals. Animals in lot 4, however, which were fed the highest level of supplemental feed on pasture, had an average slaughter weight of 790 pounds, compared to 710 pounds for lot 1 animals, which received the lowest amount of feed on pasture (fig. 1).

Data are presented in Figure 2 that were obtained for the succinoxidase activity in the heart and gracilis muscle of heifers in the four supplemented groups. Each bar in the graph is the average of values obtained from 12 heifers. The activity is expressed

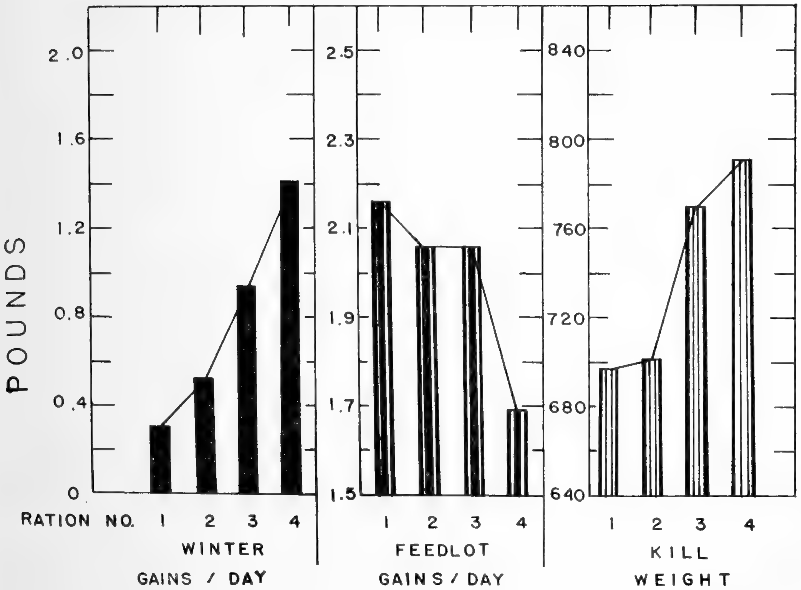

Fig. 1. Pounds of gain per day for heifers. *Left*, under varying levels of protein and energy during 148 days on winter pastures. *Center*, subsequently during 140 days in the feed lots. *Right*, slaughter weights of the heifers.

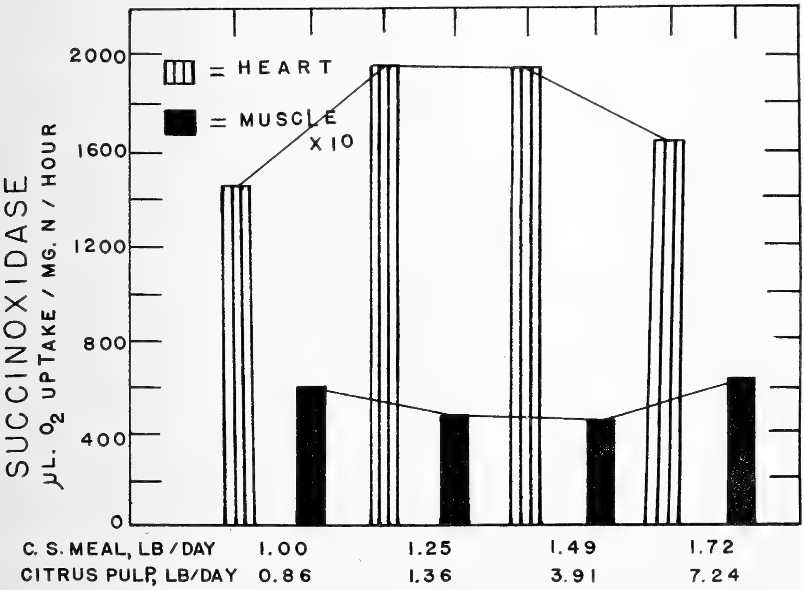

Fig. 2. Effect of varying levels of protein and energy supplementation on winter pastures prior to feed lot feeding on succinoxidase activity in the heart and gracilis muscle of heifers.

as the microliters (μl.) of oxygen uptake per mg. of nitrogen per hour. The values obtained for the gracilis muscle were multiplied by 10 in order to show them in Figure 2 with the heart. The 30 to 40 times greater succinoxidase activity found in the heart than in the gracilis muscle indicates that this enzyme system is particularly active in heart respiration. Differences between the four supplemented groups were not significant. This is interesting in light of the differences in the rate of gains of these animals on pasture and in the feed lot. Differences that may have resulted from the pasture treatments may have been minimized during the feed lot period. It is evidence that cellular metabolism may remain nearly constant while physical and dietary features are being varied.

The succinoxidase activity of the heart muscle of heifers, grading U. S. Standard and U. S. Good as well as the various amounts of Brahman and British blood, are compared in Figure 3. Neither breeding nor carcass grade had any significant effect on the enzyme activity. The data in Figure 4 show the corresponding values for the gracilis muscle. These data indicate that succinoxidase activity was essentially the same in both Standard and Good grades; however, the increase in enzyme activity as the percentage of Brahman blood decreased approached statistical significance.

SUMMARY

Forty-eight Brahman-British crossbred heifers were evaluated for growth and succinoxidase activity in the heart and gracilis muscle after they had been divided at 8 months of age into four dietary groups and fed on winter pastures four different levels of protein and energy for 148 days followed by 140 days of feeding in the feed lot.

The highest level of supplementation on pasture gave average gains of 1.4 lbs., compared to 0.3 lbs. per day for the lowest supplemented group. In the feed lot where all animals were fed the same ration, the average daily gain per day was greatest in those having the lowest daily gains while on pasture. The heart muscle had approximately 30 to 40 times as much succinoxidase activity as the gracilis muscle, but dietary treatments had no effect on the enzyme activity in either tissue. There was no significant differences in enzyme activity between animals in U. S. Standard and Good grades. The enzyme activity of the heart muscle of the

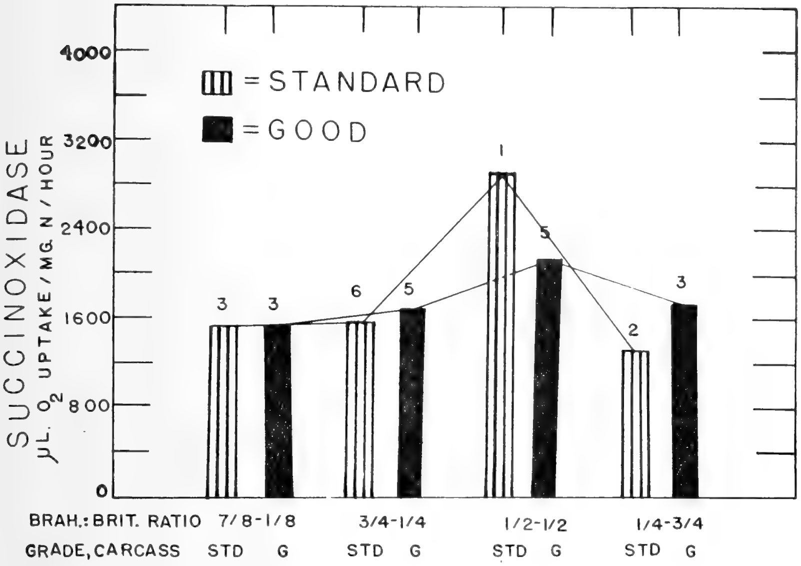

Fig. 3. Effect of grade and crossbreeding on the succinoxidase activity of the heart of heifers. The number of heifers treated is given at the top of the vertical bars.

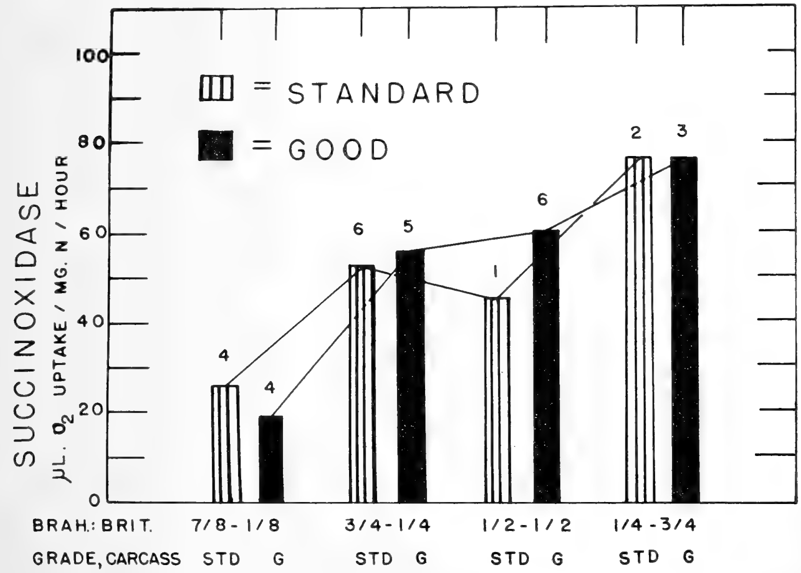

Fig. 4. Effect of grade and crossbreeding on the succinoxidase activity of the gracilis muscle of heifers. The number of heifers treated is given at the top of the vertical bars.

heifers with various amounts of Brahman and British breeding was similar, but increasing the British blood resulted in an increase of enzyme activity of the gracilis muscle that approached significance.

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DERIVATIVES OF FLUORENE S-35-LABELED SULFONIC ACID IN TUMORS OF MICE AND HAMSTERS

Danuta Malejka, Mary F. Argus, and F. E. Ray

Diagnostic cancer studies in this Laboratory with sulfur-35-labeled high molecular weight sulfonic acid derivatives of fluorene and biphenyl showed that compounds with primary or secondary sulfonamido groups have a tendency to localize in the liver and spleen of tumor-free animals to a greater extent than in tumor-bearers (Argus and Hewson, 1954; Argus, Hewson, and Ray, 1956; Argus, Lemasters, Gutierrez, and Ray, 1957; Argus, Seepe, Gutierrez, Hewson, and Ray, 1958). Secondly, the presence of strong acid, e.g., sulfonic (Argus and Hewson, 1954; Argus, 1953) or carboxylic groups (Argus, Seepe, Gutierrez, Hewson, and Ray, 1958), provides a more favorable tumor localization. The results of these investigations were summarized by Argus (1961). Of the entire series tested, fluorene-2,7-di(sulfonamido-2-naphthalene)-S-35 was the subject of particularly extensive studies of the effects of x-radiation and cortisone on the distribution of this compound in the animals (Argus, Hewson and Ray, 1956; Argus, Lemasters, Gutierrez, Hewson, and Ray, 1957; Argus, 1961). It was found that the presence of tumor in each of the animal species reduced the uptake of this compound by the liver and spleen, but the two stress situations, x-radiation and cortisone treatment, appeared not to affect the distribution of S-35 fluorene derivatives (Malejka, Argus, and Ray, 1961).

In an attempt to find more useful data for liver-spleen or tumor localization, the distribution of two new radioactive compounds, N,N′-bis(p-sulfamoylphenyl)-2,7-fluorene-disulfonamide-S-35, Compound I, and disodium X-nitroso-N,N'(9-oxo-2,7-fluorenlyenedisulfonyl-S-35)-disulfanilate, Compound II, was recently examined by Malejka (1962) in Wistar rats bearing Walker carcinosarcoma 256. This investigation demonstrated a high concentration of Compound I in the liver and spleen of tumor-free rats (ratio values, tumor-free/tumor bearers, 1.54 and 4.00, respectively), *and a considerable increase in excretion of this compound in the urine of tumor bearers.* Compound II, containing sulfonic acid, demonstrated an increased concentration in tumor tissue.

TABLE 1

DISTRIBUTION OF RADIOACTIVITY IN CAF$_1$/JAX MICE

Tissue	Tumor-bearing Mice *				Tumor-free Mice *			
	Compound I †		Compound II ‡		Compound I ‡		Compound II ‡	
	μg/g	Per cent	μg/g	Per cent	μg/g	Per cent	μg/g	Per cent
Blood cells §	20	.29	19	.24	22	.31	22	.27
Blood plasma §	55	.80	29	.37	79	1.07	31	.37
Liver	341	9.54	162	3.52	330	7.84	148	3.04
Lung	296	.78	60	.15	236	.67	86	.22
Spleen	67	.22	19	.06	64	.11	26	.04
Kidney	1614	11.23	96	.48	1682	11.28	135	.98
Thymus	65	.09	33	.03	66	.07	39	.03
Skin	199	16.76	91	6.27	211	17.00	69	4.82
Leg muscle	37	.17	10	.05	21	.11	13	.07
Stomach + content	125	.88	181	.69	220	.98	159	.84
Small intestine + content	616	14.15	247	5.11	576	12.45	237	5.26
Large intestine + content	1647	28.06	2992	34.39	2130	28.35	3355	43.05
Carcass	58	13.22	20	4.17	45	9.98	20	4.42
Urine §	200	2.00	945	9.45	166	1.66	739	7.39
Feces	1302	2.26	8483	12.50	2308	4.20	10360	15.10
Tumor	45	.40	57	.35				
Total		100.86		77.84		96.08		85.90

* Intravenous injection of N,N′-bis(p-sulfamoylphenyl)-2,7-fluorene-disulfonamide-S^{35} (compound I) and disodium X-nitroso-N,N′(9-oxo-2,7-fluorenylenedisulfonyl-S^{35})-disulfanilate (compound II); dose of S^{35}-labeled compound I or II, 5 mg for each mouse; time 6 hours.

† Average value from 8 mice (4 sets of 2 each).

‡ Average value from 12 mice (6 sets of 2 each).

§ Concentration in μg compound/ml; others expressed in μg compound/g tissue.

The present investigation is aimed at determining whether this phenomenon can be demonstrated for other tumors and animal species. Accordingly, the distribution of these two compounds was examined in male CAF_1/Jax mice bearing a transplanted squamous cell stomach carcinoma and in female golden Syrian hamsters with transplanted sarcoma. The experiments were conducted under the conditions described previously by Malejka (1962): the tissue distribution of Compounds I and II was studied at an interval of 6 hours following their intravenous injection. Since the earlier derivatives of fluorene and biphenyl series were tested mostly in mice (Argus and Hewson, 1954, 1955; Argus, Hewson, and Ray, 1956; Argus, Lemasters, Gutierrez, and Ray, 1957; Argus 1953, 1961), and fluorene-2,7-di(sulfonamido-2-naphthalene)-S-35 in hamsters (Argus, Lemasters, Gutierrez, Hewson, and Ray, 1958; Argus, 1961), these two species offered the possibilities of comparing the previous results with the present results.

MATERIALS AND METHODS

A total of 44 male CAF_1/Jax mice, 4-5 weeks old, and 21 female golden Syrian hamsters, 6-8 weeks old, were used. Twenty mice were used for subcutaneous transplantation of a keratinizing squamous cell carcinoma (Line A, stomach carcinomata originally obtained from the Animal Supply and Research Units of the British Empire Cancer Campaign) now in its 148th transplant generation in this Laboratory. Twenty-four tumor-free mice served as a control group. Similarly, 10 hamsters received, by the subaxillary route, a transplanted sarcoma which originally had developed spontaneously. It is now in its 49th transplant generation in this Laboratory. Eleven non-tumor hamsters were used as controls. When the tumors were one month old, the radioactive compounds were administered by tail vein injections to mice and by femoral vein injections to hamsters. Each of the mice and hamsters was given 0.5 ml and 1 ml, respectively, of 0.05N sodium hydroxide containing 10 mg/ml of N,N′-bis(p-sulfamoyl-phenyl)-2,7-fluorene-disulfonamide-S-35, or disodium X-nitroso-N,N′(9-oxo-2,7-fluorenylenedisulfonyl-S-35)-disulfanilate. Subsequently, each animal was placed in an individual metabolism cage and sacrificed 6 hours following administration of the compounds. The concentration and per cent recovery of radioactive material in the tissues and excreta of the

TABLE 2

DISTRIBUTION OF RADIOACTIVITY IN SYRIAN HAMSTERS

	Tumor-bearing Hamsters [*]				Tumor-free Hamsters [*]			
	Compound I [†]		Compound II [†]		Compound I [‡]		Compound II [†]	
	μg/g	Per cent	μg/g	Per cent	μg/g	Per cent	μg/g	Per cent
Blood cells §	3	.09	13	.43	3	.09	2	.08
Blood plasma §	28	.89	124	4.31	10	.35	153	4.84
Liver	155	5.57	76	3.04	92	3.46	58	2.10
Lung	54	.24	54	.30	26	.14	100	.53
Spleen	11	.05	22	.06	10	.02	32	.03
Kidney	2035	20.48	60	.56	2045	21.30	56	.51
Thymus	26	.03	26	.03	9	.01	48	.07
Skin	27	4.67	42	9.23	27	4.96	44	8.68
Leg muscle	21	.13	22	.15	11	.08	31	.19
Stomach + content	17	.40	29	.58	13	.56	22	.67
Small intestine + content	907	18.40	154	3.79	286	7.05	144	3.76
Large intestine + content	735	25.47	1109	47.51	743	48.57	815	46.76
Carcass	19	7.18	20	10.28	10	4.47	26	12.84
Urine §	446	4.46	604	6.04	457	4.57	637	6.37
Feces	23[**]	.03	—	—	148[†]	.30	14	.04
Tumor	37	5.38	79	6.61				
Total		94.83		92.92		95.93		87.47

[*] Intravenous injection of N,N′-bis(p-sulfamoylphenyl)-2,7-fluorene-disulfonamide-S^{35} (compound I) and disodium X-nitroso-N,N′(9-oxo-2,7-fluorenylenedisulfonyl-S^{35})-disulfanilate (compound II); dose of S^{35}-labeled compound I or II, 10 mg for each hamster; time 6 hours.

[†] Average value from 5 animals.

[‡] Average value from 6 animals.

[§] Concentration in μg compound/ml; others expressed in μg compound/g tissue.

[**] Average value from 4 animals.

animals were determined by the methods previously described by Argus, Kane, and Ray (1960). The radioactive compounds and the equipment for radioactivity measurements were the same as previously employed by Malejka (1962).

RESULTS

The distribution in the tissues of CAF_1/Jax mice of the two radioactive compounds, N,N′-bis(p-sulfamoylphenyl)-2,7-fluorene-disulfonamide-S-35, I, and disodium X-nitroso-N,N′(9-oxo-2,7-fluoreneylenedisulfonyl-S-35)-disulfanilate, II, is shown in Table 1. A larger amount of both compounds is found in the blood plasma than in the cells. The ratio (controls/experimentals) of Compound I, Table 3, lines 1-3, shows no significant difference for the blood cells and doubtful significance ($.1<P<.2$) for the plasma. Similar ratios for liver, spleen and urine also fail to show real differences.

Compound II, however, produced a significant difference between controls and experimentals in the spleen of CAF_1/Jax mice (ratio 1.36 [$.01<P<.02$]), Table 3, lines 7-9. Both compounds gave a similar but statistically non-significant difference in the urine.

The data for Compound I in hamsters, Tables 2 and 3, show a reversal of the ratios for blood plasma in controls/tumor-bearers as compared with the same ratios for mice. The probability that this is significant seems, however, low. The same could be said of the decreased ratio in the liver of hamsters. Compound I, therefore, does not seem to show any convincing difference in concentration in the organs of tumor and non-tumor bearing CAF_1/Jax mice or in hamsters, such as was reported previously for rats by Malejka (1962). Another compound, 2,7-di(sulfonamido-2-naphthalene)-S-35, has also shown different concentrations in organs of tumor and non-tumor bearing animals in mice (Argus and Hewson, 1954), rats (Argus, 1961) and hamsters (Argus, Seepe, Kane, and Ray, 1958).

Compound II, on the other hand, shows several highly significant results (Table 2). The concentration in the spleen of the control CAF_1/Jax mice is much higher than in the spleen of the tumor-bearers, with a ratio of 1.36 ($.01<P<.02$), Table 3, lines 7-9. The hamster also shows several differences between controls and tumor-bearers. As found for the mouse, the hamster spleen gives a ratio (controls/tumor-bearers) greater than one (1.45, $P \cong .01$).

TABLE 3

CONCENTRATION OF RADIOACTIVITY IN MICE AND HAMSTERS

Compound and Group *	Blood Cells	Blood Plasma	Liver	Spleen	Urine
N,N′-bis(p-sulfamoylphenyl)-2,7-fluorene-disulfonamide-S^{35}, I					
CAF$_1$/Jax Mice					
Ratio $\left(\frac{\text{av. control } \dagger}{\text{av. exper. } \ddagger}\right)$	1.10	1.43	0.96	0.95	0.83
Probability §	$.3<P<.4$	$.1<P<.2$	$\cong .7$	$.8<P<.9$	$.3<P<.4$
Mean dif. ± std. dev.	2 ± 2.05	24 ± 15	11 ± 31.5	3 ± 17	34 ± 32
Syrian Hamsters					
Ratio $\left(\frac{\text{av. control } \dagger}{\text{av. exper. } \ddagger}\right)$	1.00	0.77	0.59	0.91	1.02
Probability §	$>.9$	$.4<P<.5$	$.1<P<.2$	$.7<P<.8$	$>.9$
Mean dif. ± std. dev.	0 ± 0.4	18 ± 13	63 ± 41.4	1 ± 3.15	11 ± 151
Disodium X-nitroso-N,N′(9-oxo-2,7-fluorenylenedisulfonyl-S^{35})-disulfanilate, II					
CAF$_1$/Jax Mice					
Ratio $\left(\frac{\text{av. control } \dagger}{\text{av. exper. } \dagger}\right)$	1.15	1.03	0.91	1.36	0.79
Probability §	$.3<P<.4$	$.8<P<.9$	$\cong .6$	$.01<P<.02$	$.3<P<.4$
Mean dif. ± std. dev.	3 ± 2.29	1 ± 5.76	14 ± 26.3	7 ± 2.41	207 ± 210
Syrian Hamsters					
Ratio $\left(\frac{\text{av. control } \ddagger}{\text{av. exper. } \ddagger}\right)$	0.15	1.23	0.76	1.45	1.05
Probability §	$\cong .1$	$.02<P<.05$	$\cong .02$	$\cong .01$	$.8<P<.9$
Mean dif. ± std. dev.	11 ± 6.16	29 ± 11.4	18 ± 6.63	10 ± 2.83	33 ± 192

* Intravenous injection of S^{35}-labeled compound I or II; dose 5 mg for each mouse and 10 mg for each hamster; time 6 hours.

† Average value from 12 mice and 6 hamsters.

‡ Average value from 8 mice and 5 hamsters.

§ Based on null hypothesis for true difference between experimental (tumor-bearing) and control (tumor-free) groups.

The hamster liver shows a significant ratio *less* than one (0.76, $P \cong .02$). It will be recalled that the hamster liver for Compound I also gave a ratio less than one (0.59), but with only a significance of $.1<P<.2$. This finding in liver may thus be a real if not a statistically significant difference.

The same reasoning would cause us to discard the ratio for Compound I in the blood plasma of hamster, 0.77 ($.4<P<.5$), because Compound II yields a ratio for blood plasma which is significantly greater than one, 1.23 ($.02<P<.05$).

CONCLUSIONS

We have ascribed the lower uptake of previous compound (Argus, Hewson, and Ray, 1956) by the liver and spleen of tumor-bearers to impaired phagocytic power of these organs (Benacerraf, Biozzi, Cuendet, Halpern 1955; Benacerraf, Bilbey, Biozzi, Helpern, and Stiffel, 1957; Halpern, 1959). One of the possible explanations is that it now seems evident that we have reached the limit in molecular type and size for differential phagocytosis to operate. Compound I ($C_{25}H_{22}O_8N_4S_4$), with a molecular weight of 634, was entirely ineffective in showing a statistically significant difference between controls and tumor-bearers. The previously successful localization (Argus, Hewson, and Ray, 1956) occurred with fluorene-2,7-di(sulfonamido-2-naphthalene)-S-35 ($C_{33}H_{24}O_4S_2N_2$) with a molecular weight of 576. Perhaps, in addition, the lack of substituents on the outer rings would give a more compact spatial configuration to the naphthalene and thus facilitate phagocytosis.

Compound II, with its free sulfonic acid groups, shows a differential uptake between controls and tumor-bearers in the spleen of CAF_1/Jax mice and in hamsters. The liver of hamsters, however, shows the opposite effect, which would again lead us to believe that the limit has been reached.

In both mice and hamsters an enormous amount of Compound I was found in the kidneys (11-20 per cent) with a considerable amount in the urine. Compound II, being more soluble because of its free sulfonic acid groups, did not localize to any great extent (0.4-0.5 per cent) in the kidneys; it was, however, found in much larger amounts in the urine (6-9 per cent) as compared to Compound I (2-4 per cent). This may indicate a similar metabolic pathway for the two compounds, if allowance is made for some difference in properties. The values for liver and gastrointestinal tract seem to support this view. More of Compound I is found in the liver and small intestine, but much more of Compound II occurs in the large intestine and feces.

The concentration of these compounds in tumor tissue is similar to that reported previously by Malejka (1962). Compound II, because of its free sulfonic acid groups, tended to localize in tumor to a somewhat greater extent than Compound I. The concentration of Compound I in tumor tissue is greater than in spleen for hamsters, but not for mice. Compound II was found to be greater in tumor than in spleen in both mice and hamsters. It is about equal to liver in hamsters but considerably less than the concentration in mouse liver. Here again, the performance of these compounds is considerably below that found by Argus and Hewson (1954) for disodium fluorene-2,7-disulfonate and fluorene-2,7-di-sulfonamidobenzene) or biphenyl-4,4′-di-(sulfonamido-benzene-S-35-4-sulfonamide) found by Argus, Seepe, Gutierrez, Hewson, and Ray (1957).

SUMMARY

The distribution of two radioactive compounds, N,N′-bis(p-sulfamoylphenyl)-2,7-fluorenedisulfonamide-S-35 and disodium X-nitroso-N,N′(9-oxo-2,7-fluorenylenedisulfonyl-S-35)-disulfanilate, six hours after intravenous injection into tumor-bearing and control mice and hamsters was studied. The former compound showed some trends but no statistically significant differences between tumor-bearers and controls. The latter showed a significant difference in the spleen of both mice and hamsters and in the liver and blood plasma of hamsters. Some localization of both compounds occurred in tumor tissue, but was not sufficiently greater than the concentration in the liver to hold much promise as a diagnostic aid.

ACKNOWLEDGMENTS

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CITRONELLE SEDIMENTS OF PENINSULAR FLORIDA

E. C. Pirkle, W. H. Yoho, A. T. Allen, and Allen C. Edgar

Slightly micaceous quartz sands and clayey sands, locally containing important percentages of small quartz or quartzite gravel and larger discoid quartzite pebbles, are common throughout extensive areas in the central part of the Florida peninsula (figure 1). During the past most workers have considered these sediments as a part of the Citronelle Formation of Pliocene or early Pleistocene age. Studies are now in progress to attempt to determine the relationships of these materials to other formations and landforms such as the Hawthorne and Bone Valley formations, late Miocene and younger shell beds, Pleistocene terraces, and various ridges.

A surface blanket of loose sand is present over most areas of Citronelle sediments. Thus exposures available for study are meager, being present only in occasional sinkholes, along road cuts, and in excavated pits. Reliable information is not easy to secure from most of the cuts along roads nor from exposures in sinks. Sedimentary features can be examined with confidence only in fresh cuts of sand and clay pits, but such fresh exposures last only a short time. They are either destroyed through mining activities or else soon become so masked through exposure to the elements that many of the original characteristics of the materials can no longer be recognized.

Two excellent exposures of Citronelle sediments have been examined recently. One of these is at the Diamond Interlachen sand mine in Putnam County, Florida; the other is at the Grandin sand mine in northern Putnam County. Because of the excellence of these exposures and the limited amount of published descriptions of such materials, and because these sediments undoubtedly are an important key in deciphering much of the late Cenozoic history of peninsular Florida, pictures at the exposures were made, sections measured, and sedimentary features noted while the cuts were still fresh and available for examination. It is hoped that the report, in addition to furnishing specific data on these sediments, will suggest interesting new problems to workers of geology in the area and will indicate methods by which some lingering geological problems may be attacked.

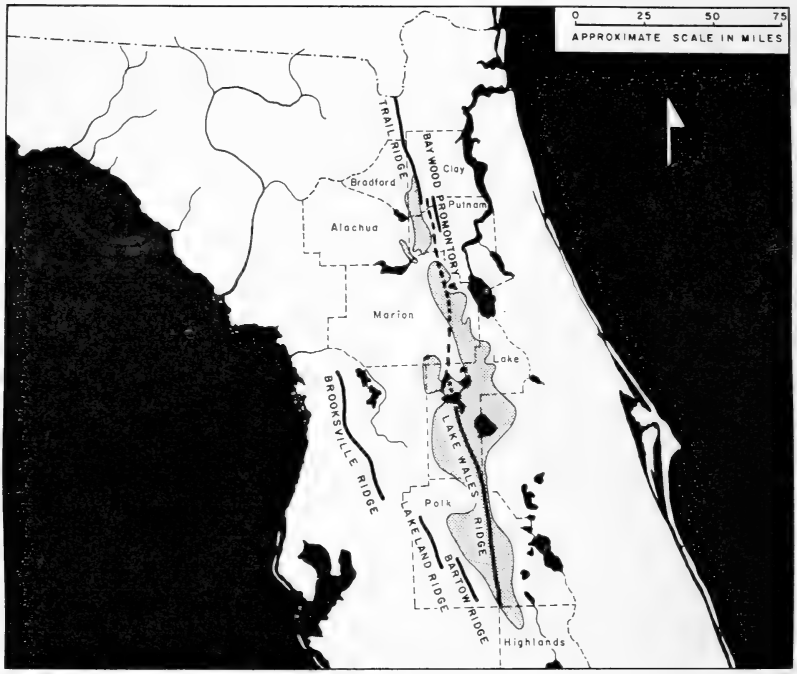

Fig. 1. Location map showing by stippled pattern the distribution of kaolinite-bearing sediments in peninsular Florida as mapped by Cooke (1945). The locations and boundaries of these materials are highly generalized. The crests of various ridges are named and their positions indicated by heavy lines. Only in the area of the Lake Wales Ridge are thick sections of Citronelle sediments present. The Lake Wales Ridge is not well defined in its northern part. On the map the crest of that part of the ridge is represented by a dashed line. Neither the extension of the Lake Wales Ridge southward into Highlands County nor the extension of Trail Ridge northward into Georgia are shown on the map. Counties mentioned in the report are labeled. For a discussion of the ridges of central peninsular Florida the reader is referred to White (1958).

DIAMOND INTERLACHEN SAND MINE

During the spring of 1961 mining operations at the Diamond Interlachen sand mine resulted in an exposure of Citronelle sediments showing prominent development of fore-set type cross-bedding. Because the features shown in this face have not been clearly visible at any other part of the mine a section of the new face was measured by E. C. Pirkle and W. H. Yoho during March, 1961 (see Appendix).

TABLE 1

Diamond Interlachen Sand Mine, Putnam County, Florida

Unit*	5 Percentile (diam. in mm)	Sorting (So)	Clay in %	230 in %	120 in %	Heavies % on 230	Heavies total %
29	.80	1.34	1.72	1.74	21.32	7.14	.31
28	1.30	1.57	12.57	2.84	6.34	.40	.05
27	3.30	1.87	14.22	.70	3.79	1.07	.03
26	1.15	1.53	10.75	1.02	8.47	1.17	.05
25	4.20	1.78	4.82	.76	4.60	1.08	.02
24	.95	1.35	8.16	.37	3.63	1.26	.03
23	1.00	1.44	3.92	.95	24.05	1.42	.05
22	2.40	1.64	7.08	.58	8.14	1.97	.07
21	.73	1.40	3.24	1.06	30.70	3.28	.11
20	1.65	1.45	2.05	.57	5.25	3.52	.11
19	1.35	1.33	1.92	.46	4.16	8.39	.47
18	2.60	1.71	3.05	.89	3.23	1.69	.06
17	1.15	1.40	2.94	.66	10.30	3.45	.14
16	.93	1.41	3.90	1.08	28.08	6.80	.20
15	1.40	1.65	3.40	1.04	20.13	5.28	.15
14	1.10	1.49	3.04	1.15	21.06	6.55	.25
13	1.80	1.68	2.69	.83	14.22	8.53	.14
12	1.25	1.51	2.49	1.41	33.67	8.39	.24
11	1.60	1.84	11.32	3.47	21.59	1.50	.10
10	1.00	1.54	15.40	9.64	44.57	2.00	.30
9	1.80	2.05	6.91	4.66	22.08	2.67	.22
8	.78	1.36	12.87	8.76	54.99	3.50	.45
7	1.95	1.49	.87	1.36	4.57	1.84	.02
6	.98	1.41	4.08	.87	5.64	2.27	.03
5	1.95	1.58	3.49	1.02	6.99	3.10	.04
4	1.95	1.88	10.12	1.30	11.63	5.42	.14
3	1.85	1.77	3.01	1.45	16.23	4.49	.14
2	1.20	1.62	4.37	1.52	25.86	4.55	.12
1	Covered Interval						

*Units are labeled respectively on the measured section (see Appendix).

TABLE 2

Grandin Sand Mine, Putnam County, Florida

Unit*	5 Percentile (diam. in mm)	Sorting (So)	Clay in %	230 in %	120 in %	Heavies % on 230	Heavies total %
41	1.25	1.47	4.20	4.04	32.42	8.62	.81
40	1.45	1.76	16.75	1.04	10.33	2.60	.36
39	1.15	1.44	4.24	.46	7.58	4.20	.18
38	4.80	1.79	2.60	.68	4.32	1.65	.04
37	1.55	1.41	2.48	.53	14.69	11.58	.21
36	1.45	1.46	2.40	.49	7.42	4.44	.09
35	.93	1.35	2.62	.94	27.81	8.08	.25
34	3.10	1.79	2.00	.68	8.94	3.43	.05
33	3.00	1.76	2.04	.54	5.88	2.05	.10
32	.83	1.35	1.55	1.03	27.46	10.15	.23
31	1.35	1.44	1.70	.53	14.80	6.84	.12
30	.36	1.20	4.11	4.38	80.10	1.41	.12
29	1.75	1.88	2.84	.82	20.78	9.72	.12
28	.93	1.40	1.36	.76	29.15	9.48	.16
27	.85	1.38	3.20	1.87	40.09	8.65	.28
26	.78	1.41	11.83	1.34	35.02	13.31	.36
25	.44	1.24	12.11	6.62	64.33	1.61	.24
24	1.45	1.95	3.15	2.79	36.08	4.11	.32
23	.45	1.20	1.95	4.70	79.04	11.08	.87
22	.39	1.28	17.13	4.53	64.34	4.22	.33
21	1.35	1.73	2.21	1.95	34.97	8.01	.22
20	1.80	2.03	9.92	1.01	17.57	5.71	.14
19	1.85	1.97	6.97	1.90	15.91	5.92	.16
18	1.25	1.69	1.69	1.70	28.95	4.34	.11
17	3.00	2.19	2.67	.87	25.20	7.98	.13
16	Covered slope						
15	1.95	1.64	6.06	.60	6.10	3.44	.07
14	1.70	1.69	9.95	.96	9.90	3.15	.08
13	.43	1.85	22.92	13.13	42.28	4.44	.76
12	.73	1.41	6.28	12.01	51.16	6.52	.78
11	3.10	1.80	3.28	1.53	8.39	3.62	.10
10	1.50	2.49	16.42	17.30	39.07	3.35	.64
9	2.00	1.84	6.08	6.50	10.34	1.26	.11
8	1.25	1.55	15.86	14.19	48.35	4.35	.67
7	2.70	2.36	6.61	4.91	12.66	1.25	.09
6	1.15	1.80	20.48	15.54	37.68	.67	.10
5	3.30	1.87	6.35	4.20	9.80	1.04	.08
4	2.40	2.58	10.98	9.33	37.63	2.22	.23
3	3.30	2.74	4.79	6.07	15.74	1.57	.11
2	2.40	2.46	8.14	13.19	27.73	2.45	.34
1	Covered slope						

*Units are labeled respectively on the measured section (see Appendix).

Histograms, Statistical Values and Explanations of Terms. Lithologic features and characteristics of the sediments of each unit of the section measured at the Diamond Interlachen sand mine are illustrated by the histograms (figures 2-4) and by data in table 1. In collecting the samples for making the histograms and for determining various statistical values, channel samples were carefully taken across the complete face of each unit. Spot samples were collected at selected sites to furnish data for later studies of special problems.

By convention the largest diameter value for the sediments is placed on the left side of the histograms. The median diameter and the quartile measurements (listed on the histograms) are obtained from cumulative curves. The median diameter (Md) is the diameter which represents the middle member of the distribution; half of the distribution by weight is smaller and half larger. The third quartile (Q_3) is that diameter of which 25 percent by weight of the distribution is larger and 75 per cent smaller; the first quartile (Q_1) is that diameter of which 75 per cent of the distribution is larger and 25 per cent smaller (Krumbein and Pettijohn, 1938, pp. 230-231). Inconsistencies in the conventional plotting of the histograms and cumulative curves with normal statistical procedures are recognized but do not affect the results.

The terms in table 1 are used with the following meanings. The 5 percentile figure represents a diameter of which 5 per cent of the distribution by weight is larger and 95 per cent smaller. This figure frequently is used as a measure of the coarseness of a sample. The sorting is measured by the coefficient of sorting (So) which is the square root of the ratio of the quartiles, where Q_3 is greater than Q_1. A perfectly sorted sediment would have a sorting coefficient of 1.0. The value listed as the per cent clay is the percentage of the sediments that passed through the 325 mesh screen. Numerous analyses run by the Edgar Plastic Kaolin Company indicate that most of that fraction is of clay size, only a small portion being of silt size. The per cent 230 is the per cent of the total sample that passed through the 120 mesh screen and was retained on the 230 mesh screen; the per cent 120 is the per cent of the material that passed through the 60 mesh screen and was retained on the 120 mesh screen. These two fractions have proven of unusual interest in the comparisons of analyses and statistical values in regard to a number of different types of geological problems.

TABLE 3

Prospect data of sand deposit at Edgar, Putnam County, Florida*

Hole No.	4M	8M	Per cent of sand less than 16M	20M	30M	50M	100M	Clay in % (-325M)	Clay Color	Depth of overburden in feet	Thickness in feet of Sediments analyzed
C-3	100	99.5	95.6	89.4	80.2	56.5	10.0	14.8	Cream	18	21
C-4	100	99.8	96.0	89.9	80.6	52.6	9.6	20.7	Cream	21	18
C-5	100	99.8	95.7	89.8	81.8	62.5	12.5	15.1	Cream	21	18
C-6	100	99.6	96.3	90.7	81.8	61.5	11.5	16.5	Cream	24	15
C-9	99.8	99.3	95.8	90.5	83.3	63.1	12.3	17.1	Cream	18	21
D-3	99.9	99.7	95.7	89.1	80.6	57.2	14.4	16.6	Cream	18	21
D-4	100	99.8	96.2	89.2	78.4	45.2	7.6	14.2	Cream	18	21
D-5	100	99.7	95.0	89.0	80.4	55.8	11.9	16.1	Cream	18	18
D-6	99.8	99.0	93.5	86.8	76.7	52.7	15.4	18.2	Cream	18	18
D-7	99.9	99.7	95.4	86.6	73.0	38.3	8.9	12.2	Cream	15	24
D-8	100	99.6	94.1	86.3	76.4	51.6	11.4	14.3	Cream	18	21
D-9	100	99.8	96.3	89.5	79.5	50.4	9.1	11.8	Cream	18	21
D-12	100	99.5	93.6	85.6	75.8	54.8	12.8	16.0	Cream	21	18

* Borings, covering an area of approximately 80,000 square feet, were made in the spring of 1962. In these sediments only about 8 to 15 per cent of the sand is finer than 100 mesh.

The clay content ranges from approximately 12 to 20 per cent. In contrast, the sand portion of the sediments represented in table 4 is finer and the clay content higher. Data are published through the courtesy of the Edgar Plastic Kaolin Company.

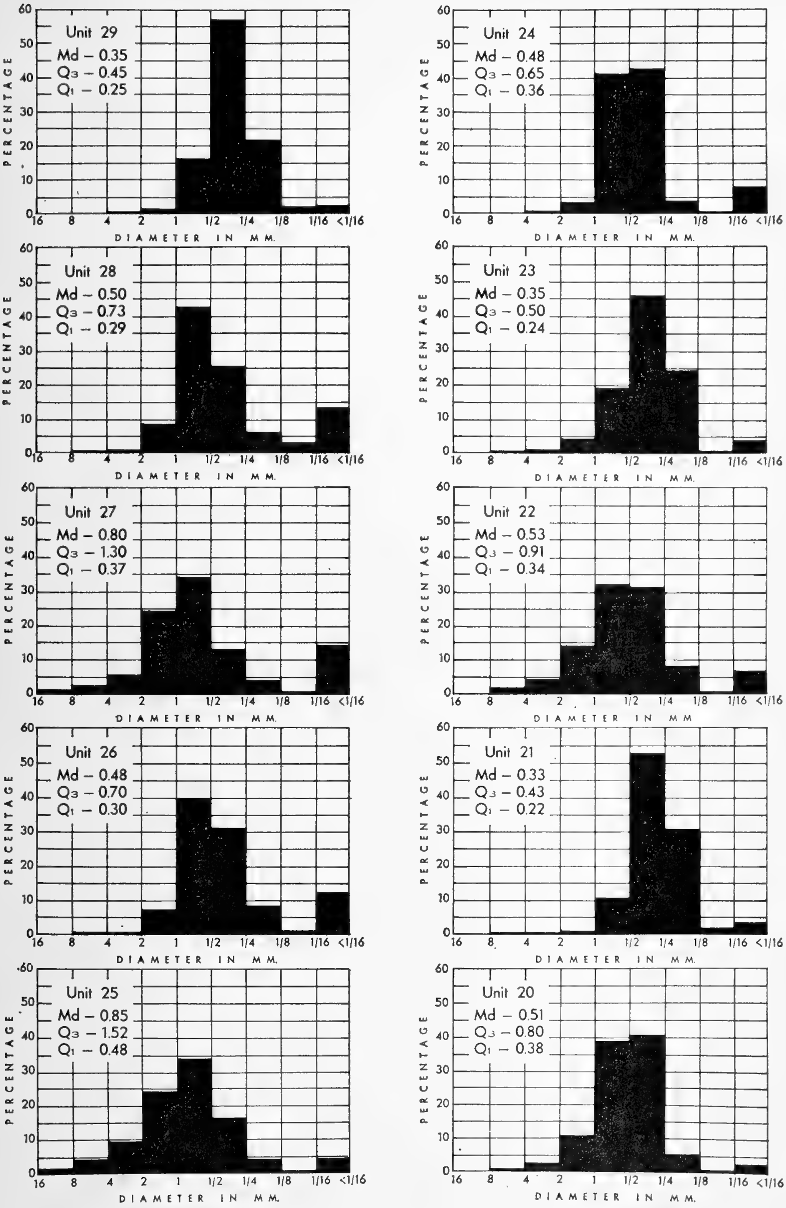

Fig. 2. Histograms of channel samples collected at the Diamond Interlachen sand mine, Putnam County, Florida. Units are labeled respectively on the measured section. The analyses of unit 25 showed 0.51 per cent material in the 8 to 16 mm fraction and 1.15 per cent material in the 16 to 32 mm fraction. For convenience these amounts were combined and the total shown on the histogram in the 8 to 16 mm column.

TABLE 4

Prospect data of kaolin deposit at Edgar, Putnam County, Florida*

Hole No.			Per cent of sand less than					Clay in % (-325M)	Clay Color	Depth of overburden in feet	Thickness in feet of Sediments analyzed
	4M	8M	16M	20M	30M	50M	100M				
Sec. D	100	99.7	98.1	96.6	94.7	89.7	62.4	25.3	White	16	26
D-26	99.8	99.2	95.3	92.1	88.9	84.2	48.8	26.7	White	17	25
D-25	99.3	98.3	95.0	92.0	89.2	84.9	60.6	26.3	White	18	24
D-24	100	99.2	94.1	89.5	84.2	75.1	46.6	24.7	White	18	24
D-23	100	99.8	97.4	94.3	91.0	86.2	60.0	28.7	White	18	24
D-22	No value								Dark Brown	30	
Sec. E	100	99.8	98.3	97.2	96.0	92.8	59.5	29.0	White	18	24
E-26	100	99.3	96.9	94.2	91.2	85.7	60.8	25.7	White	18	24
E-25	100	99.1	95.0	91.9	85.9	79.6	47.0	25.3	White	18	24
E-24	100	99.1	96.1	93.2	89.8	84.8	60.0	26.4	White	15	27
E-23	100	98.9	94.4	90.9	87.9	82.8	46.3	27.7	White	18	24
E-22	No value								Dark Brown	18	
Sec. F	100	99.6	99.0	98.1	96.2	88.9	61.7	27.1	White	18	24
F-26	99.3	98.2	95.1	92.2	88.2	80.0	48.5	28.6	White	18	24
F-25	99.8	98.9	92.9	87.6	82.1	72.9	47.3	24.2	White	18	24
F-24	100	99.6	95.2	91.4	87.8	81.4	46.6	27.3	White	18	24
F-23	100	99.2	91.7	82.5	73.5	63.9	39.9	21.7	White	18	24
F-22	No value								White	30	
Sec. G	99.9	99.2	98.0	96.4	94.4	90.7	61.1	30.5	White	18	24
G-26	100	99.5	97.8	95.9	93.5	88.1	53.6	26.8	White	18	24
G-25	100	99.4	96.1	92.8	89.1	83.2	50.9	23.2	White	18	24
G-24	99.1	98.5	95.1	90.1	84.0	74.8	39.1	24.2	Cream	18	24
G-23	100	99.6	93.8	87.4	79.1	67.0	38.8	22.4	White	18	21
G-22	99.8	99.3	94.5	86.3	77.0	63.0	30.7	20.3	White	18	21

The per cent heavies on the 230 mesh screen represents that percentage of the 230 mesh fraction consisting of heavy minerals. The heavy mineral suites of this fraction have value for correlation purposes. The total per cent heavies is the per cent heavies present in the complete sample or bed. In running the heavy mineral separations tetrabromethane was used in order to eliminate the white mica, thus making for cleaner slides for later heavy mineral counts.

General Description. As a result of weathering the section shows three rather distinct zones. The same zones are present in many pits developed in Citronelle sediments. The upper zone (unit 29) consists of a blanket of loose to slightly indurated surface sands. These sands overlie a second zone characterized by red and yellow colors (units 28 through 22). The lower part of this red and yellow zone (including parts of unit 25 and units 24, 23, and 22) is transitional into a lower, third zone that is dominantly white. All sediments beginning with unit 21 and continuing to the lake level are a part of this lower white kaolin zone.

Orange and yellow bands are present within the lower white kaolin zone and especially in the areas transitional between this zone and the overlying red and yellow zone. These bands usually follow bedding but occasionally follow such features as small joints or fractures. In the upper parts of the white kaolin zone the bands often are some shade of orange; lower in the section the bands are a lighter, more yellow color. Most of these orange and yellow bands are associated with stringers of coarser sediments. These coarse sediments contain less clay and thus are more permeable, a factor that has favored weathering.

From an inspection of the complete face at the sand pit, it appears that the sediments of the upper part of the exposure (units 28 through 20) are essentially horizontally bedded although some cross-bedding is present. The horizontally bedded units are underlain by sediments characterized by fore-set type cross-bedding.

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[*] Borings, covering an area of 200,000 square feet, were made during April and May, 1962, for final checking in preparation for mining. The sand portion of this deposit is fine with approximately 30 to 60 per cent of the sediments passing the 100 mesh screen. The clay content is relatively high. Although the two areas represented in tables 3 and 4 are less than 2,000 feet apart and are a part of the same formation with essentially the same surface elevation, the kaolinitic clay from the two areas has different properties. There is compelling evidence that these differences are at least in part the result of the work of ground water. Data are published through the courtesy of the Edgar Plastic Kaolin Company.

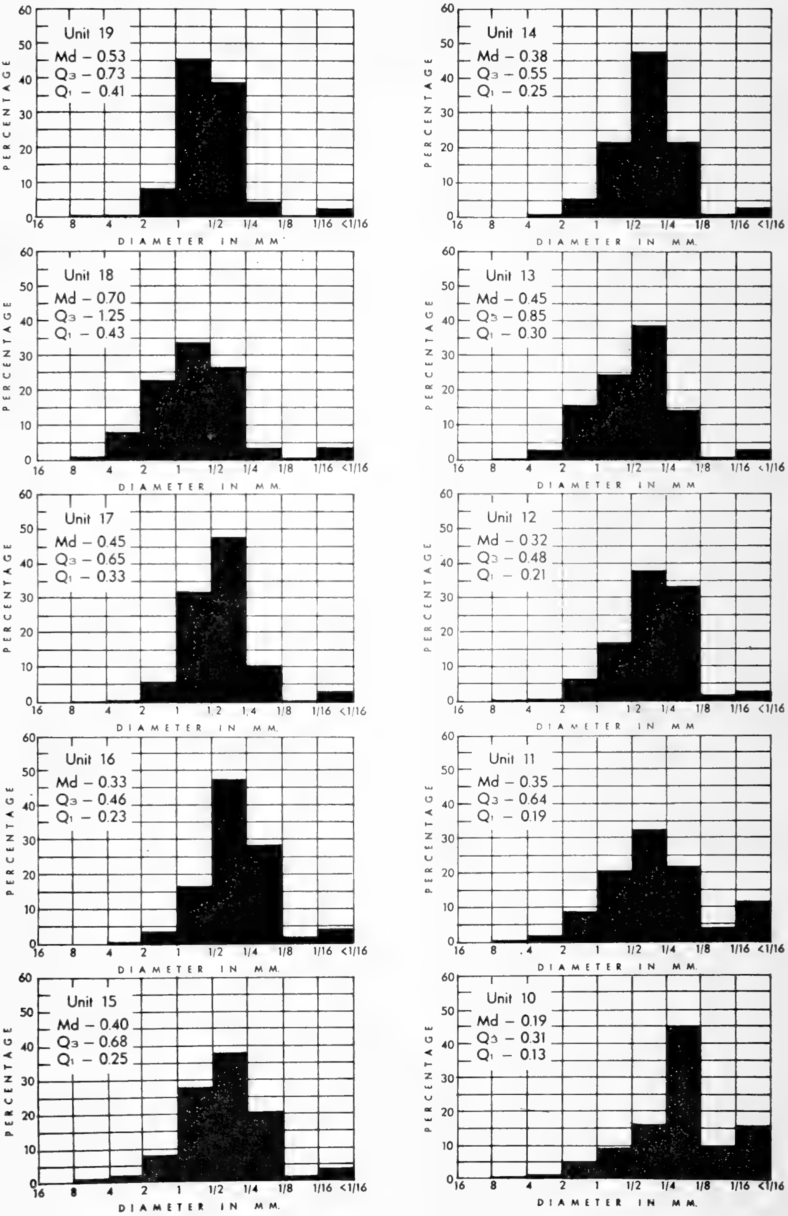

Fig. 3. Histograms of channel samples collected at the Diamond Interlachen sand mine. Units correspond to those on measured section.

Seven different sets of cross-laminations are present, one over the other, as seen clearly in figure 5. The fore-sets (units 19, 17, 16, 15, and the upper three cross-bedded sets in unit 14) cover a vertical range of approximately 9 feet and are separated from each other by small lenses or thin stringers of gravel. At the top of some of the fore-set units, scour type cross-bedding is present.

In the fore-set units, sediments usually become coarser and the dips of the cross-laminations more gentle with depth. During deposition of such units, larger sediments may slide or roll down fore-sets to areas of gentle dip. There, the pebbles may take on the appearance of small, horizontal lenses of gravel. Understandably such lenses could be present at irregular intervals throughout a deposit.

Beneath this group of fore-set units (beginning with unit 12 and including much of the lower part of the exposure), scour type cross-bedding becomes more prominent, clay and mica content in general increases, and specific and clear sedimentary features become more difficult to recognize and interpret. Scour type cross-bedding, though often difficult to recognize because of the nature and condition of exposures, characterizes large areas of Citronelle sediments. Frequently individual units are composed of several different sets of scour type cross-laminations. It is obvious that within such units the amounts and the directions of greatest dip of cross-laminations may vary considerably. Gravel normally accumulates in the lower portions of these cross-bedded sets, a feature that has proven of value in recognizing and unraveling sedimentary structures in some of the poorer exposures. Possible environments under which the unusual combinations of gravel, sand, silt, and clay found together in these Citronelle beds could have been deposited have been discussed elsewhere (Bell, 1924; Bishop, 1956; Pirkle, 1960).

GRANDIN SAND MINE

Recently an excellent face of Citronelle sediments was examined at the Grandin sand mine of the Davenport Sand Company in northern Putnam County (figures 6-8). There, mining into a slight hill has resulted in an unusually thick exposure of Citronelle sediments. The face shows beautifully developed scour type cross-bedding. A section was measured at the southeast part of

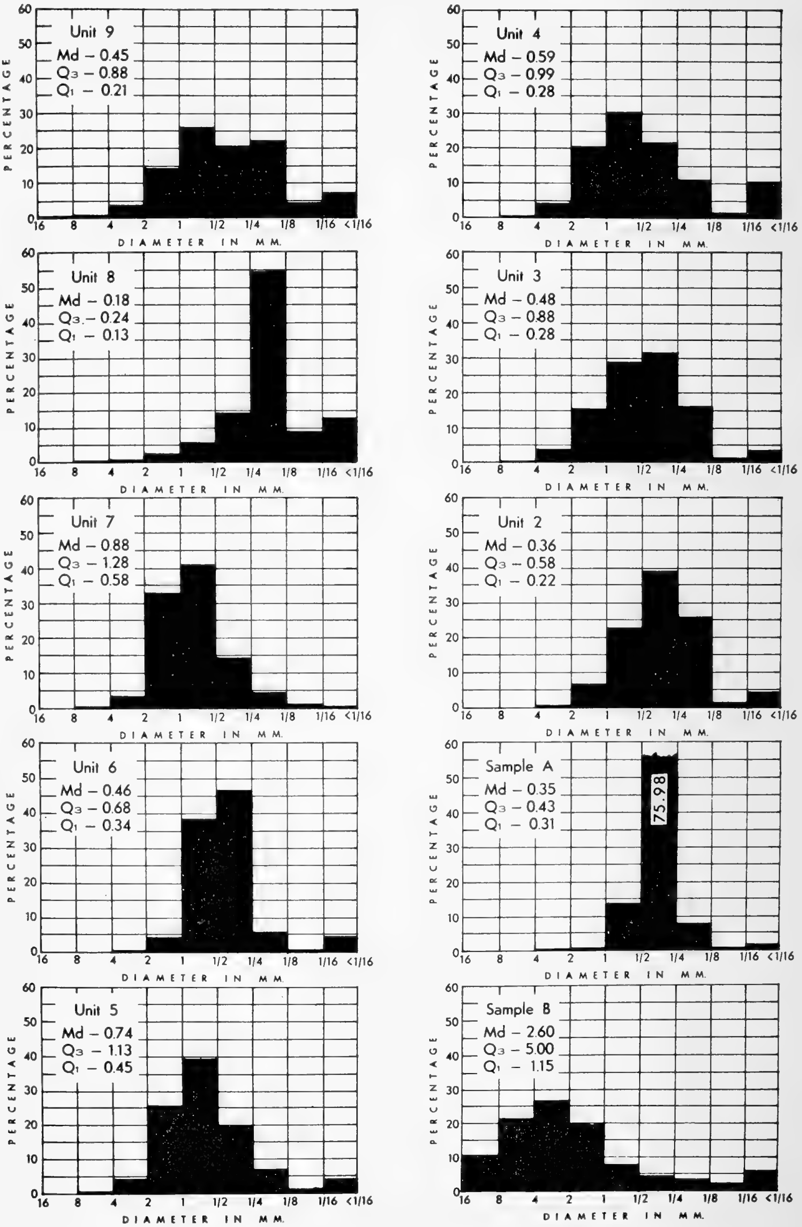

Fig. 4. Histograms of channel samples and spot samples collected at the Diamond Interlachen sand mine. Histograms of units 9 through 2 are of

the pit during January and early February, 1962, by E. C. Pirkle, William A. Pirkle, and W. H. Yoho (see Appendix).

The photographs, figures 6-7, of the Grandin sand mine show loose surface sands, the red zone (dark), and underlying white clayey sands. Characteristics of the sediments are illustrated by the histograms of figures 9-12, and by data in table 2.

The bedding of the upper Citronelle sediments at the Grandin mine is essentially horizontal. In some areas where the sedimentary features are not completely masked by weathering, some of the materials appear to be thinly laminated. Only minor amounts of cross-bedding are present. Sediments of this type cover a vertical range of 19 feet (units 40 through 38).

Beneath these horizontally laminated sediments and occupying the central portion of the face are beds characterized by conspicuous cross-bedding (figures 8 and 13-16). Much of the cross-bedding is of the scour type. These cross-bedded sediments cover a vertical distance of 27 feet (units 37 through 16). Intercalated with these highly cross-bedded sediments (especially in the lower half of the cross-bedded group) are occasional horizontal lenses of finer materials that in places stand out as slight ledges (units 26 and 25, 22, and 20). These beds contain a higher clay content than the highly cross-bedded units.

The sediments of the lower part of the section, beginning just beneath the fore-set unit 14 and continuing to the lake level, have no clearly visible bedding features or structures. In unusually favorable exposures, this type of sediments has been found to be thinly laminated, consisting of alternating laminae of coarse sands and fine sands. Even though analyses of individual laminae result in a normal sediment distribution, combinations of these laminations may give a bimodal distribution of the sand size sediments

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channel samples. These units are labeled respectively on the measured section. Histograms of samples A and B are of spot samples. Sample A was collected approximately 200 feet west of the site of the measured section to illustrate characteristics of a thin lens containing a relatively high percentage of heavy minerals. The lens, approximately 25 feet beneath the land surface, has a maximum thickness of about one foot. In this spot sample 47.07 per cent of the 230 mesh fraction and 5.97 per cent of the total sample consisted of heavy minerals. The sorting coefficient of the sample was calculated as 1.18. Spot sample B, collected 75 feet west of the site of the measured section, was selected to show textural variability of a lens 14 inches thick consisting of a mixture of gravel, fine gravel, and sand. Analyses of the sample showed 7.82 per cent sediments in the 8 to 16 mm fraction and 2.23 per cent material in the 16 to 32 mm fraction. These two fractions were combined and entered on the histogram in the 8 to 16 mm column.

(often low in 60 mesh; see histograms in figure 12). The fine sands normally contain a relatively high content of clay and fine mica. It should be noted that the per cent 230 fraction increases sharply in this zone.

EXAMPLE OF APPLICATION OF STATISTICAL DATA

Analyses of hundreds of samples of Citronelle sediments indicate interesting relationships, which are useful in examining the

Fig. 5. Approximately 12 feet of a nearly vertical face showing cross-bedding at Diamond Interlachen sand mine. Units are labeled respectively on the measured section.

analytical data of various pits. The coarser sediments are usually more poorly sorted than the finer sediments. This relationship has been found to hold when large numbers of samples of Citronelle sediments were selected at random and compared. However, better results should be expected if sediments laid down under the same environment could be isolated for comparison.

The coarser sands and gravels usually contain less clay than the finer sands. This relationship can be illustrated by comparing

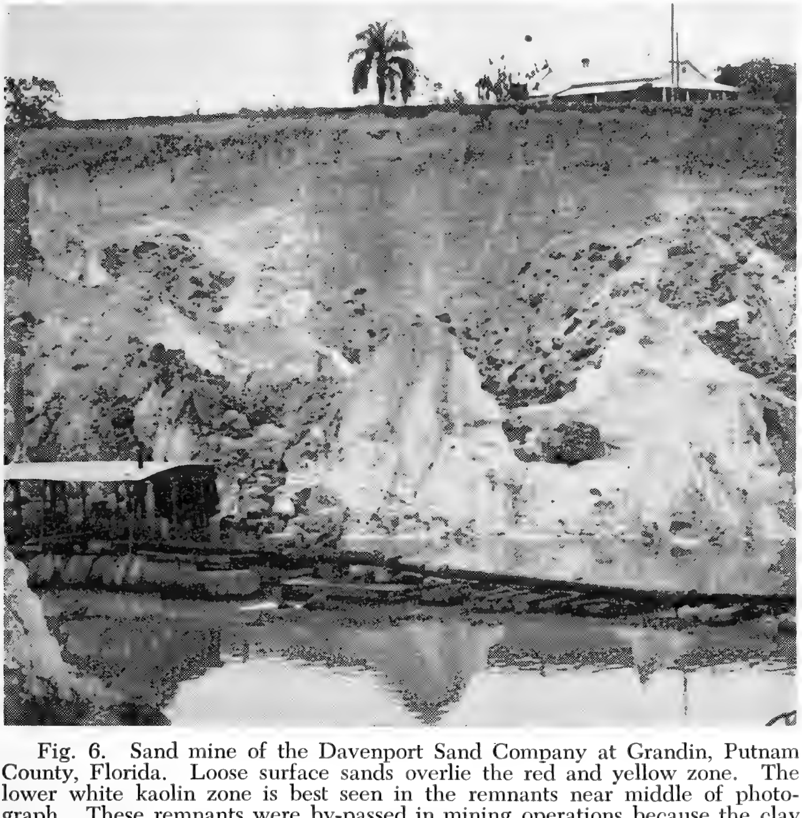

Fig. 6. Sand mine of the Davenport Sand Company at Grandin, Putnam County, Florida. Loose surface sands overlie the red and yellow zone. The lower white kaolin zone is best seen in the remnants near middle of photograph. These remnants were by-passed in mining operations because the clay content was too high and the sand too fine. In the pit face, bedding can be seen dipping downward slightly toward the left. This dip is the result of slumpage due to solution in underlying limestone. To the right of the area photographed, the beds dip gently downward to the right. Where extensive faces have been developed in these sediments it is not unusual to find beds dipping in different directions, frequently toward lake or swampy regions. Close inspection reveals that the bedding is at an angle to the red zone with red and yellow colors following downward a considerable distance along some of the coarser and more permeable beds.

the data in tables 3 and 4. Table 4 represents the analyses of a deposit of fine sand with its relatively high clay content, table 3 a coarser deposit with a lower clay content. In determining the analyses shown in these tables all of the samples from the "ore" zone of a hole were combined, then carefully and continually halved until the desired representative fraction needed for analysis was reached. Thus the analyses are of composite samples. Deviations from the usual relationships of coarseness to clay content in the case of some cross-bedded units are recognized.

Fig. 7. Loose surface sands overlying red and yellow zone (dark). The surface sands are approximately 3 feet thick in this nearly vertical face at the Grandin sand mine.

Heavy mineral content tends to be relatively high in the finer sediments and in the better sorted materials. Nevertheless, as is well known, sediments deposited in different environments may have almost identical grain sizes and almost identical degrees of sorting, with markedly different concentrations of heavy minerals (table 5).

Possible Downward Migration of Clay during Weathering. Regardless of the interest and value of such statistics when applied to many types of problems, it must be emphasized that considerable care should be exercised in the application and interpretation of such data. In fact a case can be made that the statistical analyses should be used largely in helping to evaluate hypotheses drawn from field observations. An example of the possible application of these statistical data can be given.

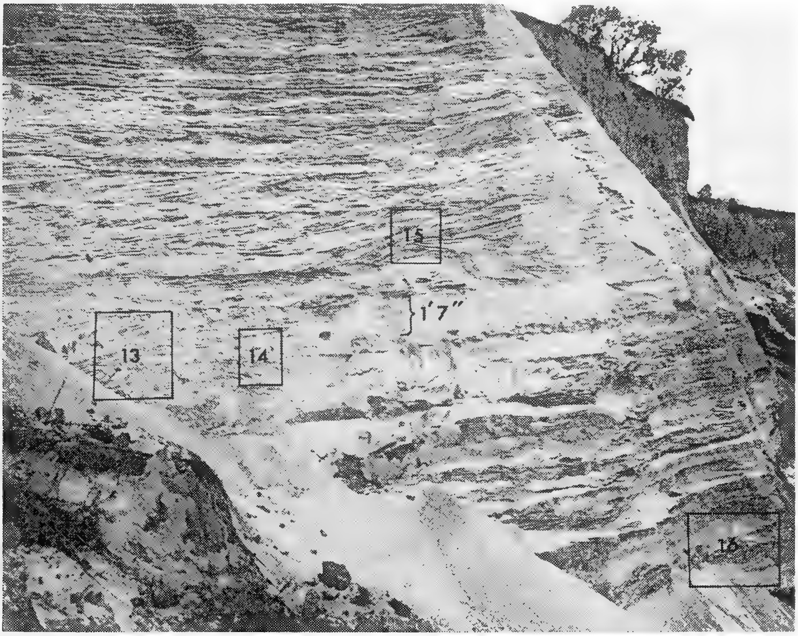

Fig. 8. Part of the nearly vertical face where section was measured at the Grandin sand mine. Cross-bedding is evident. The material in the left-hand corner and near the bottom of the picture is talus. Areas are marked off to correspond with figures showing details of the cross-bedding. The measured area near the center of the photograph can be used to approximate the scale of the inserts.

Throughout the areas around the sand mines discussed in this report, a blanket of loose surface sands covers the underlying red and yellow Citronelle sediments. The red and yellow zone follows the present topography. As streams are approached, the upper surface of the red and yellow sediments dips downward toward the streams. Such relationships strongly suggest a weathering phenomenon. Close examination of the red and yellow zone has disclosed flat-lying discoid quartzite pebbles with kaolin caps. The kaolin caps (figure 17) contain a higher percentage of clay than surrounding sediments, suggesting the possibility that clay has migrated downward within the sediments.

In summary, the field relationships indicate the possibility that clay has migrated downward into the red and yellow zone during post-depositional weathering leaving behind a blanket of loose surface sands (Sellards, 1912). The problem now arises as to whether the statistical figures are compatible with this concept. The conditions at the Diamond Interlachen sand mine can be selected for consideration and illustration.

From an examination of data in table 1 it is noted that the upper part of the red and yellow zone at the Diamond Interlachen

TABLE 5

Analyses of sediments from Crescent Beach, St. Johns County, Florida

Sample *	Median Diam.	Sorting (So)	Clay in % (-325M)	230 in %	120 in %	Heavies % on 230	Heavies total %
A: Foreshore area	.18	1.21	.96	8.20	90.00	.27	.21
B: Back slope oceanside	.18	1.21	0.00	4.00	95.02	3.16	.39
C: Back slope landside	.19	1.21	0.00	3.74	93.91	12.32	1.51
D: Sand dune area	.18	1.21	0.00	4.56	94.58	8.50	1.11
E: Big sand dune	.19	1.21	.05	4.14	92.84	15.67	1.63
F: Tidal area	.17	1.27	10.14†	10.41†	77.77	3.76	.94

* Sediments for these analyses were obtained from shallow channels cut at essentially right angles to the shore line. The channels were approximately 10 feet in length and 2 inches in depth.

† Contains much organic material.

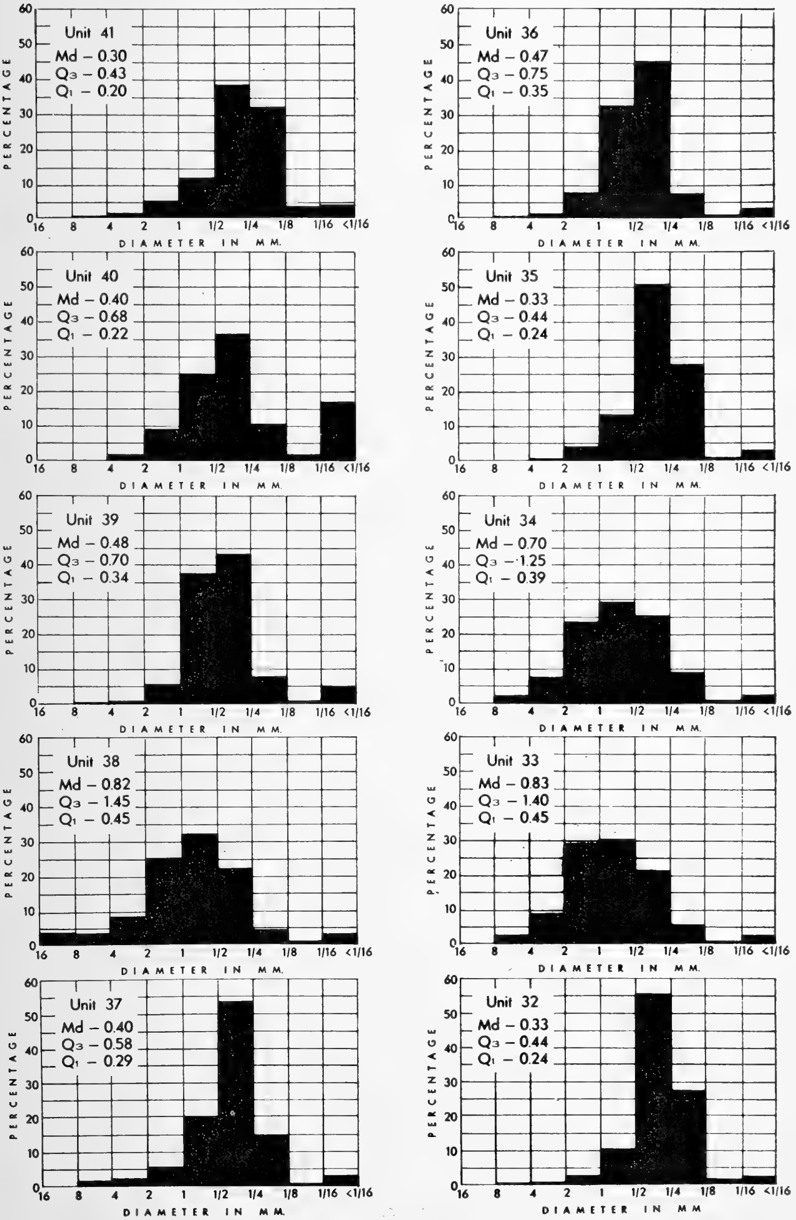

Fig. 9. Histograms of channel samples collected at the Grandin sand mine of the Davenport Sand Company. Units are labeled respectively on the

sand mine (units 28, 27, and 26) has a relatively high clay content. Even the coarse parts of the sediments are high in clay. Such occurrences represent a marked departure from the usual relationships of coarseness to clay content. The units are also low in mica. An examination of the 230 and 120 mesh fractions shows that these fine sediments make up only a small percentage of the units, and it should be expected that other fine material such as clay should not have been laid down as the sediments were accumulating. The data indicate the possibility of downward migration of clay into the beds after the sands of the beds were deposited. For contrast, the relatively high content of clay in units 10 and 8, when considered with the high content of 230 and 120 mesh sediments, suggests that the clay in those beds was laid down under an environment favorable to the accumulation of fine sediments. Also, fine mica is very high in these two units, again suggesting an environment favorable to the deposition of fine materials.

Likewise it should be noted that the sediments of the upper part of the red and yellow zone (units 28, 27, and 26) are relatively low in total heavy mineral content. This is a feature characteristic of coarse sediments, and coarse sediments of these Citronelle materials normally contain little clay. Thus the distribution of heavy minerals suggests that high percentages of fine sediments were not laid down while the materials were accumulating, and the clay subsequently migrated downward into the red and yellow zone.

It is clear that the statistical data considered are compatible with downward migration of clay during post-depositional weathering, to leave behind loose surface sands. However, definite conclusions should not be drawn until other possible explanations based on regional studies and comparisons can be considered and tested. For example, downward migration of clay into the sediments of the red and yellow zone could have taken place before the overlying sands were deposited. Likewise, the environment of deposition of the upper part of the Citronelle sediments may have been different from that of underlying Citronelle materials. According to one hypothesis the Citronelle sediments were laid down as part of a prograding delta that built southward into Florida. As that

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measured section. In sample of unit 38 analyses showed 0.75 per cent sediments of 8 to 16 mm size-grade and 2.29 per cent sediments of 16 to 32 mm size-grade. These two quantities were combined and listed on the histograms in the column for the 8 to 16 mm fraction.

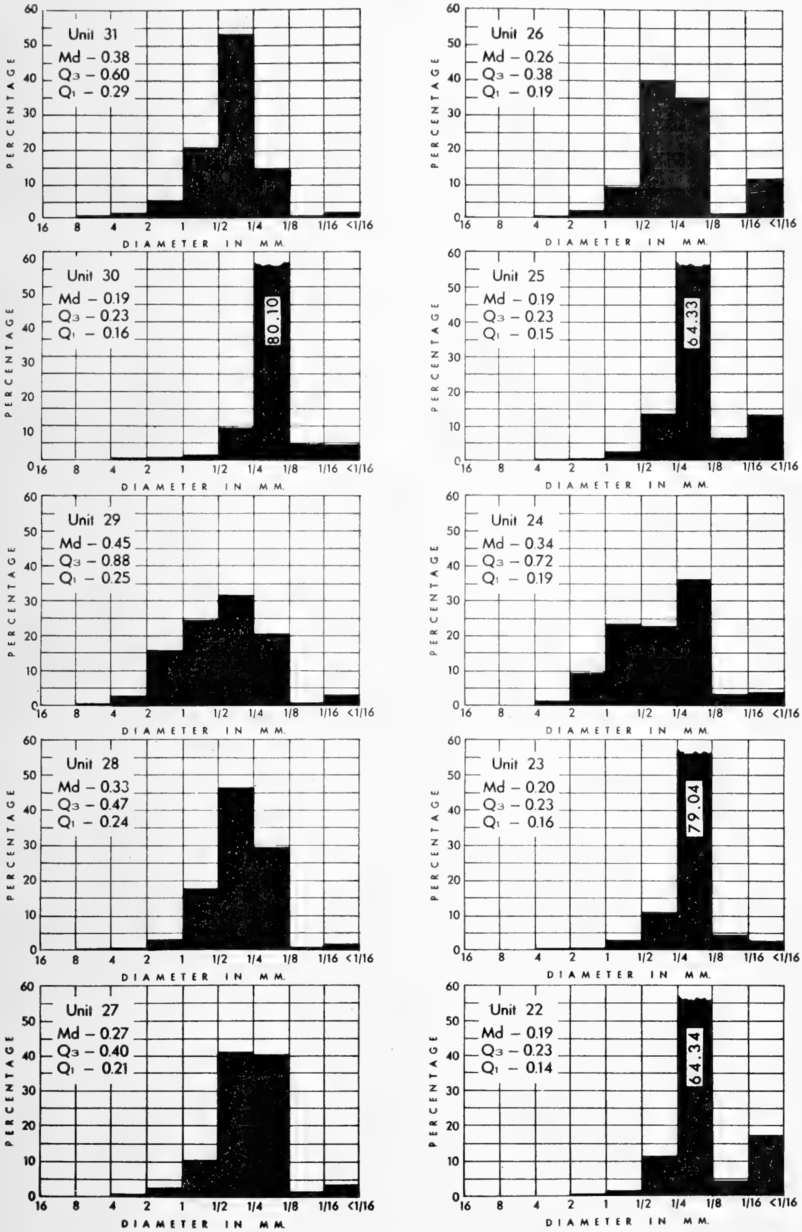

Fig. 10. Histograms of channel samples collected at the Grandin sand mine. Units correspond to those on the measured section.

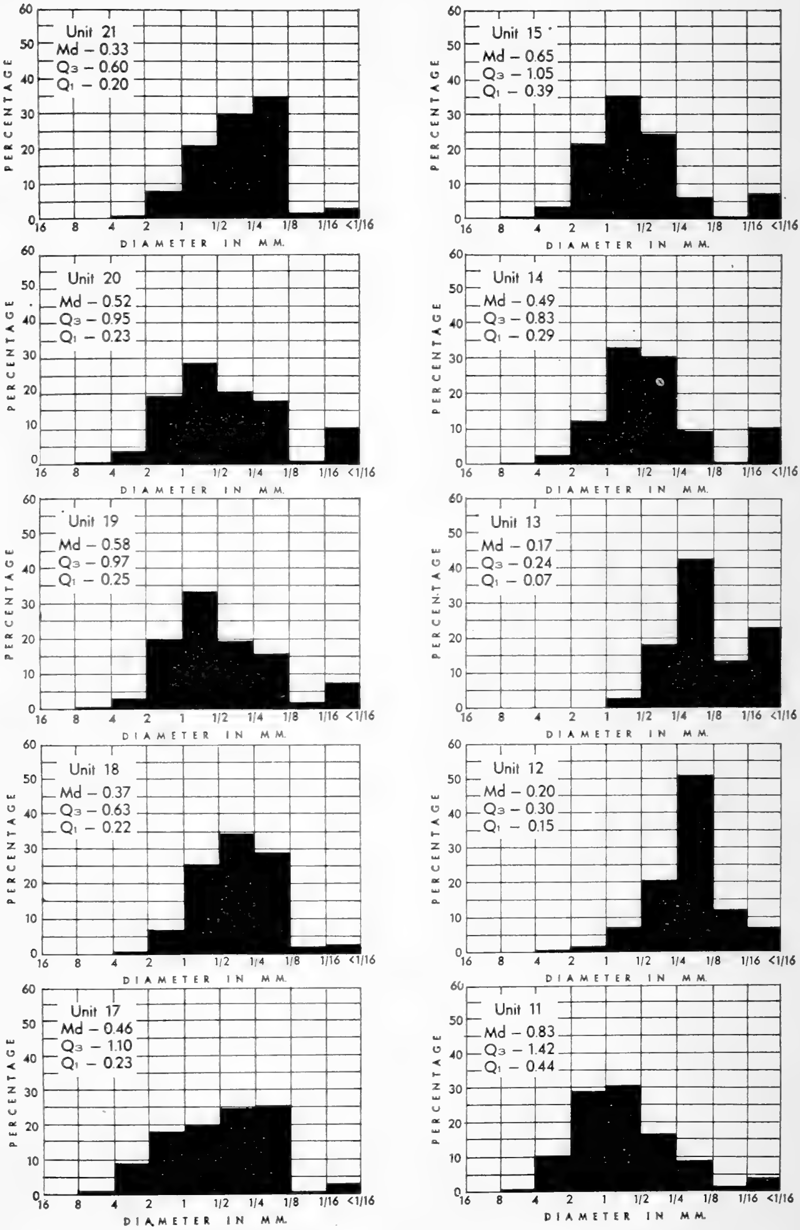

Fig. 11. Histograms of channel samples collected at the Grandin sand mine. Units correspond to those on the measured section. There is no histogram for unit 16. That unit was covered slope.

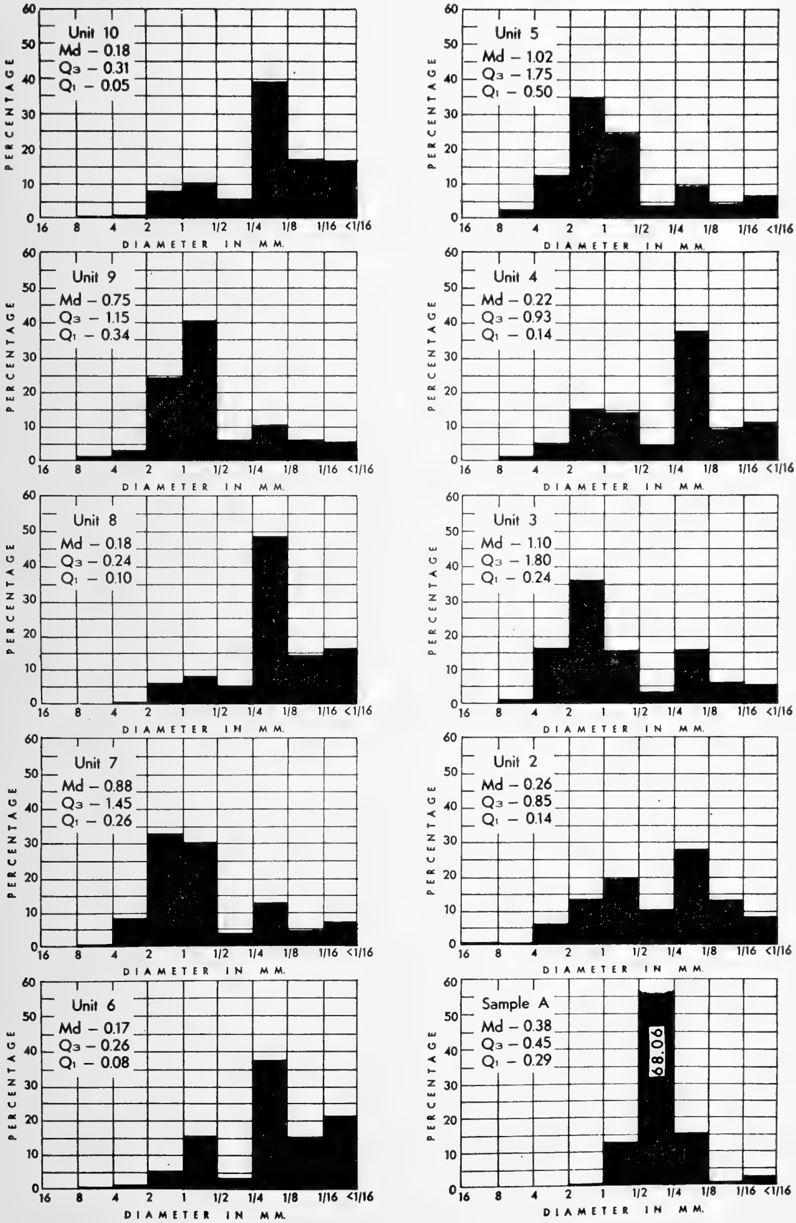

Fig. 12. Histograms of samples collected at Grandin sand mine. Units 10 through 2 are labeled respectively on the measured section. These histo-

delta developed, reduction in stream gradients would occur, with alluviation along streams and the formation of flood plains. Thus the higher parts of the Citronelle sediments may possibly represent materials deposited under environmental conditions conducive to the deposition of higher percentages of clay.

It is obvious that many types of comparisons, similar to the ones briefly discussed in regard to the possible downward migration of clay, could be drawn from these kinds of statistical data. To illustrate, the percentage of heavy minerals in the 230 mesh fraction as compared to the total percentage of heavies can be of much interest in the study of possible origins of the surface sands. This comparison is of especial interest when heavy mineral suites are analyzed and degrees of sorting considered. In all probability certain concepts can be eliminated with confidence as a result of such studies, and new hypotheses conceived and tested. Interpretations of data of these types have been utilized successfully in exploration work on mineral resources and in a number of other types of geological studies. As an example, consideration of statistical data was practiced in an exploration program conducted by Allen Edgar and E. C. Pirkle for sand and clay deposits. One of the results of this program was the recognition of an excellent deposit of glass sand of flint grade quality (both texturally and chemically) in the ground. Such a deposit is a rare find. This natural occurrence of flint grade glass sand is currently being mined near Plant City, Polk County, Florida by the Edgar Plastic Kaolin Company. Also, the largely buried outlier of the Lake Wales Ridge mentioned in a later part of this report was predicted from regional studies involving statistical analyses of surface sands. The outlier was later confirmed by borings and surface outcrops.

REGIONAL ASPECTS OF CITRONELLE SEDIMENTS IN PENINSULAR FLORIDA

Problems concerning regional aspects of the Citronelle formation are challenging. The importance of these materials cannot

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grams are of channel samples. The histogram labeled Sample A is of a spot sample collected about 60 feet east of the site of the measured section to show characteristics of a lens containing a relatively high percentage of heavy minerals. This lens, occurring approximately 20 feet beneath the land surface, has a maximum thickness of 1½ feet. Heavy minerals constitute 61 per cent of the 230 fraction and 5.02 per cent of the total sample. The sorting coefficient was calculated as 1.24.

be overemphasized when it is realized that the sediments make up the backbone of the Lake Wales Ridge, the most distinct topographic feature in central peninsular Florida. In parts of Lake, Polk, and Highlands counties the ridge runs in a nearly north-south direction (slightly northwest-southeast), in general paralleling the present coast lines and dividing the state into two nearly

Fig. 13. Details of cross-bedding at Grandin sand mine. Scour and fill structures are present in the sediments at this pit. A small amount of talus is present in lower left-hand corner of photo. For location of this cross-bedding, see insert of figure 8.

equal parts. Northward from the central part of Lake County the ridge does not exist as a distinct topographic feature, but remnants can be traced by exposures through the eastern part of Marion County, through Putnam County, and into Clay County as far north as Gold Head Branch State Park. Regardless of the final solution of the late Cenozoic history of the Florida peninsula, the part played by the Lake Wales Ridge, and thus by the Citronelle sediments, in controlling late Cenozoic sedimentation must have been significant. Such control can be illustrated by briefly discussing one of the current hypotheses.

The Citronelle sediments of the Lake Wales Ridge are believed to represent alluvial and other terrestrial materials deposited as a

Fig. 14. Cross-bedding at the Grandin mine. It is clearly seen that the laminations in these cross-bedded sets dip in different directions. In some places in the pit face borings filled with coarse sediments are present. See figure 8 for location of photograph.

prograding delta built southward into Florida (Bishop, 1956). Erosion by rainwash, streams and advancing Pleistocene seas has resulted in the destruction of a considerable part of the original delta. Nevertheless, the higher parts of the delta, containing a large proportion of terrestrial sediments, were not covered by the seas but have been left as a remnant ridge, the Lake Wales Ridge. Thus one of the problems concerning some geologists as to how alluvial sediments could be deposited down the center of Florida, paralleling in essence old Pleistocene shore lines and the present coast line, does not exist. To the contrary, the trend of the Pleistocene shore lines and the present shape of peninsular Florida were largely determined by the delta.

Fig. 15. Herringbone cross-bedding at the Grandin sand mine. Site of picture is indicated on figure 8.

Many large areas west of the Lake Wales Ridge correspond to a marine Pleistocene terrace with a shore line now present at an elevation of approximately 150 to 160 feet above sea level (MacNeil, 1950). In some localities these terrace sediments have been eroded and cut up to such an extent that recognition is difficult, or even impossible, but throughout other extensive regions the terrace is a clear topographic feature. As the 150 foot Pleistocene seas advanced, the older Citronelle deltaic sediments were covered in places and in other places eroded away. The thick sands in some large areas as in the central, northern, and northeastern parts of Alachua County represent these Pleistocene sediments with only minor contamination from the Citronelle deltaic sediments. Through other large regions, as for example in parts of Polk County, an important percentage of the 150 foot terrace deposits represents materials reworked from the Citronelle sediments as the seas encroached on the delta. Other large areas west of the Lake Wales Ridge correspond to lower and younger Pleistocene marine terraces or to areas of degradation including limestone plains originally developed at or near the ground water table.

An example of a remnant of the original deltaic materials, now essentially detached from the Lake Wales Ridge, covered and

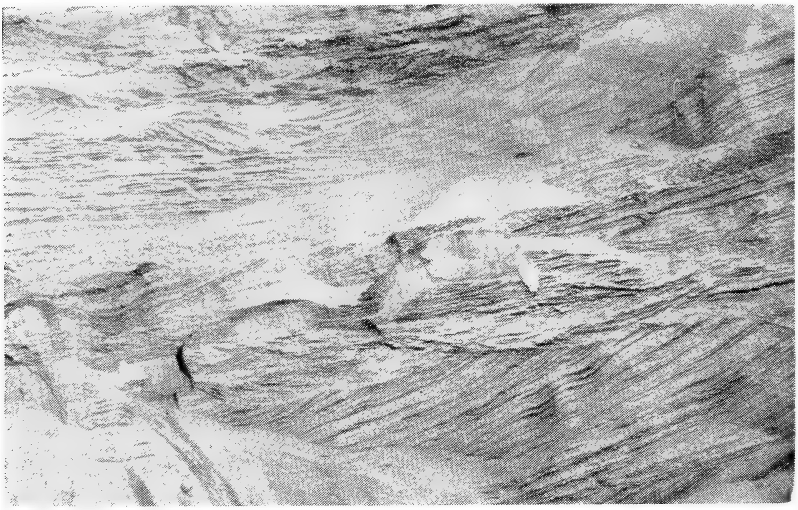

Fig. 16. Cross-bedding features at Grandin sand mine. Talus is present in the lower left-hand part and along the bottom of the photograph. Location is indicated on figure 8.

Fig. 17. Kaolin caps at the Diamond Interlachen sand mine. Small gravel and discoid quartzite pebbles are common. Close inspection (see arrows) shows that kaolin domes or caps are present on the upper surfaces of some of the flat lying quartzite pebbles. The results of mechanical analyses verify that these caps contain more clay than immediately adjacent sediments. This phenomenon suggests downward migration of clay within the sediments. The largest pebbles are from 1 to 1¾ inches in longest dimension. Photograph made at an angle to the vertical face to better display the caps.

largely concealed by Pleistocene terrace sediments, can be cited from Polk County. The elongation of this largely buried remnant in general parallels the Lake Wales Ridge, its axis passing along the eastern edge of the town of Lake Alfred.

The sediments of Trail Ridge (figure 1) are associated with the 150 foot Pleistocene terrace. In Clay and Bradford counties, the ridge rises conspicuously in elevation to heights of as much as 250 feet above sea level. In this area at least parts of Trail Ridge were built up on the western flank of the Lake Wales Ridge. Remnants of similar ridges, developed on the west side of the Lake Wales Ridge along the 150 foot shore line, are present in Lake and Polk counties.

Along the eastern side of the Lake Wales Ridge the 150 foot marine terrace sediments were largely eroded away by rainwash, streams, and by an advancing Pleistocene sea whose shore line today is present at an elevation of approximately 90 to 100 feet above sea level. Much of the land eastward from the Lake Wales Ridge corresponds to terrace deposits of this 90 to 100 foot Pleistocene sea or to a lower and younger marine terrace with a shore line now present at elevations of about 25 to 30 feet above sea level. The conspicuous ridge in northern Putnam County known as the Baywood Promontory probably represents a ridge built up along a shore line flanking the eastern side of the Lake Wales Ridge. The axis of the crest of the eroded Lake Wales Ridge occurs between Trail Ridge to the west and the Baywood Promontory to the east.

The loose surface sands that cover most parts of the Lake Wales Ridge have diverse origins. Some of the sand may be residual in place, resulting from the downward and lateral migration of clay during weathering of slightly clayey to clayey sands of the Citronelle Formation. Throughout other areas the sand is windblown. The Pleistocene beaches along the flanks of the Lake Wales Ridge undoubtedly furnished sand, some of which was blown along the shore lines to form dunes and ridges and some blown inland over the ridge. Throughout other regions marine Pleistocene sands were deposited over Citronelle sediments. Regardless of the type of original deposit, the sand has been reworked in many areas by rainwash, winds, and streams. Much of the reworked sediment has come to rest along streams, in lake basins and in other low places within the ridge area. However, in some localities sheet wash and streams have transported sediments from the ridge area onto adjacent regions flanking the ridge.

From the simple hypothesis herein described, which in final analysis must take into account the many evidences of both pre- and post-Hawthorne warpings, or from any of the other current hypotheses that could be given, it is obvious that the Lake Wales Ridge (and thus the Citronelle Formation) has been a dominant and controlling feature in the late Cenozoic history of the Florida peninsula. Likewise, the sediments composing the ridge have considerable economic significance, being the source for all of the pure white kaolin mined in the state and the source for most of the coarse, high grade silica sands produced.

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SUMMARY

This report describes in detail two sections of kaolinitic sediments of the Citronelle Formation from localities in Putnam County, Florida. At the site of these sections, cross-bedding is exceptionally prominent. Analyses disclose several interesting features of the Citronelle sediments. The coarser materials are generally more poorly sorted than the finer materials. The clay content usually is higher in the finer sands than in the coarser sands. In most cases, the percentage of heavy minerals is higher in the finer and in the better sorted sediments. Such relationships are of much value in testing hypotheses drawn from field observations and when applied to the immediate area of the pits described, indicate the plausibility of downward migration of clay into underlying sediments to leave behind loose surface sands.

According to one of the current hypotheses these Citronelle materials were laid down as part of a prograding delta that built southward into Florida. Much of the original delta has now been destroyed by the erosional work of rainwash, streams, and advancing Pleistocene seas. The Pleistocene seas did not cover all of the delta but left the highest parts, containing a large percentage of alluvial and other terrestrial sediments, as a remnant ridge, the Lake Wales Ridge. Thus to an important degree the trends of various Pleistocene shore lines and the shape of peninsular Florida were determined by the delta. Parts of Trail Ridge and the Baywood Promontory are believed to be ridges built along Pleistocene shore lines flanking the Lake Wales Ridge.

APPENDIX

In naming and describing the sediments in the following sections the terminology is that used by local sand and clay operators. In explaining this nomenclature Pirkle and Yoho (1961, pp. 252-253) state:

. . . When complete mechanical analyses are available, the following terminology, utilizing size divisions of Wentworth (1922), is used locally in describing the various combinations of sediments. The material is referred to as gravel (>4 mm), fine gravel (<4,>2 mm), sand (<2,>1/16 mm), silt (<1/16,>1/256 mm), or clay (<1/256 mm) according to which of these components constitutes more than 50 percent by weight of the bed or sample. Any material that makes up between 10 and 50 percent of the total bed is represented by the correct adjective form, and in naming the material this adjective precedes the term corresponding to the dominant component. The adjective forms are gravelly, fine gravelly, sandy, silty, and clayey. If a type of sediment constitutes more than 5 percent of the bed but less than 10 percent, the appropriate adjective is placed after the name referring to the dominant type of sediment and separated by a comma. If no component makes up as much as 50 percent of the sediments, the material is referred to as a mixture of the dominant constituents.

As an illustration of this system, the name "clayey sand, gravelly," would indicate that sand made up more than 50 percent of the material, clay more than 10 percent but less than 50 percent, and pebbles more than 5 percent but less than 10 percent with no other component constituting as much as 5 percent of the total sample. For producers of sand, gravel and clay such nomenclature lends itself readily to an understanding of various economic aspects of the deposits in addition to illustrating relative distributions of important constituents.

DIAMOND INTERLACHEN SAND MINE

Section 16, T. 10 S., R. 24 E., Putnam County, Florida

Unit	Description	Thickness (in feet & inches)	
29–	Loose surface sands. Fine to coarse, light yellow. Sample collected 200 feet west of site of measured section	5′	0″
28–	Clayey sand. Medium to coarse, red to orange. Casehardened	3′	5″
27–	Clayey sand, fine gravelly. Sand medium to very coarse, red to brown. Occurs as a small lens. Casehardened		11″
26–	Clayey sand. Medium to coarse, orange to brown. Casehardened		9″
25–	Sand, fine gravelly and gravelly. Sand medium to very coarse, orange to brown, locally banded white and red. Lower part of unit contains small lenses of whitish sand. Granules and small pebbles of quartz or quartzite occur in thin stringers and disseminated through the unit. Casehardened	8′	5″

24–	Sand, clayey. Sand medium to coarse, brown to orange. Occurs as a small lens. Casehardened		3″
23–	Sand. Fine to coarse, white with occasional orange bands ¼ inch thick. One orange band 2 inches thick near center of unit. Orange bands in this and underlying units usually follow bedding but in places cut across bedding. Sand becomes coarser toward base of unit and includes a few disseminated granules and pebbles of quartz or quartzite		10″
22–	Sand, clayey. Sand medium to very coarse, orange to brown. Disseminated granules and pebbles of quartz or quartzite. Occurs as a small lens. Casehardened		2″
21–	Sand. Fine to coarse, white with orange bands ⅛ inch thick, spaced ½ to 1 inch apart. Bedding appears essentially horizontal		7″
20–	Sand. Medium to very coarse, whitish. Horizontally bedded. Few feet to east of measured section upper 6 inches of unit is cut by sediments filling a channel scour. Sediments of scour filling are cross-bedded. Technique used in determining dip and strike of cross-laminations explained elsewhere (Pirkle and Yoho, 1961, p. 252). Cross-bedding reading made in scour sediments (greatest dip; 16 degrees to S. 15 E.)		8″
19–	Sand. Medium to coarse, whitish with orange bands ¼ inch thick, spaced 1 to 2 inches apart. Sediments appear to be one cross-bedded set with the cross-laminations dipping generally toward the southeast, cut off sharply at the top and tapering to an almost horizontal position toward the base of the unit. Granules and small pebbles of quartz or quartzite occur in thin stringers and especially near the base of the unit. The sediments of this and most other cross-bedded sets given in this section become coarser toward the base of the cross-bedded sets. Scattered discoid quartzite pebbles up to ¾ inch in longest dimension lie flat on cross-laminations, dipping the same degree as the cross-laminations. Cross-bedding reading (greatest dip; 22 degrees to S. 68 E.)	1′	3″

18–	Sand, fine gravelly. Sand medium to very coarse, whitish to tan. Occurs as a small lens. Essentially horizontal		3″
17–	Sand. Fine to coarse, white with orange bands ¼ inch thick and spaced ½ to 2 inches apart. Appears to be one complete cross-bedded set with cross-laminations dipping generally to the southeast. Cross-bedding reading (greatest dip; 20 degrees to S. 13 E.)	1′	0″
16–	Sand. Fine to coarse, white with orange bands ¼ inch thick, spaced from ¼ to 1 inch apart. Sediments appear to be one set of cross-bedding with laminae dipping toward the southeast. The cross-laminations become more horizontal and the sediments coarser with depth. Cross-bedding reading (greatest dip; 20 degrees to S. 14 E.)	1′	2″
15–	Sand. Fine to coarse, whitish with orange bands ⅛ to ½ inch thick, spaced from ½ to 2 inches apart. One complete set of cross-bedding with cross-laminations dipping generally toward the southeast. Capped in places by 10 inch zone characterized by scour type cross-bedding. Toward base of unit cross-laminations become more nearly horizontal and sediments are coarser containing disseminated granules and small pebbles of quartz or quartzite. Cross-bedding reading (greatest dip; 19 degrees to S. 79 E.)	2′	5″
14–	Sand. Fine to coarse, whitish with orange bands ¼ inch thick in upper part of unit. This interval actually consists of 4 complete cross-bedded sets, each set separated by thin lenses or stringers of coarse sand with included disseminated quartz granules. Locally scour type cross-bedding is present at top of the fore-set units. Going downward in the section the thicknesses of the individual cross-bedded sets are 9 inches, 14 inches, 13 inches, and 15 inches. Because of a failing face could not sample and treat each cross-bedded set separately. In the bottom set the cross-laminations are not clearly of the fore-set type. The direction of greatest dip of the dominant cross-laminations of the fore-set type is toward the southeast. However, for the small scour type cross-bedding the direction and amount of dip of cross-laminations vary		

according to the particular point at which the reading is made as illustrated by the following random readings.
Cross-bedding readings:
(First reading—greatest dip; 12 degrees to S. 75 W.)
(Second reading—greatest dip; 12 degrees to S. 60 W.)
(Third reading—greatest dip; 3 degrees to S. 75 E.)
(Fourth reading—greatest dip; 3 degrees to S. 50 W.) 4′ 3″

13– Sand. Fine to very coarse, whitish.
Noticeable granules of quartz disseminated through sand.
Occurs as a small, horizontal lens 4″

12– Sand. Fine to coarse, white.
Occasional stringers and small lenses of quartz granules and quartzite pepples, especially near top of unit.
Unit highly cross-bedded with considerable small scale scour type.
Cross-bedding readings:
(First reading—greatest dip; 16 degrees to S. 70 E.)
(Second reading—greatest dip; 9 degrees to S. 73 W.)
(Third reading—greatest dip; 10 degrees to S. 49 E.)
(Fourth reading—greatest dip; 8 degrees to N. 72 W.) 1′ 9″

11– Clayey sand. Fine to coarse, white with yellow bands ¼ inch thick and spaced from 1 to 2 inches apart.
Upper 3 inches well indurated, grading downward into loose to slightly consolidated coarser sands containing disseminated quartz granules and pebbles 11″

10– Clayey sand. Fine to medium, white with yellow bands ¼ inch thick and spaced from 1 to 5 inches apart.
Occasional stringers and small lenses containing noticeable granules and pebbles of quartz and quartzite.
Highly cross-bedded.
Cross-bedding reading (greatest dip; 19 degrees to S. 72 E.) 1′ 4″

9– Sand, clayey. Sand fine to very coarse, white.
Suggestions of faint cross-bedding.
Occasional stringers of coarser sediments with included quartz and quartzite granules and pebbles.
Locally sediments of this unit thicken, cutting down into underlying unit as if filling shallow channels.
Occurs as a small, nearly horizontal lens 5″

8– Clayey sand. Fine to medium, white with yellow bands ¼ inch thick, spaced from 1 to 4 inches apart throughout unit.
Highly cross-bedded.

	Scattered pod-like lenses of coarse sediments with included quartz or quartzite granules and pebbles. Cross-bedding reading (greatest dip; 11 degrees to S. 16 E.)	3′	1″
7–	Sand. Medium to very coarse, white. No visible bedding. Loose and free-falling. Occasional discoid quartzite pebbles with lengths up to 2 inches. Occurs as a small lens		10″
6–	Sand. Medium to coarse, whitish with slight yellow banding		8″
5–	Sand. Medium to very coarse, white. Noticeable quartz or quartzite granules and small pebbles disseminated through unit. Occasional stringers of fine sediments with higher clay content		10″
4–	Clayey sand. Fine to very coarse, white. Occurs as a small lens		3″
3–	Sand. Fine to very coarse, white, cut by occasional faint yellow bands ¼ to 1 inch thick. Slight cross-bedding visible. A few quartz or quartzite granules and pebbles disseminated through unit. Cross-bedding reading (greatest dip; 14 degrees to N. 70 E.)	1′	2″
2–	Sand. Fine to coarse, with occasional light yellow bands ⅛ to ¼ inch thick. Scour type cross-bedding faintly visible but could not measure amount or direction of dip		10″
1–	Covered zone. To lake level	24′	0″
	Total depth to lake	67′	9″

GRANDIN SAND MINE

Section 8, T. 9 S., R. 24 E., Putnam County, Florida

Unit	Description	Thickness (in feet & inches)	
41–	Loose surface sands. Fine to coarse, light yellow to tan. Noticeable quartz granules disseminated through sediments	3′	1″
40–	Clayey sand. Fine to coarse, red, orange and maroon. Bedding features obscured by weathering. Casehardened	6′	9″
39–	Sand. Medium to coarse, orange to brown to ochre, locally whitish with maroon to orange bands ranging in thickness from a fraction of an inch to 2 inches and spaced approximately 2 inches apart. Sediments appear to be horizontally laminated	7′	6″
38–	Sand, fine gravelly and gravelly. Sand medium to very coarse, whitish with orange bands from ½ to 1½ inches thick and spaced from 1 to 5 inches apart. Bedding laminations appear to be essentially horizontal	4′	8″
37–	Sand. Fine to coarse, white with orange mottling and slight banding. Disseminated granules and small pebbles of quartzite. This unit is the topmost unit of the highly cross-bedded group. Could not read accurately the direction of greatest dip of the cross-bedding where section was measured because of nature of exposure. However, direction of greatest dip is in general toward the southeast	2′	0″
36–	Sand. Medium to coarse, white with orange bands ¼ to ½ inch thick, spaced from ½ to 1½ inches apart. Noticeable quartz granules and small pebbles of quartzite disseminated through unit and concentrated in thin stringers and small lenses. Unit is highly cross-bedded with two dominant cross-bedded sets, one with cross-laminations dipping to the southeast and the other with cross-laminations dipping to the southwest. Cross-bedding readings: (First reading—greatest dip; 14 degrees to S. 38 W.) (Second reading—greatest dip; 11 degrees to S. 57 E.)	2′	10″

35– Sand. Fine to coarse, whitish with orange bands about ¼ to ½ inch thick. These bands are spaced from 1 to 4 inches apart toward top of bed. In lower 7 inches of unit there are noticeable quartz granules, sand is coarser and orange bands are more closely spaced, being about ½ inch apart.

Where section was measured (and samples collected) unit appears to be horizontally bedded. However, these materials grade laterally into highly cross-bedded sediments. The following reading was made about 10 feet northeast from the site of the measured section where cross-bedding in this unit is pronounced.

Cross-bedding reading (greatest dip; 12 degrees to S. 52 E.) .... 1′ 8″

34– Sand, fine gravelly. Sand medium to very coarse, whitish to gray with orange bands ½ inch thick, spaced 1 to 3 inches apart.

Unit consists of 2 cross-bedded sets, a minor upper set and a major lower set. Cross-laminations in both these sets dip to southeast.

Occasional discoid quartzite pebbles with lengths up to 1½ inches occur disseminated through the unit.

Cross-bedding readings:

(First reading, upper minor set—greatest dip; 12 degrees to N. 66 E.)

(Second reading, lower major set—greatest dip; 20 degrees to N. 64 E.) .... 1′ 10″

33– Sand, fine gravelly. Sand medium to very coarse, grayish white with orange bands ¼ to ½ inch thick. Bands spaced ¼ to 3 inches apart.

Unit consists of one complete set of cross-bedding with cross-laminations dipping to southeast.

Occasional discoid quartzite pebbles with lengths up to ¾ of an inch.

Cross-bedding reading (greatest dip; 18 degrees to S. 72 E.) .... 1′ 0″

32– Sand. Fine to coarse, whitish with orange bands ¼ inch thick, spaced ½ to 1½ inches apart. Bands not only follow cross-bedding laminae but also follow fractures that cut across laminations at varying angles.

Unit highly cross-bedded.

Cross-bedding reading (greatest dip; 12 degrees to S. 59 E.) .... 11″

31– Sand. Fine to coarse, whitish, slightly mottled orange.

Unit is one cross-bedded set with cross-laminations dipping to southeast.

	Cross-bedding reading (greatest dip; 28 degrees to S. 19 E.)		6″
30–	Sand. Fine, white. Disseminated through unit are rather hard, slightly yellowish "concretions" consisting of fine quartz sand cemented with clay. Most of unit shows no distinct bedding but locally sediments become slightly coarser and cross-bedding can be detected. Cross-bedding reading (greatest dip; 13 degrees to S. 17 W.)	1′	7″
29–	Sand. Fine to very coarse, white. Unit shows cross-bedding but because of nature of exposure direction of greatest dip of cross-laminations could not be determined with confidence		8″
28–	Sand. Fine to coarse, white. One inch gravel zone at base of unit. This gravel was not included in the channel sample of this unit		10″
27–	Sand. Fine to coarse, whitish with orange bands from ⅛ to ½ inch thick and spaced from ¼ to 3 inches apart. Unit consists of numerous cross-bedded sets. Laminations of most sets dip toward the southeast. However, about 12 feet to southeast this unit doubles in thickness, and there the cross-laminations of most sets dip to the southwest. Readings were made in 3 different sets of cross-laminations cut by the channel sample. (First reading—greatest dip; 9 degrees to S. 81 E.) (Second reading—greatest dip; 8 degrees to S. 8 E.) (Third reading—greatest dip; 22 degrees to S. 52 E.)	1′	10″
26–	Clayey sand. Fine to medium, gray to orange with occasional dark orange and maroon bands. No definite cross-bedding. Occurs as a horizontal lens. To the northwest this unit is separated from the underlying unit 25 by a small cross-bedded lens in which cross-laminations dip to the southeast. This unit together with unit 25 forms a slight ledge separating highly cross-bedded sediments		7″
25–	Clayey sand. Fine to medium, white. Occurs as a slight ledge. In a few places where sediments are coarser, cross-bedding is visible. Cross-bedding reading (greatest dip; 17 degrees to N. 79 W.)		5″

24– Sand. Fine to coarse, white with numerous orange bands. Orange bands are ¼ to ⅛ inch thick and are spaced from ¼ to ½ inch apart. Lower 14 inches of the bed consists of coarser sediments and is more highly banded.

Unit is highly cross-bedded with cross-laminations in some sets dipping to the southeast and in other sets dipping toward the southwest. The predominant cross-bedding direction is to the southwest. Within this unit the sediments dipping to the southwest are noticeably coarser.

Cross-bedding readings:

(First reading—greatest dip; 7 degrees to S. 85 W.)
(Second reading—greatest dip; 7 degrees to S. 7 E.) 1′ 8″

23– Sand. Fine to medium, white, loose and free falling.

At site of measured section no cross-bedding visible but sediments of this unit thicken to southeast grading into materials characterized by scour or rippled type cross-bedding. Cross-laminations dip to the southwest.

Stringers of black heavy minerals are present near base of sand lens.

A few feet to the southeast of the site of the measured section readings were made in 2 different cross-bedded sets.

(First reading—greatest dip; 15 degrees to S. 69 W.)
(Second reading—greatest dip; 19 degrees to S. 26 W.) 3″

22– Clayey sand. Fine to medium, orange grading downward into light tan.

Occurs as a slight horizontal ledge separating major cross-bedded units.

At a few places where sediments are coarser, cross-bedding is faintly visible with cross-laminations dipping to the southeast .... 4″

21– Sand. Fine to coarse, white with orange bands ¼ inch thick and spaced ¼ to ½ inch apart.

Unit shows beautifully developed herringbone cross-bedded structure. The cross-laminations of the upper half of herringbone structure dip to the southwest; those of the lower half dip to the southeast. Small scour type cross-bedding is present at top of unit. Only a few feet from the site of the measured section a minimum of four scour sets of cross-bedding are present within this unit.

Cross-bedding readings:

(First reading—Cross-laminations of upper part of herringbone structure—greatest dip; 9 degrees to S. 70 W.)

(Second reading—taken in cross-laminations of lower part of herringbone structure directly beneath first reading—greatest dip; 10 degrees to S. 44 E.)

(Third reading—taken in a scour set a few feet to northeast of measured section—greatest dip; 19 degrees to N. 52 W.) .... 11″

20– Sand, clayey. Sand fine to very coarse, tan to brown, partly lithified.

Occurs as a slight ledge, horizontal.

Such lithified lenses (units 26, 25, and 22) separate units of highly cross-bedded sediments throughout the middle cross-bedded part of the exposure. This is the lowermost of these slight ledges.

Where sediments of this unit are coarser, cross-bedding is visible. In these types of partly lithified units the grain size usually is small, and cross-bedding can not be detected .... 5″

19– Sand, clayey. Sand fine to very coarse, whitish to gray with orange banding .... 6″

18– Sand. Fine to coarse, whitish.

Major part of unit appears horizontal and is thinly laminated.

Upper 3½ inches of unit characterized by small scour type cross-bedding.

At one place fore-set appearing laminations are present in unit. A reading was made in these cross-laminations.

Cross-bedding reading (greatest dip; 24 degrees to S. 30 E.) .... 1′ 3″

17– Sand, fine gravelly. Sand fine to very coarse, upper part of unit white with orange bands ⅛ to ¼ inch thick, spaced from ¼ to 1 inch apart; lower part of unit is orange.

In lower 6½ inches of unit grain size increases with a relatively high content of quartz granules and noticeable small pebbles of quartzite. From lower coarser zone upward for 14½ inches sediments are characterized by scour type cross-bedding with all of the cross-laminations dipping toward the southeast. Upper 9 inches of bed shows rippled or small scale scour cross-bedding with cross-laminations dipping in various directions.

A horizontal stringer of small quartzite pebbles separates the sediments of the upper 9 inch zone of rippled bedding from the underlying 14½ inch zone of scour type cross-bedded materials.

	Cross-bedding readings: (First reading—from upper 9 inch rippled zone—greatest dip; 12 degrees to S. 4 W.) (Second reading—cross-laminations in middle 14½ inch zone—greatest dip; 26 degrees to S. 17 E.)	2′	6″
16–	Covered slope. This is really a rippled or scour type cross-bedded unit. It is the lowermost such unit in the exposure, thus marking the beginning of the scour type cross-bedded group of sediments that continue upward for approximately 24 feet (through unit 37). Unit was not sampled because of probable slumpage	2′	7″
15–	Sand, clayey. Sand medium to very coarse, white to gray in upper 24 inches, mottled and banded yellow in lower 9 inches	2′	9″
14–	Sand, clayey. Sand medium to very coarse, tan to orange to brown. Noticeable quartz granules disseminated through bed. Unit is one set of fore-set cross-laminations. This is the lowest clearly visible cross-bedding noted in the face of the pit where section was measured. Occurs above a thin clay seam at top of unit 13. Cross-bedding reading (greatest dip; 24 degrees to S. 5 E.)	1′	4″
13–	Clayey sand. Very fine to medium, whitish. Bounded on top and bottom by thin seams of almost pure white clay approximately ⅛ to ¼ inch thick. The sample collected from this unit includes the seams of clay		2″
12–	Sand, clayey. Sand very fine to medium, white. Occurs as a small, thin lens		1″
11–	Fine gravelly sand. Medium to very coarse, orange. Occurs as a small lens		2″
10–	Clayey sand. Very fine, fine and coarse, whitish to gray with occasional orange bands and orange mottling. Noticeable quartz granules disseminated through unit. A few intercalated stringers and small lenses of fine white sand	3′	1″
9–	Sand, clayey. Sand fine, coarse and very coarse, whitish to tan. Noticeable granules and small pebbles of quartz or quartzite. Occurs as a small lens		2″

8–	Clayey sand. Very fine to fine, whitish to grayish, some slight yellow mottling	1′	2″
7–	Sand, fine gravelly and clayey. Sand fine, coarse and very coarse, whitish toward top, orange at base. Occurs as a small lens		9″
6–	Clayey sand. Very fine, fine and coarse, whitish to orange. Noticeable quartz granules. Occurs as a small lens		2″
5–	Fine gravelly sand, clayey. Sand coarse to very coarse, brown to orange. Noticeable small pebbles of quartzite	1′	0″
4–	Clayey sand, fine gravelly. Sand fine, coarse and very coarse, whitish with orange bands ¼ inch thick. In bottom 2 inches of lens sediments are much coarser; toward top of lens clay is more abundant		5″
3–	Fine gravelly sand. Fine, coarse and very coarse, white to slightly orange. A few discoid quartzite pebbles disseminated through lens		3″
2–	Sand, clayey and fine gravelly. Sand very fine to very coarse, white, slight development of orange banding	1′	7″
1–	Covered slope to lake level	2′	9″
	To lake level	64′	11″

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A NEW PLEISTOCENE *PLATYLEPAS* FROM FLORIDA

ARNOLD ROSS

ASIDE from scattered references in the literature to Tertiary and Pleistocene barnacles, all too generally cited as *Balanus* sp., no attempt has yet been made to determine the exact nature of the fossil barnacle fauna of Florida as a whole or its many constituents. It is hoped that this and subsequent studies will serve to fill the existing void in our knowledge of the fossil Cirripedia of Florida.

During the latter part of 1962 a small number of Neogene turtle-barnacles (*Platylepas* and *Chelonibia*) was borrowed from the U. S. Geological Survey collections. This material was supplemented with specimens from the Florida State Museum collections at the University of Florida and by a small collection of *Chelonibia* received from Dr. William K. Emerson of the American Museum of Natural History, New York. The present paper is the first in a series of papers on the fossil turtle-barnacles of Florida.

Only one species of *Platylepas* was in the collections assembled. Inasmuch as this was represented by a single parietal plate of a heretofore undescribed species, the author revisited the collecting area during February 1963 in an unsuccessful attempt to find additional material. At the time a small but representative collection of macro- and microscopic invertebrates was made (Ross, 1963). These specimens are deposited in the Florida State Museum collections at the University of Florida (accession number 383).

TYPE LOCALITY

The platylepad was collected from the spoil banks adjacent to Rim Ditch Canal (U. S. Geological Survey Cenozoic locality 22805), St. Lucie County, Florida (Fort Pierce S.W. Quadrangle). The site is located in the NE ¼ Sec. 29, T. 36 S., R. 39 E., on the northeast side of the canal, approximately 500 yards northeast of the Florida East Coast Railroad (see fig. 1) and about 2 miles southeast of the intersection, at bridge 27, of Shinn Road and Rim Ditch Canal. Shinn Road crosses U. S. Highway 70 about 11 miles southwest of Fort Pierce, St. Lucie County. The intersection of Shinn Road and Rim Ditch Canal is approximately 3.1 miles south of the intersection of U. S. Highway 70 and Shinn Road.

Fig. 1. View of Rim Ditch Canal looking southeast toward the Florida East Coast Railroad bridge.

A brief geological and paleoecological discussion of the late Pleistocene, Sangamon interglacial, deposits of this area is given in Ross (1936). The molluscan fauna occurring along the spoil banks consists of a mixture of four distinct ecological types, marine, brackish, fresh-water, and terrestrial. On recent analogues the mixed fauna indicates successive stages, from marine to terrestrial (probably in response to sea level and climatic fluctuations), in the evolutionary history of what is believed to have been initially a marine lagoonal environment.

Order THORACICA Darwin, 1854

Family **Balanidae** Gray, 1825

Subfamily Coronulinae Leach, 1825

Genus *Platylepas* Gray, 1825

Platylepas Gray, 1825, Ann. Philos., new ser., vol. 10, p. 105, for *P*[*latylepas*] *pulchra* Gray and "*C*[*helonibia*] *bisexloba* [*sic*] Ranz." [not of Ranzani, 1818, 1820]. Type species, *Platylepas pulchra* [=*Platylepas hexastylos* (Fabricius), 1798], by subsequent designation of Pilsbry, 1916, p. 284.

Coronula: de Blainville, 1825, in part, Manuel de malacologie et de conchyliologie, p. 599-601, for *Coronula bisexlobata* de Blainville, *C[oronula] testudinaria* (Linnaeus), *C[oronula] balanarum* [*sic*] (Spengler), *C[oronula] diadema* (Linnaeus), and *C[oronula] tubicinella* (Lamarck) [reference to *Coronula bisexlobata* only].

Columellina Bivona-Bernardi, 1832, Effermeridi Sci. Lett. Sicilia, p. 14. Type species, *Columellina bi-sexlobata* (de Blainville) [= *Platylepas hexastylos* (Fabricius), 1798], by original monotypy and subsequent designation of Pilsbry, 1916, p. 284.

Coronula: Philippi, 1836, in part, Enumeratio molluscorum Siciliae . . . , p. 252, for *Coronula bissexlobata* [*sic*] de Blainville [reference to species only].

Coronula: Chenu, 1843, in part, Illustrations Conchyliologiques, unpaginated, pt. 3, pl. 2, pts. 18-19, pl. 1, for *Coronula sulcata* Chenu, *Coronula diadema* (Linnaeus), *Coronula balaenaris* [*sic*] (Spengler), *Coronula testitudinaria* [*sic*] (Linnaeus) and *Coronula californiensis* Chenu [reference to *Coronula sulcata* and *Coronula californiensis* only].

Culumellina (error for *Columellina* Bivona-Bernardi, 1832): Krüger, 1911, Abh. Bayer. Akad. Wiss., Math.-Phys. Kl., vol. 2, suppl. 6, p. 59.

U[latylepas] (error for *Platylepas* Gray, 1825): Pilsbry, 1916, Bull. U. S. Nat. Mus., no. 93, p. 286.

Definition. Small, slightly asymmetrical, hexamerous, conic barnacles, with the base usually decidedly larger than the orifice. Parietal "tubes" are either present or the walls are solid. Each compartment is generally bilobate and inwardly produced, thus forming an internal median rib; in addition there may be secondary or tertiary ribs or riblets or both. The basal and inner edges of the parietes and internal ribs are sharply denticulate or smooth. The basis is membraneous. The opercular valves are simple, and approximately of the same size and shape.

Distribution and Habitat. RECENT: Sicily, Corsica, Baluchistan, Malay Peninsula, Japan, Borneo, Timor Sea, New Caledonia, Australia, Marutéa Atoll (Tuamotu Archipelago), Honduras, United States, and Gambia. PLEISTOCENE: United States (Florida).

Platylepas occurs in tropical and warm-temperate seas (between 45° N. and 45° S. latitude) on turtles (*Caretta, Chelonia, Thalassochelys*), sea snakes (*Enhydris, Distira*), fishes (*Hydrophis, Lepisosteus*), and manatees (*Trichechus*). At the present time there is no information available to indicate any preferential site of attachment on the host.

Remarks. The platylepads are one of the more poorly known barnacle groups owing to their small size and unusual occurrence. Only three species were known to Darwin (1854), *P. bisexlobata*

[= *P. hexastylos*] from the Mediterranean Sea and *P. decorata* from the Galapagos Archipelago; the third species, a juvenile from Borneo, has never been named. Lanchester (1902) described the fourth species referred to this genus, *P. ophiophilus* from the Malay Peninsula. *Cryptolepas ophiophilus* [= *Platylepas krugeri;* see Pilsbry, 1916], the fifth species, was described by Krüger (1912) from Thailand. Pilsbry (1916) described a new "variety", *P. hexastylos ichthyophila* from Florida, which was the last species assigned to this genus. Until the present time no fossil species of *Platylepas* have been described.

The type specimen of this genus was presumed, by Pilsbry (1916), to have been lost. At the author's request Dr. Torben Wolff kindly searched the collections of the Universitetets Zoologiske Museum, København, only to discover " . . . that the type of *Platylepas hexastylos* is definitely not to be found in this museum anymore" (letter of January 30, 1963). Designation of a neotype, which is beyond the scope of the present study, is now being undertaken by the author.

Platylepas wilsoni, new species

Figs. 2-3

Diagnosis. The compartment is quadrilobate and ornamented with strong regular or bifurcating longitudinal ribs and imbricating growth ridges, thus presenting a shingled appearance. Internally there is one primary rib, two secondary ribs, and two tertiary riblets. The radius is a hollow tube closed at the apex but open at the base.

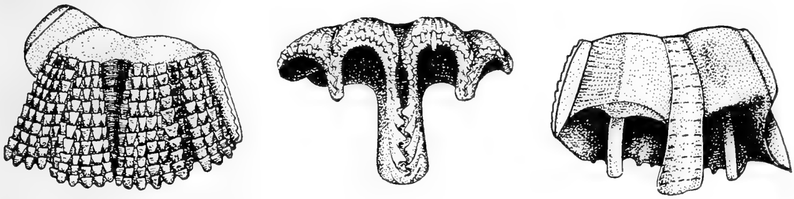

Fig. 2. *Platylepas wilsoni,* n. sp. Drawing of external, basal and internal views of holotype compartment (actual width, 3.7 mm.).

Description. This new species is represented by a right lateral or carinolateral compartment. The external surface of the compartment is divided into four lobes. There are a deep primary sulcus and two shallower sulci all of which are, more or less, equidistantly spaced. The shell sculpture consists of pronounced longitudinal ribs and imbricating growth ridges, giving a somewhat shingled appearance. Each shingle is in the form of a square-bottomed V. Midway between the base and the apex of the compartment one or two of the ribs of each lobe bifurcate. Hence, near the apex there are three or four ribs, but at the base there may be four to seven ribs. The outer lamina appears vitreous, through which can be seen a dense, white, presumably calcitic material which is in the form of a Y or V. There is one such figure for every shingle. Fusion of adjoining corners of the shingles produces at several points on the external surface of the plate either deep or shallow pits, depending upon the depth of the intercostal grooves.

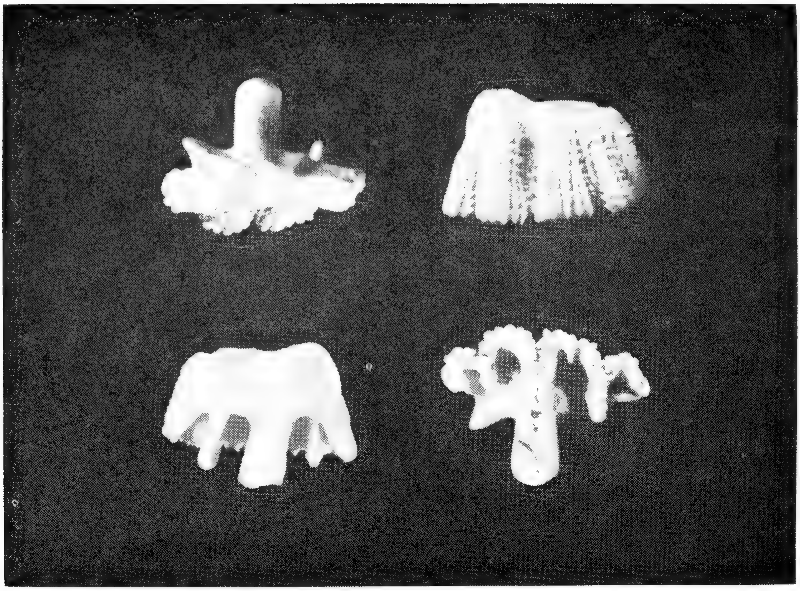

Fig. 3. *Platylepas wilsoni,* n. sp. (Top) apical, external, (bottom) internal and basal views of holotype compartment (actual width, 3.7 mm.).

The radius is narrow and of a uniform width from the apex to the base. Its external surface is rugose and lacks distinct vertical or transverse striae. The radius is hollow, being merely a tube open only at the base. The sutural edge of the radius is broad and tapers slightly, from the apex to the base. The denticulation is simple, occupying less than one-half of the outer sutural face. Some of the uppermost denticles are bifid. The interdenticular areas open into the hollow behind the outer radial surface. From the external surface of the compartment the sutural denticulations would presumably appear as simply a row of pores if the other parietal plates were present and joined. The sutural edge of the ala is smooth.

The sheath is approximately one-half the height of the compartment. The upper one-half of the medial rib forms a slight convexity on the sheath surface, which appears smooth, except on this longitudinal ridge. Here, under oblique reflected light the sheath surface is seen to bear a few moderately broad, evenly rounded, parallel growth ridges. These horizontal ridges also extend down the face of the medial rib.

The infolding of the wall is reflected internally by three strong ribs, one primary and two secondary. On each side of the midrib there is a hollow behind the depending basal margin of the sheath. Tertiary riblets, one on each side of the midrib, extend upward but do not enter into these shallow hollows. The external ribs cross the basal margin of the compartment and extend a very short distance, internally, towards the apex, thus presenting a serrate basal margin.

The strong sculpture on the basal margin of the primary and secondary ribs is probably formed by the modification of the ribbed external shell sculpture, i.e., presumably as the wall folds inward the external ribs meet and interlock in such a manner as to produce the basal ridges. Total fusion of the walls comprising the medial rib is complete only at the distal end of the rib whereas the secondary ribs exhibit complete fusion. There are no parietal "tubes".

Measurements of the holotype are as follows: height of compartment, 2.5 mm.; width of compartment, 3.7 mm.; depth of compartment (measured from outer lamina to tip of internal rib), 2.7 mm.

This new species may be easily distinguished from all of the presently known platylepads by the quadrilobate parietes, the shingled external ornamentation, and the hollow radius. *Platylepas ophiophilus* and *P. hexastylos ichthyophila* have, respectively, three to four and four to five secondary ribs on each side of the internal medial rib and thus differ from *P. wilsoni* n. sp., which has one secondary rib and one tertiary riblet on each side of the median rib. *Platylepas krugeri* has only a medial rib, which serves to distinguish it from this new species. *Platylepas hexastylos hexastylos* possesses parietal "tubes," whereas *P. decorata, P. wilsoni* n. sp., and the above mentioned species do not. *Platylepas decorata* is the only species that has a medial rib with a smooth basal margin. All of the Recent species of *Platylepas,* with the exception of *P. wilsoni* n. sp., have bilobate parietes. It should be noted here that each of the known species has a distinct external ornamentation, which apparently is species-specific.

Type Depository. The holotype of *Platylepas wilsoni* n. sp. is deposited in the collections of the U. S. National Museum, Washington, D. C., catalogue number 648508.

Etymology. It is a great pleasure to name this species in honor of Druid Wilson, U. S. Geological Survey, who has often emphasized the need for a systematic study of the Atlantic Coastal Plain fossil barnacles, and who kindly loaned this and other specimens he collected to the author for study.

ASSOCIATED CIRRIPEDIA

Three other balanomorph cirripeds were found associated with *P. wilsoni* n. sp. in the Rim Ditch Canal fauna, one of which also appears to be a new species. *Chelonibia testudinaria* (Linnaeus), here reported for the first time in the Florida Pleistocene fauna, exhibits no morphological variations from Recent specimens. The specimen, a right lateral compartment measures 8.7 mm. in width, 4.1 mm. in height, and 4.4 mm. in depth. Large numbers of *Balanus niveus* Darwin were also collected. The scuta of at least two specimens have faint traces of longitudinal striae. No other morphological differences were noted in the specimens of this species examined.

ACKNOWLEDGMENTS

The author is indebted to Druid Wilson of the U. S. Geological Survey for permission to study the turtle-barnacles contained in the Survey collections. Dr. Torben Wolff, Universitetets Zoologiske Museum, København, kindly provided information on the type species of *Platylepas.* The author is also indebted to Dr. William

K. Emerson, the American Museum of Natural History for several photocopied references from journals deposited in the American Museum Library. Drs. Pierce Brodkorb and H. K. Brooks, University of Florida, rendered many courtesies during the course of this study. The drawings, fig. 2, are the fine work of Mr. Anthony D'Attilio of the New York Shell Club. Expenses incurred during the preparation of the present paper were borne by the author.

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MIOCENE BIRDS FROM THE HAWTHORNE FORMATION

Pierce Brodkorb

Only a single bird, *Palaeochenoides mioceanus* Shufeldt (1916) from the Hawthorne Formation in South Carolina, is presently known from marine beds of early Miocene age in eastern North America. In the present paper four additional species are described from the Hawthorne beds in Gainesville and Tallahassee, Florida. They are of interest not only as adding to our knowledge of the early Miocene avifauna but especially as they afford evidence that the Hawthorne Formation belongs in the Lower Miocene and permit its correlation with the rich land vertebrate fauna of the Thomas Farm in northern Florida, with the Arikareean provincial age in the interior of western North America, and with the Aquitanian stage in Europe.

In naming these beds Dall (1892) used the spelling Hawthorne, after the town in Alachua County, Florida. Following usage by the Post Office Department, the spelling was emended to Hawthorn (Cooke and Mossom, 1929; Wilmarth, 1957). Nevertheless, in a letter dated August 23, 1956, Hon. Sidney Martin informs me that the original settlement was known as Graball, later as Waets Crossing, and then changed to Hawthorne after its founder, Sam Hawthorne. The city has always used the spelling with the final *e*. At the request of Mayor Martin in 1948, Representative Harry E. Bennett obtained passage through Congress of a bill requiring the post office to adopt the spelling Hawthorne. In view of these considerations it is apparent that the formational name should likewise revert to the original and official spelling in use by the city, the post office, and the state road department.

Much of the field work during this study was under cooperative agreement with the Florida Geological Survey. The National Science Foundation aided laboratory work, through grant number G-19595. Stanley J. Olsen and Druid Wilson identified specimens of mammals and mollusks, respectively. The photographs are by Robert W. McFarlane.

Family Procellariidae Boie. Shearwaters

Puffinus micraulax, new species

Plate 1, figs. *a-b*

Holotype. Distal portion of left humerus, University of Florida no. 4872. From Hawthorne Formation along Hogtown Creek, at

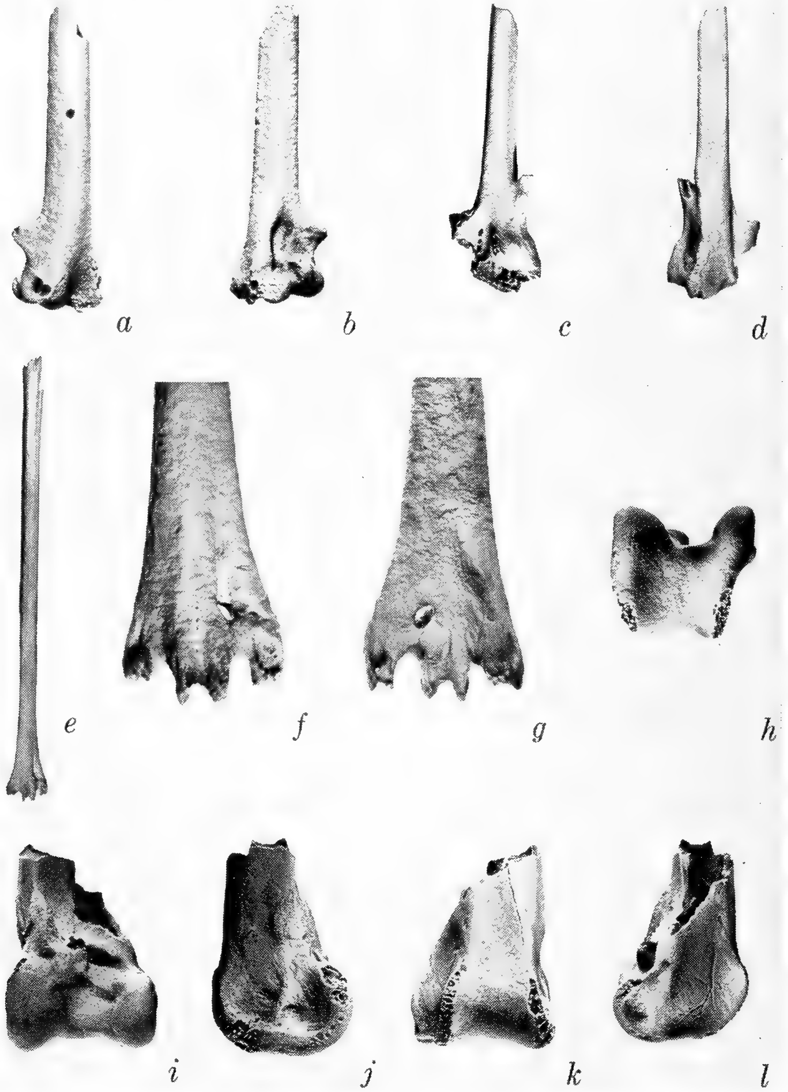

Plate 1. Holotype of birds from the Hawthorne Formation. Figs. *a-b*: *Puffinus micraulax*, n. sp.; length as preserved, 26.8 mm. Figs. *c-d*: *Sula universitatis*, n. sp.; length as preserved, 42 mm. Figs. *e-g*: *Propelargus olseni*, n. sp.; length as preserved, 232; distal width, 21.7 mm. Figs. *h-l*: *Probalearica crataegensis*, n. sp.; length as preserved, 21.4; distal width, 15.3 mm.

northeast corner of NW 16th Street and NW 39th Avenue, Gainesville, Alachua County, Florida, in SE ¼ of SE ¼, section 19, Township 9 South, Range 20 East. Collected by Kent Ainslie, January-June 1961.

Diagnosis. A very small species of *Puffinus* Brisson, slightly smaller than living *Puffinus lherminieri* Lesson, from which it differs further in having brachial depression much less deep; distal edge of ectepicondylar process more concave; common pit of origin of extensor digitorum communis and supinator brevis and common pit of origin of flexor metacarpi radialis and anconeus much smaller.

Length as preserved, 26.8; greatest distal width, 8.3; width through condyles, 5.4; length through ectepicondylar process, 7.0; width of shaft, 3.6 mm.

In Europe Tertiary species of *Puffinus* occur from the Middle Oligocene to the Middle Miocene, with *P. raemdonckii* (Van Beneden), *P. arvernensis* Milne-Edwards, *P. aquitanicus* (Milne-Edwards), and *P. antiquus* (Milne-Edwards). In California six species occur from the Middle Miocene to the Lower Pliocene, with *P. inceptor* Wetmore, *P. priscus* L. Miller, *P. mitchelli* L. Miller, *P. diatomicus* L. Miller, *P. felthami* Howard, and *P. kanakoffi* Howard. The only species of shearwater previously described from the Tertiary of eastern North America is *P. conradi* Marsh from the Middle Miocene of Maryland. All of these are much larger than *P. micraulax*.

Etymology. The specific name is from Greek *micraulax*, with small furrows.

Family SULIDAE (Reichenbach). Boobies
Sula universitatis, new species
Plate 1, figs. *c-d*

Holotype. Proximal portion of left carpometacarpus, with proximal portion of trochleae and process of metacarpal I missing, Brodkorb no. 8505 at University of Florida. From Hawthorne Formation along unnamed creek flowing south from Fraternity Row toward Lake Alice, University of Florida campus, Gainesville, Alachua County, Florida, in NW ¼, section 3, Township 10 South, Range 19 East. Collected by Robert Strawn, May 1958.

Diagnosis. Agrees with *Sula* Brisson and and differs from *Morus* Vieillot in having pollical facet compressed, with lower end of outer portion strongly elevated (facet wide in *Morus,* with lower edge of outer portion only slightly elevated); a longitudinal groove with raised borders below and distal to scar of flexor metacarpi radialis (groove obsolete in *Morus*); fossa for ulnare deep and compressed (wide and shallow in *Morus*).

Similar in size to living *Sula leucogaster* (Boddaert), from which it differs in having a large pneumatic foramen on external side of base of metacarpal I; external trochlea with lower edge notched only slightly by ligamental groove to ulnare; scar of flexor metacarpi radialis not laterally produced; fossa for ulnare without pneumatic foramina; internal trochlea with distal portion of internal face nearly flat (strongly concave in S. *leucogaster*); a row of 4 large pneumatic foramina above pisiform process.

Length as preserved, 42; least width of metacarpal II, 5.5; least height of metacarpal II, 3.2; width of pollical facet, 4.0 mm.

Extinct fossil species of typical *Sula* occur in France from the Lower Oligocene to the Middle Miocene, with S. *ronzoni* (Gervais), S. *arvernensis* Milne-Edwards, and S. *pygmaea* Milne-Edwards. Tertiary species occur in California from the Middle Miocene to the Middle Pliocene, with S. *willetti* L. Miller, S. *pohli* Howard, and S. *humeralis* L. Miller and Bowman. In the Lower Pliocene of Florida S. *guano* Brodkorb and S. *phosphata* Brodkorb are known.

Sula universitatis is smaller than S. *ronzoni,* S. *arvernensis,* S. *pohli,* and S. *humeralis,* and than described species of the genera *Miosula* L. Miller and *Palaeosula* Howard. It is larger than S. *pygmaea* and S. *willetti,* as well as *Microsula avita* (Wetmore) from the Middle Miocene of Maryland. Comparison with S. *guano* and S. *phosphata* is not yet possible, but the age differential of S. *universitatis* is too great for specific identity.

Etymology. This species is named for the University of Florida.

Family CICONIIDAE (Gray). Storks

Propelargus olseni, new species

Plate 1, figs. *e-g*

Holotype. Left tarsometatarsus, lacking proximal end and tips of trochleae, Brodkorb no. 8504 at University of Florida. From Hawthorne Formation in white bed above oyster bar, north of "Runaway Track," Switchyard B, Seaboard Airline Railroad Company, in Tallahassee, Leon County, Florida, in SE ¼ of NW ¼, section 3, Township 1 South, Range 1 West. Collected by Stanley J. Olsen and party, August 25, 1961.

Diagnosis. Referable to *Propelargus* Lydekker on basis of expanded distal end of tarsometatarsus, low position of distal foramen, and flatness of curve formed by trochleae. Differs from *P. cayluxensis* Lydekker of the Upper Eocene or Lower Oligocene of France in its wider intertrochlear spaces and smaller size. In *P. edwardsi* Lydekker, from the Aquitanian of France, the distal portion of the tarsometatarsus is unknown, but that species is a much larger bird, matching the size of living *Jabiru mycteria* (Lichtenstein) and *Leptoptilos javanicus* (Horsfield), whereas *P. olseni* scarcely exceeds living *Ibis leucocephalus* (Pennant).

Length as preserved, 232; length from upper end of tubercles for tibialis anticus to intertrochlear notch, 222; distal width, 21.7; least width of shaft, 9.0; width of shaft in middle, 9.2; depth of shaft in middle, 8.3 mm.

Etymology. This species, the first stork described from the Tertiary of North America, is named for Stanley J. Olsen, vertebrate paleontologist of the Florida Geological Survey.

Family GRUIDAE Vigors. Cranes

Probalearica crataegensis, new species

Plate 1, figs. *h-l*

Holotype. Distal end of right tibiotarsus, Brodkorb no. 8503 at University of Florida. From Hawthorne Formation in white bed just above oyster bar, north of "Runaway Track," Switchyard B, Seaboard Airline Railroad Company, in Tallahassee, Leon County, Florida, in SE ¼ of NW ¼, section 3, Township 1 South, Range 1 West. Collected by Stanley J. Olsen and party, August 25, 1961.

Diagnosis. Referred to *Probalearica* Lambrecht on basis of similarity to living *Balearica* Brisson (tibiotarsus unknown in type species of *Probalearica*). Distal border of intertrochlear area transverse in posterior view, only slightly inclined in distal view; external condyle with distal border rounded and notch obsolete; external ligamental rominence moderately developed (strong in *Grus,* weak in *Anthropoides*); internal ligamental prominence little produced internally and best seen in distal view; lower, external attachment for supratendinal ligament short and blunt.

Differs from living *Balearica pavonina* (Linnaeus) in having internal condyle without pronounced inward swing anteriorly, in distal view; internal ligamental prominence nearly vertical; size much less.

Length as preserved, 21.4; distal width, 15.3; antero-posterior depth of external condyle, 13.9; antero-posterior depth of internal condyle, 14.4 mm.

The internal ligamental prominence is mislabeled "Tuberculum zum Inserierung des M. peroneus profundus" in figure 155 and in the discussion on page 518 of Lambrecht (1933). The peroneal muscles run along the external instead of the internal side of the bone and insert distad to the tibiotarsus.

The only previously known Miocene cranes are *Probalearica problematica* (Milne-Edwards) and *Palaeogrus excelsa* (Milne-Edwards), both from the Aquitanian of France and both much larger species.

Etymology. The specific name is from Greek *krataigos,* Latin *crataegos,* a hawthorn bush.

CORRELATION WITH OTHER FAUNAS

Five genera of birds are now known from the Hawthorne Formation. *Sula* and *Puffinus* are here without stratigraphic significance, since these genera range from the Lower or Middle Oligocene, respectively, to the Recent. *Palaeochenoides* belongs to a family otherwise known only from the Carmanah Point beds of Vancouver Island, which underlie the Monterey Formation (Wilmarth, 1957) and hence are of early Miocene age or older. *Propelargus* and *Probalearica* are unknown after the Aquitanian (earliest Miocene) of Europe. An early Miocene age for the Hawthorne is thus strongly indicated.

At Tallahassee the type locality of the two birds contains the remains of mammals and mollusks. Olsen (1963) identifies the mammals as a camel and two horses, *Oxydactylus floridanus* Simpson, *Parahippus leonensis* Sellards, and *P. blackbergi* (Hay); all of these occur in the early Miocene Thomas Farm local fauna. Druid Wilson (letter of October 23, 1961) states that the pelecypod fauna is comparable to other known Hawthorne assemblages of early Miocene age and includes the following species: *Ostrea rugifera*

Dall, *Ostrea* cf. *pauciplicata* Dall, *Crassostrea* sp., *Pododesmus scopleus* Dall, and *Chione* cf. *chipolana* Dall.

At Gainesville lenses of oysters occur in several Hawthorne localities, including Colclough Hill, where Pirkle (1957) reported a typical Hawthorne oyster, *Ostrea normalis* Dall. At Colclough Hill I obtained in association with marine fossils a few land vertebrates, including a horse identified by Olsen (1959) as *Parahippus blackbergi,* a species that is common at the Thomas Farm and whose type locality is in the late early Miocene of Texas (Quinn, 1955). Both Colclough Hill and the type locality of *Sula universitatis* lie in stratigraphically similar positions on the southern edge of the Hawthorne escarpment at Gainesville.

The presence of identical species of mammals at Tallahassee, Gainesville, and the Thomas Farm indicates contemporaneity of the sites. The rich Thomas Farm local fauna is coetaneous with the Arikareean provincial age of the interior of western North America (Olsen, 1962, and numerous other sources). The Arikareean in turn correlates with the Aquitanian and the early part of the Burdigalian in the European chronology (Thenius, 1959). All evidence thus confirms an early Miocene age for the Hawthorne.

The Miocene history of Florida includes three invasions of the sea, the Tampa, Alum Bluff, and Choctawhatchee stages (Cooke, 1945; Puri and Vernon, 1959). In the early Miocene a warm sea deposited the Tampa limestone over the southern and western parts of the state. During Alum Bluff time the warm sea transgressed perhaps all Florida and extended north to the southern tip of South Carolina, across southern Georgia and Alabama, and westward to Texas. Lithological units formed during Alum Bluff time include the Chipola marl in the panhandle region of western Florida and the Hawthorne beds in the peninsula. The sea then withdrew, presumably beyond the present shore line. During Choctawhatchee time, in the late Miocene, the sea again covered parts of Florida, but its marine fauna reflects cooler conditions.

There is general agreement that the Tampa limestone is of early Miocene age, and the Choctawhatchee represents the late Miocene, but opinion is divided as to the occurrence of an unconformity between the Tampa and Alum Bluff stages. The Alum Bluff was formerly considered early Miocene, but Cooke (1945) transferred it to the Middle Miocene. Such assignment is followed by the Florida Geological Survey (Puri and Vernon, 1959) but is not accepted by the U. S. Geological Survey, which still places these beds in the Lower Miocene (Wilmarth, 1957).

On the basis of the invertebrate fauna Woodring (1960) correlates the Lower Miocene of the Caribbean area with the Aquitanian of Europe and further subdivides this portion of the epoch into early and late divisions. In view of the above considerations it would appear that the Hawthorne-Alum Bluff stage belongs in the late portion of the Lower Miocene. The Hawthorne Formation may merely represent a higher stand of the same warm, transgressing sea that deposited the Tampa limestone during its opening phase.

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LAKE APOPKA, FLORIDA, A CHANGING LAKE AND ITS VEGETATION

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ECOLOGICAL changes have been observed in many Florida lakes over a period of years. Many of these changes have been attributed either directly or indirectly to man. With regard to its plant and animal life, Lake Apopka, Florida, is an example of a changing lake which has been affected by man and his activities.

The following paragraphs are a brief description of how Lake Apopka appeared fifteen years ago, a few of the basic changes that have occurred during this interval of time, and a description of the plant life in 1959. Undoubtedly in another fifteen years additional changes will occur in Lake Apopka's ecology. Possibly this report will be useful in determining the changes that may occur in the plant succession and physical changes in the next fifteen year cycle of this lake, and will serve as a clue to the future for this and other lakes in Florida.

LAKE APOPKA, FLORIDA

Lake Apopka, the fourth largest fresh water lake in Florida, is a 31,000 acre lake in Orange and Lake counties of central Florida. It has an average depth of 5.5 feet and a total water volume of about 170,000 acre feet.

Up to and through 1946 Lake Apopka was described as being extremely clear (John F. Dequine, personal communication). A heavy growth of pondweed, *Potamogeton illinoensis,* began approximately 200 yards from the shoreline and extended across the entire lake except in areas where the depth exceeded eight feet. Water hyacinth, *Eichhornia crassipes,* grew very profusely around the edge of the entire lake, and large floating mats of hyacinth occasionally shifted around on the lake surface.

A plankton bloom was observed on the lake for the first time in the fall of 1947 (Dequine, 1950). At approximately the same time a combination of external factors began to exert an influence on Lake Apopka. The initiation of a hyacinth control program resulted in an unusually large amount of decaying vegetation in the lake. Prior to 1952 hyacinth control was performed by private interests. In 1952 the Florida Game and Fresh Water Fish Commission started its Hyacinth Control Program (John W. Woods, personal communication). A citrus processing plant at Winter Garden, although in operation for a number of years, greatly increased its capacity between 1946 and 1950. As a result of this the volume of its waste products, believed to contain a considerable amount of sugar, was increased during this period. The muck farms at the north end of Lake Apopka were greatly expanded in the middle 1940's, and at this time pumping stations were constructed and put into operation (Harold L. Moody, personal communication). Water was pumped out of the farming areas, and perhaps a percentage of the plant nutrients applied in these areas were leached through the soil into the canals and consequently pumped into the lake. This pumping operation also undoubtedly contributed to the siltation in Lake Apopka. Some citrus groves were located along the eastern and western shores of the lake, and possible nutrients were drained from these areas into the lake. A sewage treatment plant at Winter Garden was also pumping its effluent into the lake. Perhaps a combination of all these external factors gradually increased the fertility of the lake until the plankton bloom occurred in 1947.

The pondweed began to disappear as the plankton bloom persisted and shaded it out. By 1950 no pondweed could be found in the lake. Haul seine operations, which previously were limited by the submerged vegetation to restricted parts of the lake, could then be performed anywhere in the lake. The use of fertilizer to create a plankton bloom and thus shade out undesirable submerged aquatic plants, as described by Swingle and Smith, 1950, is a common farm pond management tool.

A change in the percentage composition of the fish species present in Lake Apopka was noted by Dequine (1950). In 1947, when the plankton bloom was first noted, the game fish population (i.e. *Micropterus salmoides, Lepomis* spp., *Pomoxis nigromaculatus*) was considered to be about 35 per cent of the species present. Gizzard shad, *Dorosoma cepedianum* (LeSueur), made up 20 per cent of the total fish population by weight. As the plankton bloom persisted, the gizzard shad population probably increased greatly in numbers, but were small in size, and provided excellent forage for the game species. This resulted in the game fish making up 69 per cent of the total population by weight in 1950. It was estimated that the total fish population increased in weight approximately tenfold during the period between December 1947 and January 1950. However, within the next few years the gizzard shad probably became too large and too numerous to be properly cropped by the game species. Consequently by 1956-1957 (Game and Fresh Water Fish Commission, 1959) it was estimated the game fish population dropped to 18 per cent with most of the remaining 82 per cent being the plankton-feeding gizzard shad.

In an effort to improve the sport fishing in Lake Apopka, the lake was treated with rotenone by the Game and Fresh Water Fish Commission in three successive years, 1957, 1958, and 1959. The rotenone was applied at a concentration which normally is not toxic to game species but quite toxic to the gizzard shad (Huish, 1958). In the three treatments it was estimated that over 20 million pounds of gizzard shad were killed (Melvin T. Huish, personal communication).

THE PLANTS OF LAKE APOPKA

This brief survey was carried out mainly during the months of August and October of 1959. Some collecting of various plant species was done the following spring in an effort to obtain flowers and seeds for identification purposes. The objects of the survey were to list the major aquatic plants of Lake Apopka along with their general distribution. This report should not be considered to cover all the plants of Lake Apopka, rather just those that would normally be encountered by and be of interest to the fishery biologist. The major plant species (Table 1) are discussed as to their general abundance and their general location in regard to the common landmarks of the lake (Figure 1).

The more common shrubs and trees of Lake Apopka include swamp cypress (*Taxodium distichum*), southern bayberry (*Myrica cerifera*), coastal-plain willow (*Salix caroliniana*), Florida elm (*Ulmus americana floridana*), scrub holly (*Ilex opaca arenicola*), red maple (*Acer rubrum*), Carolina ash (*Fraxinus caroliniana*), and buttonbush (*Cephalanthus occidentalis*). For a more detailed description of the various plants and their location the reader is referred to a typewritten report by this author entitled "The Major Aquatic and Marsh Plants of Lake Apopka, Florida, and Their General Distribution," August 28, 1961. This report is on file at the Leesburg office of the Game and Fresh Water Fish Commission.

The two major emergent hydrophytes in Lake Apopka were panic grass, *Panicum paludivagum,* and maiden cane, *Panicum hemitomon.* These two plants, usually not intermingled, formed

TABLE 1

Major Aquatic and Marsh Plants of Lake Apopka, Florida

Scientific Name	Common Name
Salvinia rotundifolia Willd.	Floating fern
Typha domingensis Pers.	Cattail
Najas quadalupensis (Spreng.) Morong	Southern naiad
Sagittaria latifolia Willd.	Duck Potato
Sagittaria lancifolia L.	Arrowhead
Vallisneria americana Michx.	Wild Celery, Eelgrass
Panicum paludivagum H. and C.	Panic Grass
Panicum hemitomon Schult.	Maiden Cane
Cyperus odoratus L.	
Eleocharis sp.	Spike Rush
Scirpus validus Vahl	Great Bulrush
Cladium jamaicensis Crantz	Saw Grass
Peltandra virginica (L.) Kunth	Arrow Arum
Colocasia esculenta (L.) Schott.	"Elephant-ear"
Spirodela polyrhiza (L.) Schleid	Large Duckweed
Eichhornia crassipes (Mart.) Solms	Water Hyacinth
Pontederia cordata L.	Pickerelweed
Crinum americanum L.	Swamp Lily
Saururus cernuus L.	Lizard's-tail
Nuphar advena Ait.	Spatterdock
Kosteletzkya althaeifolia (Chapm.) A. Gray	Fen-rose
Hydrocotyle umbellata L.	Water Pennywort
Lobelia cardinalis L.	Cardinal Flower
Eupatorium serotinum Michx.	
Mikania scandens (L.) Willd.	Climbing Hemp Vine
Solidago sp.	

narrow borders ten to twenty yards from shore along much of the eastern and western shores of the lake. The bands of panic grass and maiden cane varied in thickness from a few yards to twenty yards with the widest areas usually on the southern side of a land projection. The patches also varied from a few yards long to a few hundred yards long in a few instances. These two plants were generally located in water with a depth of one or two feet and a fairly firm sandy bottom. Neither maiden cane or panic grass could be found along the northernmost shore where the bottom material was of muck and the water usually three or four feet deep.

Cattails, *Typha domingensis,* along with pickerelweed, *Pontederia cordata,* and arrowhead, *Sagittaria lancifolia,* were usually found in the protection of small coves or between the borders of maiden cane or panic grass and the shoreline. Large stands of cattails were found bordering Smith's Island (actually a point of land) and along the north shore of Crown Point. The largest area of unmixed pickerelweed was found between the Ferndale Camp and the Beauclair Canal. Some spike rush, *Eleocharis* sp., was sparsely distributed along the western shore.

Hog Island was actually not an island, but a large area in the lake varying between 25 and 75 yards from the shore, covered with great bulrush, *Scirpus validus*. The area ranged between five and thirty yards wide and was about three-quarters of a mile long. Its location was almost due north of Oakland Dock. The only

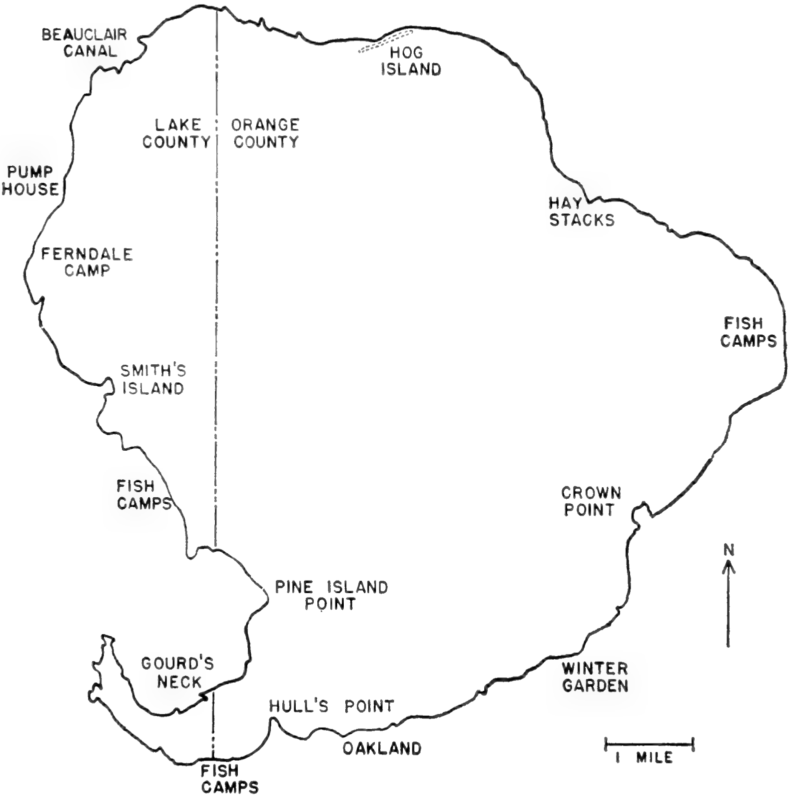

Fig. 1. Lake Apopka, Florida. Lake outline by Lake and Stream Survey, Florida Game and Fresh Water Fish Commission, July 1957.

other area in which great bulrush was found in the lake was in a large cove just south of Smith's Island.

Floating hydrophytes were not common on Lake Apopka. As mentioned previously, at one time water hyacinths, *Eichhornia crassipes,* covered much of the lake. However, because of the hyacinth control program they are now restricted to some inaccessible coves in the Gourd's Neck and in some canals adjacent to the north shore of the lake. Floating fern, *Salvinia rotundifolia,* was very common in the coves with the water hyacinths and occasionally found in backwaters around the lakes. Duckweed, *Spirodela polyrhiza,* was found only at the northeastern corner of the lake in an isolated backwater with floating fern.

Spatterdock, *Nuphar advena,* was quite common in the Gourd's Neck at the mouth of the many small coves. This plant was also found at the mouth of the Ferndale Canal and scattered among the great bulrush plants of Hog Island and between the "island" and the shore.

Only two plant species belonging to the submerged hydrophyte group were found in Lake Apopka. Eelgrass, *Vallisneria americana,* was common between the patches of maiden cane or panic grass and the shoreline between Smith's Island and Pine Island Point. It was also found along the southern half of the eastern shoreline. Southern naiad, *Najas quadalupensis,* was only found near the pump house on the western shore. This was adjacent to a large eelgrass bed.

The line dividing the marsh plants from the aquatic plants is very indefinite. For this report the marsh plants were considered those growing upon the shoreline of Lake Apopka. In much of the lake the shore is quite moist for a considerable distance landward from the water's edge. Therefore, a few of the plants discussed (i.e. arrowhead, pickerelweed) were found growing both from the lake and from the shore.

The most abundant and most noticeable plant growing on the shore of Lake Apopka was the cultivated escape *Colocasia esculenta,* locally called "elephant-ear" (identified by Dr. Daniel B. Ward, University of Florida). This large-leafed plant was found on nearly every section of the lake shore. Particularly large areas of "elephant-ear" were found along the southern half of the eastern shore to the tip of the Gourd's Neck and along the western shore from Smith's Island to Ferndale Camp. Arrowhead was the second most abundant shore plant and this species was commonly intermingled with the "elephant-ear". Also scattered along the shore and in most instances intermingled with the "elephant-ear" and arrowhead were *Kosteletzkya althaeifolia, Lobelia cardinalis, Eupatorium serotinum, Mikania scandens,* and *Solidago* sp. Arrow arum, *Peltandra virginica,* was a very common understory species of "elephant-ear" on the west shore, and duck potato, *Sagittaria latifolia,* although quite rare, was an understory species of arrowhead.

Water pennywort, *Hydrocotyle umbellata,* was quite abundantly scattered along much of the lake shoreline. Lizard's-tail, *Saururus cernuus,* was common on the south shore of the Gourd's Neck but was not noted for other areas of the lake. Small clumps of saw grass, *Cladium jamaicensis,* were scattered along the eastern and western shores of the lake. No saw grass was observed growing directly from the water as is common in South Florida. The swamp lily, *Crinum americanum,* was quite rare and when found was usually in the shade of a larger plant.

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AGING STUDIES ON *LEMNA*

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Observations of growth, life span, and cumulative aging phenomena in two duckweeds, *Lemna minor* and *Lemna perpusilla*, are reported in the present paper. The study was carried out under culture techniques more refined than hitherto reported, and which allow normal growth and reproduction under an accurately controlled and reproducible environment. Our group was stimulated to study the effects of environmental conditions on the general life cycles of these and other simple organisms by the age investigations of Ashby (1948), Ashby and Oxley (1935), Ashby and Wangerman (1951, 1954), Hillman (1961), Lacey (1952), Lansing (1952), Wangerman (1951), Wangerman and Ashby (1951), and Wangerman and Lacey (1953).

Methods and Materials

Aseptic plants were obtained by following the well defined culture methods of Hillman (1961). Plants were shaken in 100 ml. solution of 10 per cent Clorox plus one drop of Tween 80. Many plants were shaken together; then some were removed after one minute and placed into sterile distilled water. The remaining plants were again shaken for one minute and then some of these were removed and placed into sterile distilled water. This process was repeated until some had been Clorox-treated for five minutes. After mild shaking in the distilled water the treated plants were placed in sterile nutrient media. Some of the surviving plants were found to be aseptic. Since reproduction was vegetative, the use of a single clone for all experiments eliminated genetic variability, except for the theoretical possibility of somatic mutation, which so far has not been observed (Hillman, 1961).

The experimental organisms used in this study are *Lemna minor* clone 6A, and *Lemna perpusilla* clone 1. The plants are green, flat, surface floating, and oval in shape. Their long axis measures approximately 4 mm. Each plant has one thread-like root suspended in the liquid culture medium. Its vegetative reproduction consists of the formation of daughter plants that are found on each side of the narrower end of the original mother plant. The daughter plants become themselves mother plants while still attached to the original mother. Thus, attached groups or colonies are formed. The daughter plants are not formed at the same time but are alternately produced. The average lifespan of the mother plant of *L. minor* is from 50 to 70 days, while the average lifespan of *Lemna perpusilla* is 25 days. Individual daughter plants reach their maximum size upon abscission from the mother plant. Cessation of daughter plant production is accompanied by yellowing and death of the mother plant.

Culture of the organisms under study was carried out in microphytotrons consisting of doubled-walled wooden chambers, 1.5 ft. wide, 4 ft. long, and 2 ft. deep. The tops of the chambers are of two layers of glass, spaced one inch apart to form a thermal barrier. The light source for each chamber is suspended above the top of the chambers and consists of six 110 watt G.E. Power Groove fluorescent lamps with supplemental long wave radiation from ten 7 watt incandescent bulbs. Temperature is thermostatically controlled by circulating the chamber air with small electric fans over micro-heaters. Environmental conditions for this study were 1,700 foot-candles light intensity, 12 hour photoperiod, and 25°C temperature.

The nutrient medium for clone 1 and clone 6A (Table 1) was obtained by greatly modifying Hunter's basic solution (Loomis, 1949). It has been found that a more dilute medium and certain variations of N, P, and K resulted in greater growth. The source of K has been changed, and the solution has been buffered to pH 7. Buffer exhaustion has been prevented by neutralization of the solution before addition of the dilute buffers. Fifteen milliliters of this medium were placed in 50 ml. round bottom centrifuge tubes plugged with cotton. These tubes were autoclaved under 15 lb. pressure for 25 minutes. The plants were transferred once per week into new tubes containing fresh nutrient solution.

EXPERIMENTAL PROCEDURES

In order to study transmitted aging factors (Ashby, 1950; Ashby *et al.*, 1949; Ashby and Wangerman, 1954; Lansing, 1952), from mother plants of known age, every alternate progeny was taken at dated intervals and cultured separately. The dates of appearance of second generation progeny and the number produced were noted. Observations were carried out on four replications. The possibility

TABLE 1

Modified Basic Hutner Solution

Compound	Stock Solution mg/ml	Nutrient Quantity mg/ml	Stock Solution Aliquots ml
$CaCl_2$	100	166	1.66
EDTA	50	500	10
$MgSO_4.7H_2O$	100	500	5
$ZnSO_4.7H_2O$	10	65.8	6.58
$MnSO_4.H_2O$	10	15.4	1.54
$FeSO_4.7H_2O$	10	24.9	2.49
H_3BO_3	10	14.2	1.42
$Na_2MoO_4.2H_2O$	1	25.2	25.2
$CuSO_4.5H_2O$	1	3.49	3.94
$CoCl_2.6H_2O$	1	.75	.75
NH_4NO_3	100	.25	.25
KCl	10	10.8	1.08
Buffers:			
Na_2HPO_4	9.6	21.6	2.25
NaH_2PO_4	9.2	18.4	2.0

Distilled water to make one liter.

of a size cycle of first daughters of first daughters, etc., was investigated closely in connection with these studies. Each time a second generation daughter plant was formed, the producing one was preserved in alcohol and the size of the successive generations measured. Four replications and eighteen to forty generations were observed.

Experimental Results

In Table 2 a recapitulation is presented dealing with the results of experiments concerned with the study of five age parameters. Row B and C show that with increasing age of the mother plant the production of first generation sibling plants becomes increasingly slower. The relations between age of the mother and the life span of the daughters is presented in Row B and D. We note that with increasing age of the mother plant, the life span of the later daughter is less than that of the earlier daughters. Row D and E represent the effect of the inherited aging factor as it is extended into

TABLE 2

Age of mother plant, production of daughters, second generation siblings, and life span of *Lemna minor**

A. First generation alternate sibling numbers	2	4	6	8	10	12	14	16	18	20	22	24
B. Parent age (days) at time of first generation alternate sibling production	2	5	9	12	16	20	25	30	37	38	44	51
C. Days between first generation alternate sibling production	2.2	3.7	4.7	3.0	4.2	4.0	4.5	5.0	6.2	5.0	8.0	9.0
D. Life span (days) of first generation alternate siblings	73	70	70	62	60	58	59	52	50	52	48	41
E. Number of second generation siblings produced	24	23	23	22	20	22	20	17	14	15	14	9
F. Total progeny production rate by alternate first generation siblings (mean days between production)	2.3	2.3	2.5	2.5	2.8	2.6	2.9	2.5	3.4	3.0	3.4	4.8

* Average of four replications.

TABLE 3

Sizes of successive generations of first daughters of *Lemna minor*

First generation offspring number	Days between production	Area in mm ^{2}
0	–	8.195
1	3	7.655
2	4	8.969
3	4	8.908
4	3	8.428
5	3	8.581
6	3	9.169
7	3	8.371
8	4	8.766
9	3	8.449
10	3	8.859
11	3	9.045
12	3	8.505
13	3	8.389
14	3	8.790
15	3	8.893
16	3	8.789
17	3	8.437
18	2	8.990
19	3	8.439
20	3	9.764
21	2	9.346
22	2	9.142
23	2	9.025
24	2	9.175
25	2	8.946
26	3	8.128
27	2	7.203
28	4	8.319
29	4	8.839
30	2	9.934
31	3	7.643
32	4	8.378
33	3	8.061
34	3	8.898
35	4	7.774
36	2	8.337
37	3	7.645
38	3	9.168
39	4	8.870
40	4	6.402
41	4	8.376
42	3	8.546

the reproduction capacities of the daughters. We note that the earlier produced first generation siblings produce a larger number of second generation siblings than the later daughters. The number of second generation siblings by the first generations is directly correlated to the birth position that the daughters held in the mothers life span. The reproduction rate also decreased relative to the mother age.

In row F we note that the time elapsing between successive production of second generation siblings increases with the increasing age of its "first generation sibling" mother.

No size cycle was found in the course of 42 generations of first daughters (Table 3). The rate of reproduction and area stays within the ranges of usual biological variation.

Table 4 shows the sizes of successively produced sibling fronds of *Lemna perpusilla.* The data suggest that there is an increase in frond size initially. A decrease in frond sizes then occurs until the death of the parent stops the sibling production.

DISCUSSIONS AND CONCLUSIONS

From the presented data we find interesting corroborative evidence for Ashby's Lemna growth and reproduction rates, but also differences. If one studies the general data obtained in light studies, it is found that when the leaves are fully exposed, heliophytes show a light saturation at 2,500-3,000 foot-candles (Frank and Loomis, 1959). *L. minor* cultured aseptically under 1,700 foot-candles in our laboratory lived approximately twice as long and produced approximately ten times as many daughter progeny as either of the three clones cultured by Wangermann and Ashby (1951) at lower light intensities. Hillman (1961) used sucrose as an energy adjunct in his nutrient solutions.

The microphytotrons are lighted by fluorescent tubes in such a way that high intensities of light can be administered without burning the experimental objects (Went, 1957). The deviation in cultural results from the fundamental studies of Ashby and Oxley (1935) on light, temperature and medium relationships in our opinion is due to the fact that we were able to utilize refinements of modern technological advances in the present work. Ashby's reports do not mention aseptic culture conditions, and from experience in this laboratory non-aseptically cultured plants are deleteriously affected by high concentrations of algae and fungi that develop within a few days. Hillman (1961) questioned the lack of aseptic conditions of Ashby's work. The early methods of incandescent lighting of Ashby's growth chambers could possibly have produced localized hot spots at the higher foot-candles.

The aforementioned conditions may be the reason that we cannot find a continuously declining size in successively produced siblings, as reported by Ashby and Wangermann (1949), Wangermann and Ashby (1951).

TABLE 4

Sizes of successive sibling fronds of *Lemna perpusilla*

Sibling No.	Frond Size (mm^2)*
1	5.7
2	6.5
3	7.1
4	—
5	7.6
6	6.4
7	7.0
8	7.4
9	6.8
10	6.8
11	7.4
12	5.8
13	6.5
14	5.8
15	4.5
16	4.9
17	4.6
18	3.9

* Average areas of four individuals.

Our results corroborate the observations of Ashby, Wangermann, and co-workers, that a postulated transmissable aging factor is transmitted in vegetative propagation of *L. minor,* and the rate of production of daughter plants slows with age of the mother plant. It is important to note that the writers do not wish the term factor to mean solely a substance. Architecture of the aging meristem could well play a part in the subsequent sequence of events. Another important point is that the overall rate of production of second generation siblings by the first generation is affected by the temporal birth position that the first generation sibling holds in the life cycle of the mother.

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SUMMARY

It is postulated that an aging factor or factors might be transmitted to the vegetative offspring of *Lemna minor* clone 6A cultured aseptically under standardized conditions. The overall production rate of second generation siblings by the first generation is affected by the temporal birth position that the first generation sibling holds in the life cycle of the mother. The sizes of successively produced sibling fronds of *Lemna perpusilla* clone 1 show an initial increase, followed by a decrease which then ends with the death of the parent.

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A CESTODE PLEROCERCOID FROM THE CROWNED CONCH

James D. Regan

During the spring of 1960 a number of marine invertebrates from the intertidal zone of Apalachee Bay, Florida, were examined for the presence of helminthic parasites. As a part of this study, on May 26, 1960, 17 specimens of the crowned conch, *Melongena corona* Gmelin, were collected at Live Oak Point, Florida. One of these, having a shell length of 12.5 cm, harbored three specimens of a cestode plerocercoid of the order Tetraphyllidea, family Phyllobothriidae. They were recovered from the mantle cavity of the host where they were attached to the dorsal surface of the body, about 1 cm posterior to the head. This report presents a description of these larvae and is a first record of a phyllobothrid plerocercoid from this host.

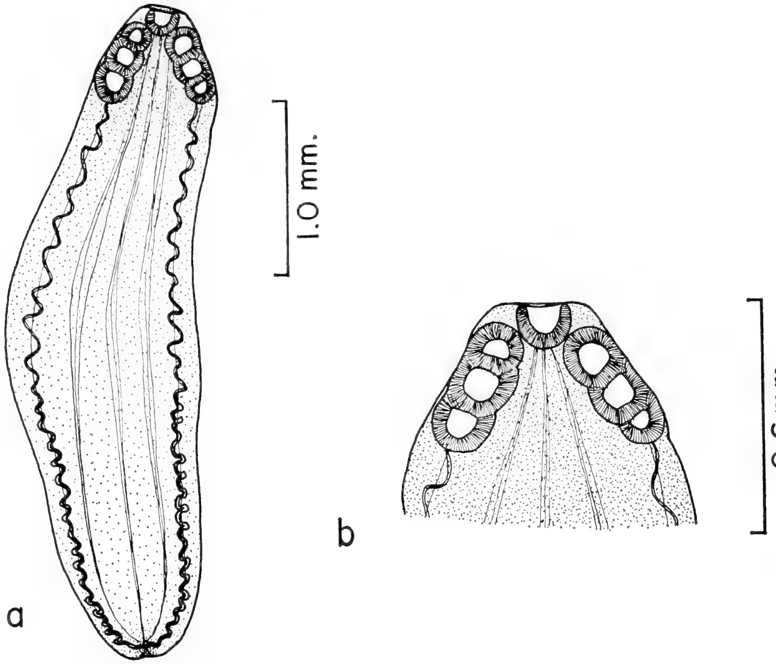

Fig. 1. Plerocercoid of a tetraphyllidean cestode from *Melogena corona.* a. Whole mount of specimen no. 2, total length 4 mm. b. Detail of scolex of specimen no. 2, total length 4 mm.

MATERIALS AND METHODS

The larvae were fixed in AFA under slight pressure, stained in acetocarmine, and mounted whole in Permount. The following description is based on a study of all three specimens. Measurements indicate the range of the series. Terminology is as recommended by Wardle and McLeod (1952).

OBSERVATIONS

Body flattened, elliptical in outline, total length 4-6 mm, greatest width (mid-portion of body) 1-1.2 mm; width at junction of scolex and body 700-900 microns; length of scolex 700-900 microns. Four sessile bothridia, two dorsal, two ventral; each bothridium divided by costae into one central and two smaller secondary areolae. Myzorhychus low, moundlike, with a muscular apical sucker. Walls of bothridia contracted marginally, showing striations. Lateral osmoregulatory canals proceeding caudad in a zigzag fashion, becoming more evident posteriorly; small caudal bladder present with caudal indentation at excretory pore.

In figure 1, which was made using the reticule grid-graph paper method, the holdfast is slightly contracted. These specimens were observed alive for about one hour before fixation and, although partial contraction of the holdfast was often seen, at no time did any of the three plerocercoids completely invaginate the holdfast.

DISCUSSION

This plerocercoid seems to be another form in the variety of larvae that have been described under the name *Scolex pleuronectis* Mueller 1788. They have been known for over 150 years and have been described from a variety of marine animals including fishes (Monticelli, 1888), copepods (Wundsch, 1912) ctenophores (Van Cleave, 1927), and mollusks (Hyman, 1951).

Regarding these larvae, Wardle and McLeod (1952) stated: "They differ from one another mainly in the degree to which the apical sucker is developed, in the size and shape of the bothridia, in the presence or absence of cross partitions or 'costae' on the bothridial surfaces, and in the presence or absence of patches of red pigment on the holdfast."

The absence of hooklets on the holdfast of this plerocercoid seems clearly to place it in the family Phyllobothriidae. Further taxonomic placement is difficult, however, for a number of reasons. Considerable difficulty has been encountered in proper generic

Fig. 2. Plerocercoid of a tetraphyllidean cestode from *Melogena corona*. Specimen no. 2, total length 4 mm.

placement of even the adult forms of this group (Southwell, 1930). Also, similar "*Scolex pleuronectis*" larvae apparently develop into a number of different species in the final host (Hutton, 1961).

It is possible that the final host of this plerocercoid may be a ray, possibly a species of *Dasyatis*. Rays are known to feed on mollusks of this kind, whose shells they are equipped to crush with their pavement dentition. Rays are quite common in the area where this plerocercoid was found, and several adult phyllobothrid cestodes have been identified from the spiral valve of *Dasyatis sabina* from this region (Loftin, 1960).

ACKNOWLEDGMENTS

The writer is indebted to Dr. Robert B. Short for his helpful criticism, and to Miss Elizabeth Twigg-Smith for doing the drawing.

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TROPICAL MARINE FISHES IN THE GULF OF MEXICO

David K. Caldwell

Recently the Los Angeles County Museum received a small collection of marine fishes obtained near Fort Walton Beach, Florida, by Winfield Brady, then of Florida's Gulfarium. Among them were specimens that represent two new records of tropical forms from the northeastern Gulf of Mexico and others that clarify the distribution of a third such species. These specimens, and others of a similar tropical origin reported upon in a number of recent papers, prompt remarks of a general zoogeographical nature concerning the distribution of tropical marine forms on the continental shelf throughout the Gulf of Mexico.

Annotated List of Specimens

Gymnothorax vicinus (Castelnau).

According to distributional data given by Briggs (1958, p. 262), a single specimen of this moray, approximately 550 mm in total length (LACM 2450), extends the range of this species some 585 shoreline miles into the northeastern Gulf of Mexico from the present northernmost recorded locality at Tortugas, Florida.

Pomacanthus arcuatus (Linnaeus).

Springer and Woodburn (1960, p. 69) reported a specimen of this angelfish from off Tampa Bay, Florida. Two specimens (LACM 2451) from off Fort Walton Beach, 70 and 107 mm standard length, extend the range of this species some 360 shoreline miles to the north and west into the northeastern Gulf of Mexico.

Eupomacentrus variabilis Castelnau.

Caldwell and Briggs (1957, p. 4) reported this damselfish from the northeastern Gulf questionably as *Pomacentrus xanthurus* Poey. Later, Loren P. Woods identified a sample of these specimens as *E. variabilis,* and I corrected the name used in the first report (Caldwell, 1959, p. 72).

Rivas (1960, p. 150) placed *P. xanthurus* in the synonymy of *variabilis.* Without seeing the specimens reported by Caldwell and

Briggs, he suspected that they were *P. fuscus* (Cuvier), or a mixture of that and some other species; but he probably did not see my later paper in time to comment on it.

To settle the status of *E. variabilis* in the fauna of the northeastern Gulf of Mexico, it is desirable to report that the Fort Walton collection contained eight specimens of this species (40 to 100 mm standard length, LACM 2452) which were determined with the aid of Rivas (*op. cit.*). Furthermore, these new specimens appear to be identical with others from the Morant Cays, off Jamaica, which Woods identified as *E. variabilis* at the same time he examined the original Florida material.

ZOOGEOGRAPHICAL REMARKS

As previously noted elsewhere (Briggs, 1958; Caldwell, 1959), the distribution of tropical marine fishes in the eastern Gulf of Mexico probably extends along the entire western edge of peninsular Florida in the deeper waters of the continental shelf. The presence of a tropical fish fauna on the shelf in the north central Gulf was suggested by Dawson (1962, 1963), and one in the northwestern Gulf by Hoese (1958) and Springer and Hoese (1958). A similar tropical fauna can be expected in all Mexican Gulf waters. Such a distribution of tropical fishes can be explained on the basis of currents and bottom types. Within the Gulf of Mexico the distribution of the tropical fishes appears to be discontinuous, and probably is similar to that recently described (Caldwell, 1962) for the short bigeye, *Pseudopriacanthus altus* (Gill). The distribution of that species is related to current patterns, in the case of the pelagic larvae, and to bottom type, in the case of the transformed life stages.

It is likely that the continued presence of tropical fishes in the more northern areas of the Gulf of Mexico can be attributed to recruitment through transport of pelagic eggs and larvae by the currents that flow up from the south (Leipper, 1954, pp. 121 and 122), and to spawning by a resident population of adults on the deeper reefs in years of favorable conditions of temperature. The presence of such a population of adults has been confirmed by observations made by SCUBA divers trained in ichthyology (Winfield Brady and J. B. Siebenaler, personal conversations).

The occurrence of tropical fishes in the Gulf may be limited primarily to coral and sponge patches which lie along the coast of Florida and spottily elsewhere in the Gulf on the continental shelf (see Lynch, 1954, p. 79; Hedgpeth, 1954, p. 206). Evidence that a tropical fish fauna occurs on the offshore reefs off Tampa Bay, midway between the tropical Florida Keys and the northeastern Gulf, was presented by Springer and Woodburn (1960). Ichthyological faunal studies (several cited by Caldwell, 1959) between Tampa Bay and the northeastern Gulf of Mexico west of Cape San Blas have been made almost exclusively in shallow inshore waters on mud and sand bottoms. When collecting efforts in this region are extended further offshore into the deeper coral and sponge areas, it is almost certain that tropical fishes will be found along the entire coast.

Continued collecting efforts, especially on the reefs and sponge bottoms that occur spottily throughout the Gulf of Mexico on the continental shelf, will almost surely demonstrate that tropical fishes are more widespread in the Gulf than present zoogeographical summaries indicate. Similar distributions can be expected for invertebrates of tropical origin (Ingle, *et al.*, 1963).

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LARGE LOOKDOWNS FROM TAMPA BAY, FLORIDA

Carl H. Saloman and Gordon R. Rinckey

During a recent cold spell (December 12-13, 1962), 17 large lookdowns, *Selene vomer* (Linnaeus), were found dead on the beaches or in a stunned condition in the water north of Pass-a-Grille channel. The water temperature at that time was 10.4°C. and salinity 33.0 o/oo, in contrast with readings for the previous week (December 3) of 18.1°C. and 32.4 o/oo.

Thirteen females and four males were in the group recovered. The largest specimen, a female, measured 287 mm., S. L. (standard length) and 375 mm., T. L. (total length). The body depth was 68.6 per cent of the length (S. L.). The fin ray counts of this specimen were as follows: dorsal (22), anal (18), and pectoral (18). The size ranges for females and males in the sample were: 163 to 387 mm. and 163 to 200 mm., S. L., respectively. The corresponding mean lengths for the sexes were 202.54 mm. and 180.00 mm., S. L.

During 18 months of regular sampling in Tampa Bay, 3 small specimens of *S. vomer* were collected. Two were caught in June, 1962 (39.0 and 43.0 mm., S. L.), and one in August, 1962 (28.0 mm., S. L.).

Several large specimens of this species have been reported, but none larger from the west coast of Florida. Reid (1954) reported one specimen 33 mm. in length, taken near Seahorse Island, Florida. Joseph and Yerger (1956) reported no adult specimens from Alligator Harbor, but one adult, 216 mm. S. L., from Gulf Beach, one mile west of Bald Point, Florida. Springer and Woodburn (1960) reported one specimen 17.9 mm. S. L., from Belle Vista Beach, Florida. Tabb and Manning (1961) collected *S. vomer* twice from Sandy Key Basin and East Cape Sable in northern Florida Bay, but gave no measurements of the specimens.

Large specimens of *S. vomer* taken elsewhere in the Gulf have been reported by various authors. The largest to date is one 483 mm. T. L., (360 mm. S. L.) taken at Port Aransas, Texas (Pounds, 1962). Ginsburg (1952) reported a specimen 317 mm. long, from Jamaica and another 195 mm. long, from the Gulf of Mexico. Gunter (1945) reported a specimen 123 mm. long from Texas. Hildebrand (1939) mentions one *S. vomer* of 320 mm. S. L. from Gatun

Locks, Panama. Hildebrand (1954) reported specimens ranging from 72 mm. to 111 mm. in length, in the western Gulf.

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POLYCHROMATISM IN SNAKES

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The present paper explores the topic of polychromatism in snakes. It is convenient to begin the discussion with the California kingsnake, for this reptile affords virtually the only case of ophidian polychromatism to have been fairly well studied in the past.

Herpetologists once recognized two sympatric species of kingsnakes, belonging to the *Lampropeltis getulus* group, in southern California. One of these, with a ringed pattern, was known scientifically as *L. g. boylii* (Baird and Girard); the other, with a lineate pattern, generally stood as *L. californiae* (Blainville). The two did not differ other than in pattern, and apparent intermediates were known. Even before the 20th Century it was suspected that the two were but phases of a single form.

Klauber (1936, 1939) showed that a ringed, a striped, or an intermediate (partially striped) female could produce a brood that included both ringed and striped individuals. He classified three kinds of "aberrant" patterns, phenotypically intermediate between ringed and striped; and held that ringed and striped examples were but pattern phases of a single taxon, to be called *Lampropeltis getulus californiae.* He also pointed out other, possibly comparable, cases of dichromatism in snakes, i.e. *Masticophis flagellum frenatum* and *M. piceus, Phyllorhynchus d. decurtatus* and *P. browni, Sonora semiannulata* and *S. miniata.*

Smith (1943) advanced a view contrary to that of Klauber, holding the ringed and striped kingsnakes to be two distinct species, and the intermediates to be hybrids between them. Klauber (1944) offered a rebuttal. Klauber's interpretation was favored by Mayr (1944) from the standpoint of taxonomic theory, and by L. C. Dunn (1944) from that of genetic theory. Nevertheless, Smith and Taylor (1945) maintained *Lampropeltis californiae* as a species distinct from *L. getulus boylii.* Smith (1952b) later held that *L. californiae* and *L. g. boylii* "were clearly species formerly, but now have so coalesced that they cannot be separately recognized at the present time level." There has been no further contribution to the problem, although most herpetologists have accepted Klauber's taxonomic arrangement.

THE LINEATE PATTERN IN EASTERN KINGSNAKES

Some previous students have been unaware that the lineate, "*californiae*" pattern is often suggested, and sometimes duplicated, in subspecies of *Lampropeltis getulus* inhabiting the eastern United States. In the subsequent discussion, I have followed other authors in describing the usual kingsnake pattern as "ringed," although the term is a misnomer since the transverse light markings are not complete ventrally.

The most easterly subspecies of the kingsnake is *Lampropeltis getulus sticticeps* Barbour and Engels (1942) from Okracoke Island, North Carolina. For unstated reasons the subspecies was synonymized with *L. g. getulus* by Schmidt (1953). Whatever the taxonomic status of the form, the type specimen had a tendency toward a lineate pattern in that there was a series of elongate spots on the neck and also on the tail, although the midbody was ringed. This individual recalls the *californiae* intermediates, of which Klauber (1939) stated, "Usually the striped sections are present at the head and tail, while the mid-body is ringed."

Lampropeltis g. getulus (Linnaeus), as currently defined, ranges from southern New Jersey southward into northern Florida, and westward as far as the Appalachian Mountains and southern Alabama. Specimens from above the Fall Line exhibit a blackish ground color with narrow, whitish rings; rarely is there any pronounced tendency toward lineate markings. Individuals from below the Fall Line, in Georgia and northeastern Florida, usually display a brownish-black ground color with slightly wider, yellowish rings; but often there is a middorsal line on the neck, extending posteriorly for as much as a quarter of the reptile's total length. Blanchard (1921) examined a kingsnake from eastern Virginia in which the rings were replaced by elongate spots, suggesting a vertebral light stripe. Blanchard emphasized the similarity of this example to some lineate *L. g. californiae*, but his remarks seem to have been overlooked by later students.

At the base of the Florida panhandle occurs *Lampropeltis getulus goini* Neill and Allen, marked with broad, blotch-like rings (Fig. 1, A). Of the more easterly subspecies of the kingsnake, this one shows the most frequent and the best development of a lineate pattern. All but five or six specimens, of 70 seen (including intergrades with *L. g. getulus*), showed at least a slight tendency toward striping (Fig. 1, B), and about 20 were as well striped as *californiae* intermediates described and figured by Klauber (Fig. 1, C).

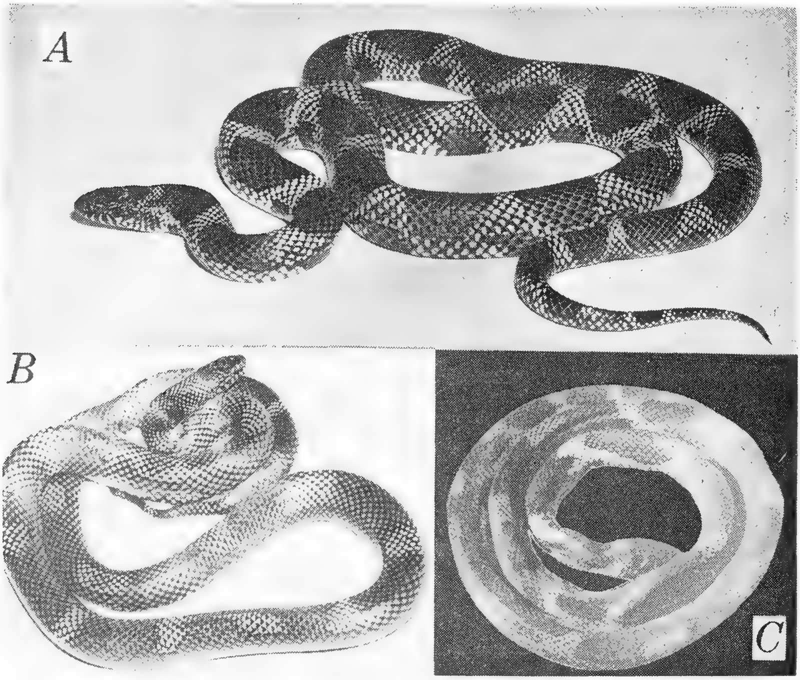


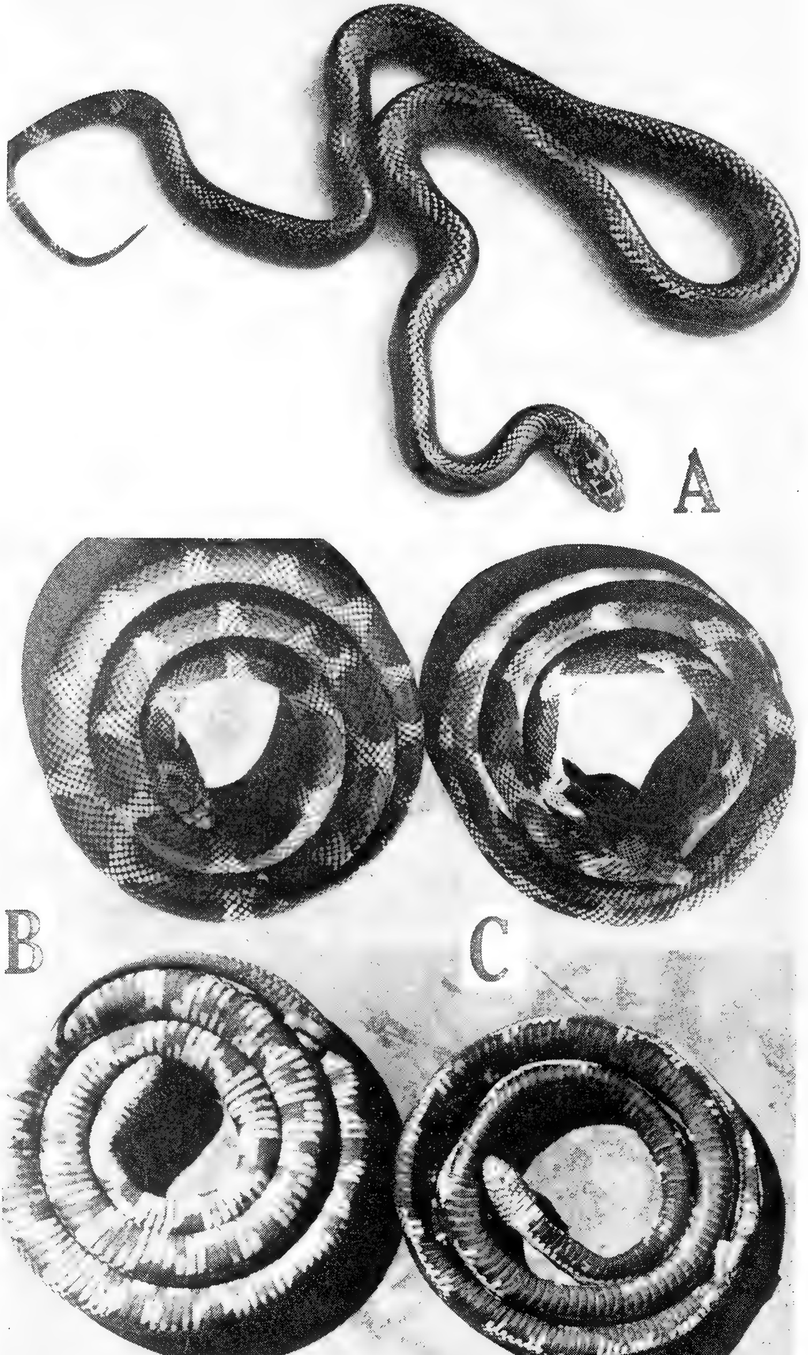
Fig. 1. Variation in *Lampropeltis getulus goini* from Gulf County, Florida. (A) Ringed pattern. (B) Light markings restricted to dorsum, suggesting a wide, broken vertebral stripe. (C) Mixed pattern of rings and stripes.

An extreme development of a lineate pattern is shown in WTN No. US-2558 from Cairo, Grady County, Georgia (Fig. 2, A). From the Cairo area I have seen about 20 kingsnakes, all more or less intermediate between *Lampropeltis g. getulus* and *L. g. goini*; and the present specimen may be considered as coming from an intergradient population. The markings include a posterior series of five saddles, one being on the body and four on the tail. Otherwise, in pattern this example closely resembles the striped phase of *L. g. californiae*. A yellow stripe, mostly about three scale rows wide, begins on the nape and extends posteriorly along the dorsal midline almost the full length of the body. As in many lineate *californiae,* the edge of the vertebral light stripe is not straight, but is laterally offset at several points. A lateral light stripe begins at the head and extends about a quarter of the length of the body; otherwise the sides are black, unmarked. In both *L. g. getulus* and *L. g. goini,* the venter is normally light-spotted, but in the present individual it is wholly black. In *californiae,* a wholly black venter is found only in the striped phase (Smith, 1943). The specimen is a female; and about 84 per cent of black-bellied *californiae* are female (Klauber, 1939). In *L. g. getulus* and *L. g. goini* there are usually some light markings on the underside of the tail; but in No. US-2558 the subcaudal region is completely black. In *californiae,* a black subcaudal region is always present in the lined, but never in the ringed, phase (Klauber, 1936; Smith, 1943).

Thus, No. US-2558, from the edge of the *Lampropeltis getulus goini* range, exhibits most of the peculiarities of the striped phase of *L. g. californiae;* while other *goini* and examples of *L. g. getulus,* as well as *L. g. sticticeps* if this latter prove valid, resemble the *californiae* intermediates which Klauber (1939) figured under the headings of "broken stripe" and "mixed ringed and striped." In *goini,* as in *californiae,* a dark, unspotted venter is found only in association with a strong tendency toward a lineate dorsal pattern (Fig. 2, B, C). Almost surely the same genic mechanism, at work in southern California, is also responsible for the occasional development of a wholly or partially lineate dorsal pattern, and a dark venter, among kingsnakes of the eastern United States.

The occurrence of a lineate pattern in both eastern and western subspecies of *Lampropeltis getulus* is not readily explained by a theory of interspecific hybridization in the past. Such a theory would imply that two distinct but closely related species of kingsnakes, one ringed and the other striped, once ranged sympatrically from the Atlantic to the Pacific; that the striped one in the range of *L. g. "boylii"* showed all the *boylii* characters except pattern, in the range of *L. g. goini* showed the *goini* characters except pattern, etc.; and that the striped one somehow blended into the ringed one everywhere, to a greater or lesser degree depending on locality.

Fig. 2. Variation in *Lampropeltis getulus goini.* (A) Almost full development of lineate pattern in WTN No. US-2558 from Cairo, Grady County, Georgia. (B) Dorsal pattern without lineate tendency, venter light-spotted in WTN No. US-2559 from Wewahitchka, Gulf County, Florida. (C) Dorsum with strong lineate tendency, venter predominantly dark in WTN No. US-2560 from Wewahitchka.


A
B
C

It is much more reasonable simply to postulate that a single widespread species, *L. getulus*, has the genetic potentiality of producing a lineate pattern along with the more common ringed one.

POLYCHROMATISM IN OTHER SNAKES

Time has shown that Klauber was correct in suggesting that *Masticophis flagellum frenatum* and *M. piceus* were but color phases; and this also proved to be the case with *Sonora miniata* and *S. semiannulata*, although *Phyllorhynchus browni* and *P. decurtatus* are still maintained as separate species. Smith (1952a) mentioned a possibility of dichromatism in the snake genus *Rhinocheilus*.

Smith (*idem*) also stated that there is an "unusual abundance in western United States, as compared with other parts of the continent, of dichromic snakes . . . " This statement has been widely accepted. However, to evaluate the contention one must first decide what constitutes ophidian dichromatism. Of course, dichromatism is but a simple form of polychromatism, which has been defined by geneticists, taxonomists, and students of several animal groups. But herpetologists, discussing pattern variants in American snakes, have usually ignored this body of literature. Hecht and Marien (1956), and J. M. Savage therein, are notable exceptions; they describe mimetic polychromatism in South American snakes of the genera *Oxyrhopus* and *Atractus*.

Riemer (1958) saw eight striped and five partially striped *Pituophis melanoleucus catenifer* from an area about 250 miles long, and concluded that there is a striped phase in this snake, comparable to the lineate phase of *Lampropeltis getulus californiae*. This conclusion is not challenged. But Riemer also set apart *P. m. catenifer* and *L. g. californiae* from all other snakes exhibiting the pattern alternatives, lineate vs. transverse, on the grounds that in all others the striped individuals occur "singly at unpredictable times and places." Should the existence of a dichromatic phase in *P. m. catenifer* have been ruled out if collections had chanced to yield, say, just three somewhat striped individuals, or just one? Should it have been ruled out if the actual specimens had come from an area three times as large, or ten times?

A partially or thoroughly lineate pattern has been reported as a rare to fairly common variant in many snakes that are usually blotched, ringed, or cross-banded. Examples include *Elaphe guttata emoryi, Lampropeltis c. calligaster, L. doliata gentilis, Sonora semiannulata isozona, Simophis rhinostoma, Agkistrodon c. contortrix, A. c. mokeson, Bothrops alternata, B. cotiara, B. jararaca, B. neuwiedii minasensis, B. n. pauloensis, Crotalus atrox, C. durissus terrificus, C. h. horridus, C. lepidus morulus, C. mitchelli stephensi, C. r. ruber, C. s. scutulatus, C. triseriatus aquilus, C. v. viridis, C. v. oreganus,* and *C. v. helleri,* as well as the hybrid combination *C. v. oreganus* X *C. s. scutulatus* (Amaral, 1932; Blanchard, *op. cit.;* Gehlbach, 1962; Gloyd, 1935, 1958; Klauber, 1956; Livezey, 1949; Stebbins, 1954).

To this list I can add *Elaphe g. guttata, E. obsoleta spiloides, Farancia a. abacura, Natrix e. erythrogaster, N. sipedon pleuralis, N. t. taxispilota* (Fig. 3), *Pituophis melanoleucus mugitus, Agkistrodon p. piscivorus, Crotalus horridus atricaudatus,* and *Lampropeltis d. doliata,* along with the previously mentioned eastern subspecies of *L. getulus.* The number of wholly or partially lineate examples known to me, from personal observation or from the literature, is one in *N. t. taxispilota,* three in *A. p. piscivorus,* 12 in *F. a. abacura,* 13 in *P. m. catenifer,* about 40 each in *P. m. mugitus* and *E. g. guttata,* etc.; but these figures are well-nigh meaningless for they do not necessarily give an idea of the frequency with which the lineate pattern occurs in nature. Most samples are small, and all are probably biased geographically. Even *L. g. goini,* with its relatively restricted range, is represented mostly by specimens from two small areas; and I have no idea what its pattern norm may be in, say, Wakulla County, Florida, whence Loftin (1962) reported a partially striped individual.

Of all snakes exhibiting a lined pattern as an alternative to a transversely marked one, only *L. g. californiae* has been sampled adequately. Klauber (1939) examined nearly 1,800 specimens from one county. Even this reptile has not been well studied in parts of its range. I believe the ratio of somewhat lined to normally blotched individuals actually is higher in *L. g. goini, E. g. guttata,* and *P. m. mugitus* than in *P. m. catenifer,* and that this ratio is exceedingly low in *N. t. taxispilota;* but other species probably fall between these extremes, and one cannot justify the selection of any point at which dichromatism begins. It is best to assume, in the absence of evidence to the contrary, that the above-listed cases, in which a snake exhibits a lineate pattern as an alternative to a more common transverse one, may all be comparable at least to a considerable degree.

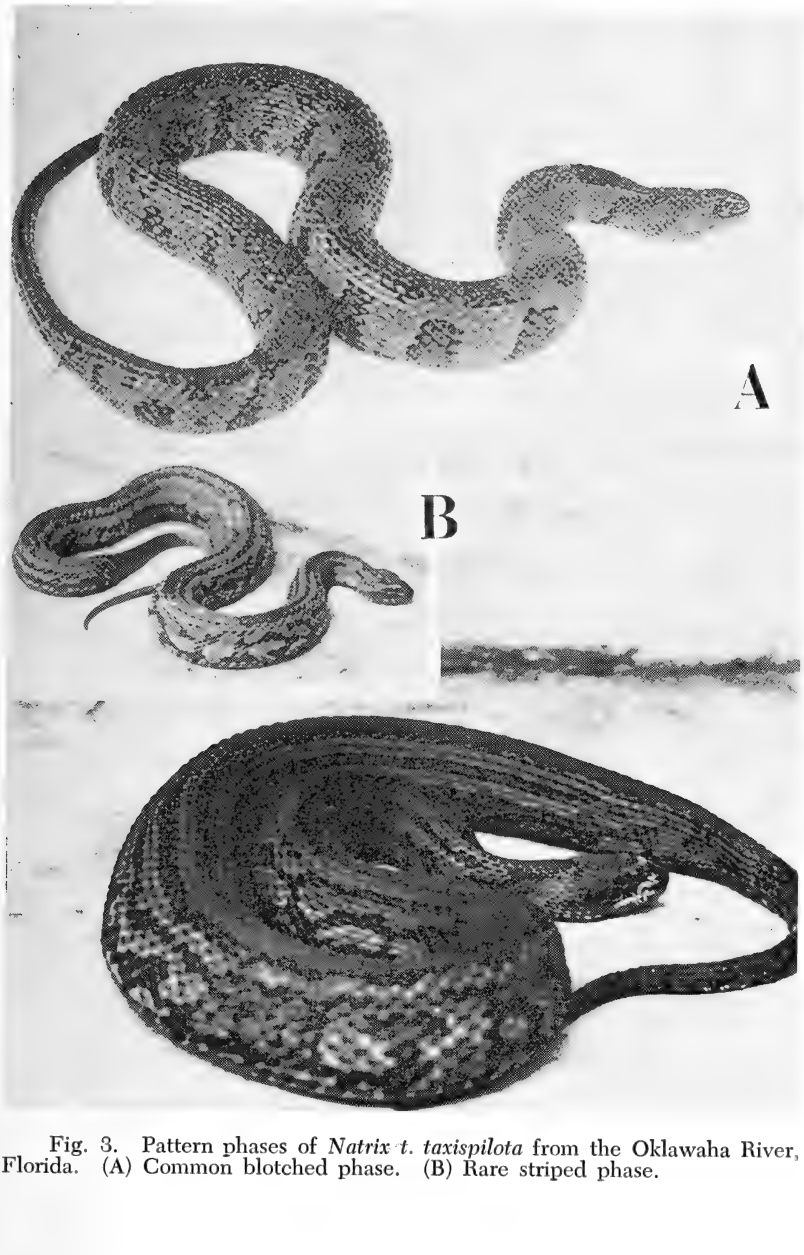


Fig. 3. Pattern phases of *Natrix t. taxispilota* from the Oklawaha River, Florida. (A) Common blotched phase. (B) Rare striped phase.

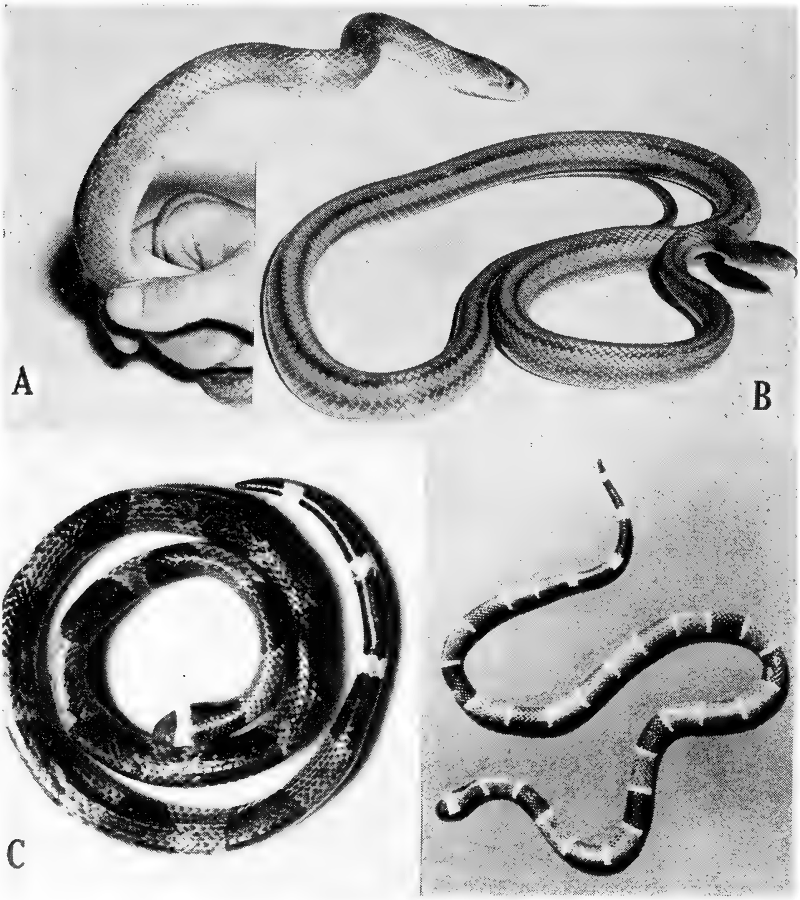


Fig. 4. Pattern dimorphism in snakes from peninsular Florida. (A) Uncommon unicolor phase and (B) common lined phase of *Elaphe obsoleta rossalleni*. (C) Uncommon saddled phase and (D) common ringed phase of *Micrurus f. fulvius*.

Some confirmation of this view may be provided by the tendency of the alternative lineate pattern to follow phylogenetic lines, as shown by the above list; and by the observation that a somewhat lineate pattern, rare in one species, may also occur rarely, or more commonly, or even as the norm, in a related species. Thus, lineate *Agkistrodon p. piscivorus* look much like the lineate *A. c. mokeson* and *A. c. contortrix* respectively figured by Gloyd (1958) and Livezey (*op. cit.*), there being an unmarked dorsum, a dark lateral band with a somewhat irregular upper edge, and the normal transverse markings on the neck, hinder body, and tail. The partially lineate pattern occurring occasionally in *Elaphe guttata emoryi* (Gloyd, 1935) and *E. obsoleta spiloides* is reminiscent of the normal condition in *E. g. rosacea,* some *E. o. lindheimeri,* and *E. o. williamsi* (Fig. 5); while in *E. o. quadrivittata* and *E. o. bairdi* the blotches are suppressed almost to the point of oblivion, leaving well-defined stripes. Several *Natrix* are normally striped, as are many species of closely allied genera. In hatchling *Farancia a. abacura* from peninsular Florida, the red ventral color extends up the sides to form rings, which may be complete but are usually somewhat interrupted dorsally. Occasionally, however, the red rings are reduced in regular fashion each to three dots, producing

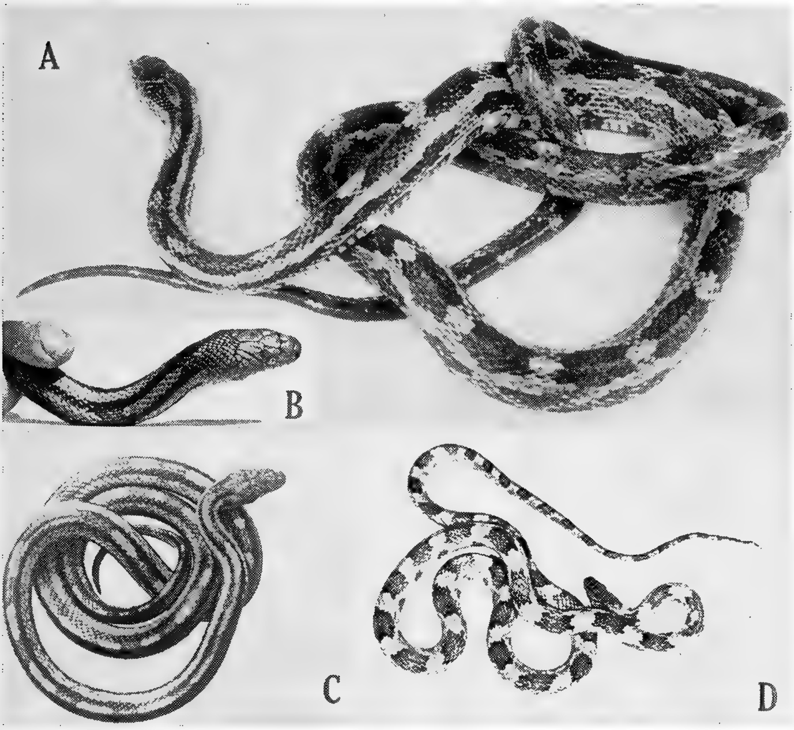


Fig. 5. Dichromatic alternatives in two related snakes. The common phase of *Elaphe obsoleta spiloides* is spotted (D). A specimen from Alabama exhibits an uncommon pattern of spots and lines (A). This latter pattern is the norm in *E. o. williamsi* from Levy County, Florida (B, C).

a dotted line down the back and one down each side of the reptile. In color and position these dotted lines are precisely like the complete stripes of *Abastor erythrogrammus,* a very closely related (actually congeneric) species.

Among the above-listed snakes, in which a lineate pattern exists as an alternative to a transversely marked one, there are seven that come from South America, and fifteen that inhabit eastern North America (excluding the subspecies of *Lampropeltis getulus*). This circumstance does not suggest any unusual concentration of dichromatic snakes in the southwestern United States. Furthermore, the discussion has so far been limited to the dichromatic alternatives, striped vs. transverse pattern; but other pattern alternatives are known. In his list of dichromatic snakes from the southwestern United States, Smith included the reptile now called *Masticophis flagellum piceus,* in which the alternatives are reddish vs. blackish. This red-black dichromatism is widespread among snakes. In species of eastern North America, it occurs throughout the wide range of *Storeria occipitomaculata;* and throughout the range of *Natrix sipedon compressicauda,* inhabiting south Florida coasts. It is found in *N. cyclopion floridana,* but only from a part of south Florida; in *Liodytes alleni* from scattered Florida localities; and in *Crotalus adamanteus,* but only from southwestern Georgia. In southern Mexico, *Stenorrhina freminvillei* has pinkish and grayish phases; in Central America, the reddish *Dryadophis sanguineus* is believed to be but an erythristic phase of *D. melanolomus alternatus.* I have not searched the literature for all reports of erythrism in usually blackish or grayish snakes, but cite Cooper (1948), Klauber (1956), Neill and Allen (1961), Stejneger (1907), and Wright and Wright (1957).

Sometimes there are more than two color phases. *Agkistrodon halys blomhoffi* is brown-banded at most localities on the main islands of Japan. A blackish phase is equally widespread but everywhere rare. A grayish phase is both rare and localized, being confined chiefly to Yamaguchi Prefecture on Honshu. A slate-colored phase occurs in Kagoshima Prefecture, Kyushu. A red phase is generally rare; but on Hachijojima, a small island south of Tokyo, it predominates. On this islet the black phase also occurs, but the common brown phase of the main islands is lacking. The distribution of all these variants has been worked out with considerable accuracy, because the Japanese popularly attribute a different medicinal value to the flesh of each phase, and afford legal protection to the especially prized gray one.

Ophidian pattern variations may be of many kinds. Limiting the discussion to species of the southeastern United States alone, one notes that *Urotheca flavilata* may be unicolor or weakly lined. *Natrix rigida* is occasionally melanistic (Etheridge, 1950). *Storeria occipitomaculata,* usually either blackish or reddish above, may occasionally be orange or yellow above; and the belly, usually red in both the reddish and the blackish phase, may occasionally be white, black, yellow, or parti-colored. *Thamnophis s. sirtalis,* generally provided with a lateral light stripe and a vertebral one, may at times lack either or both. In the Atlantic Coastal Plain population of *Lampropeltis g. getulus,* the ground color, usually brownish-black, may occasionally be yellowish, the yellow variant being at its most numerous in the region from Gainesville to Palatka, Florida; I have also seen one yellow individual of *L. g. goini,* and the discarded but probably valid subspecies *L. g. brooksi,* of southern Florida, is normally yellowish. *Elaphe obsoleta rossalleni,* usually marked with somewhat diffuse stripes, is sometimes unicolor (Fig. 4, A, B). *E. g. guttata,* usually marked with reddish and black, in many parts of Florida may completely lack the black. *Lampropeltis d. doliata* is generally marked with red, black, and yellow rings; but in parts of Florida the black rings may fuse longitudinally along the dorsal midline, and in other areas of the state all black markings may be absent. The lateral stripe in *Liodytes alleni* may be greenish, yellowish, orange, or lacking. *Pituophis melanoleucus mugitus,* strongly spotted as a norm, may also be a pale uniform tan, or a uniform medium brown, or weakly striped, or marked with weak stripes and strong spots, or so heavily suffused with black as to obscure any pattern; all these variants occur in peninsular Florida. In many areas the ground color of *Agkistrodon p. piscivorus* may be brown, olive, or black. *Crotalus h. horridus* is well known to have a yellowish and a blackish phase, with occasional intermediates. In *C. h. atricaudatus* the lateral ground color may be pinkish, gray, or yellow. In *Farancia a. abacura* the ventral ground color is normally red or pink; but a white-bellied variant has been reported at scattered localities from central Florida to North Carolina (Brimley, 1909; Hellman and Telford, 1956; Wright and Bishop, 1915). *Opheodrys aestivus* has both a yellow-bellied and a green-bellied variant in Florida and Georgia; a white-bellied variant is also known. *Crotalus adamanteus,* usually with a pattern of dorsal diamonds, is occasionally marked with narrow transverse bands, somewhat as in *C. tigris;* and I have seen one grayish, patternless individual precisely like the aberrant *C. atrox* figured by Gloyd (1958). *Micrurus f. fulvius* has a black-saddled, rather than black-ringed, phase (Fig. 4, C, D) in Florida (Meachem and Myers, 1961). *Natrix sipedon fasciata, N. s. pictiventris,* and *Heterodon platyrhinos* are described in the literature simply as "very variable," but at any given locality most specimens can be sorted into about four or five categories; some of the variation is discontinuous, *i.e.,* polychromatic. Wright and Wright *(op. cit.)* have described many pattern variants of North American snakes.

Recent investigation of snakes from southern Mexico and northern Central America suggests frequent occurrence of polychromatism in that region. Reference has already been made to the reddish vs. grayish dichromatism in both *Dryadophis melanolomus* and *Stenorrhina freminvillei;* the latter also seems to have lined and unlined phases. *Loxocemus bicolor* is dichromatic as regards ventral coloration, while *Conophis lineatus* has lined and unlined phases (Neill and Allen, *op. cit.*). To this list may probably be added *Ficimia ramirezi,* known from but a single specimen, collected in the range of *F. publia* and differing therefrom only in that the dorsal blotches are reduced in size; several other snakes are known to produce a variant with much reduced dorsal blotches. *Ninia s. sebae* has one phase with a nearly immaculate red dorsum, and another with transverse red, black, and yellow bands the full length of the body. Both phases, and intermediates, are common in British Honduras. The British Honduras coral snake, *Micrurus affinis,* a close relative of the Floridian *M. fulvius,* like the latter occasionally displays black saddles instead of rings; the saddled form in British Honduras was once given taxonomic recognition but does not seem to predominate anywhere.

I have made no extensive search of the literature relating to polychromatism in Old World snakes, but call attention to Leeson's (1950) illustration of pattern phases in the African colubrid *Psammophis sibilans,* and his remarks on the existence of three equally common color phases (green, blue, and gray) of *P. elegans;* Mao's (1962) account of lineate and brown-banded examples of the Asiatic elapid *Bungarus multicinctus,* usually cross-banded with black on a whitish ground; Gans's (1959) analysis of nine color phases among the two species of the African colubrid genus *Dasypeltis;* Mertens's (1955) portrayal of pattern phases in the African viperid *Bitis caudalis;* Bogert's (1940) discussion of a red phase of the usually grayish African elapid *Naja nigricollis,* and Loveridge's (1929) observation that this snake may also be "black, brown, khaki, olive, [or] bluish-gray, with or without markings;" Minton's (1962) figures showing several patterns of the Asiatic colubrid *Spalerosophis arenarius;* and Taylor and Weyer's (1958) notes on two phases of the African boid *Calabaria reinhardti.* Polychromatism appears to be widespread among snakes, from both geographic and phylogenetic standpoints.

DISCUSSION

It should be clear from the foregoing account that among snakes, a polychromatic variant may be very rare, fairly common, or very common in collections; as common in nature as its alternative, somewhat less common, or much rarer; widely distributed, somewhat restricted, or highly localized. This is not to contend, however, that every pattern variation in snakes should be ascribed to polychromatism.

Some variations are continuous, gradational; while by definition polychromatic variants must be discontinuous.

Some variations may also be purely phenotypic, although pattern peculiarities in snakes have rarely been linked with any environmental factor. Elsewhere I have pointed out that species of amphibians and reptiles, characteristic of inland situations, sometimes take up residence in salt-water habitats, such as strand, mangrove swamp, or salt marsh, and the individuals of these salt-water populations are apt to show color peculiarities resulting from an increase in melanin pigments (Neill, 1958). Although it is not certain that this effect is wholly environmental, I believe it to be. Simmons and Stine (1961) raised a brood of three eggs from the North American colubrid *Carphophis a. amoenus.* All the eggs became desiccated; and two of the young, upon hatching, were of normal coloration (brown above and pink below) but exhibited ankylosis of the spine at the points where the embryo was flexed within the shell. The third young was not ankylotic but was thoroughly xanthic, yellowish above and cream below. Simmons and Stine thought the xanthism was probably not the result of egg dehydration; but further investigation is needed.

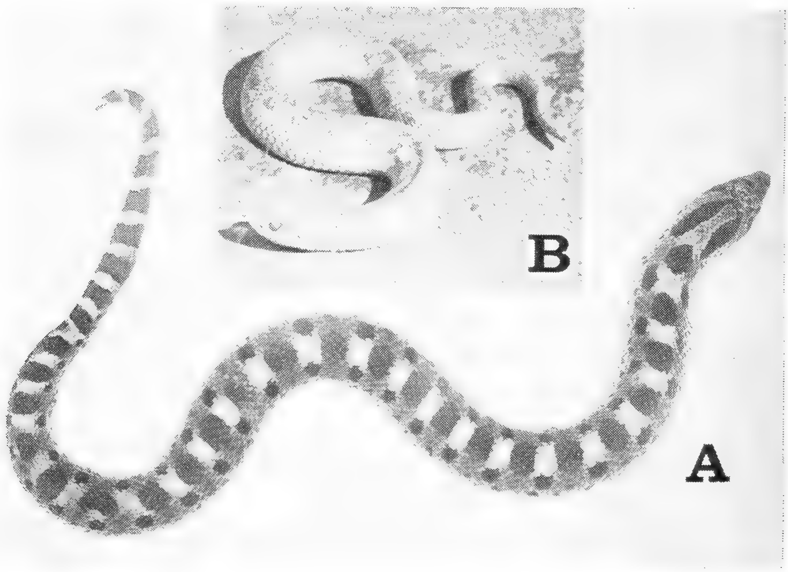


Fig. 6. A selectively disadvantageous pattern variant in *Heterodon simus* from central Florida. The normal pattern (A) is camouflaging, perhaps mimetic (of the venomous *Sistrurus miliarius barbouri*), and is produced by melanin deposits which probably facilitate thermal flux and screen against components of solar radiation. The leucistic pattern (B) is less effective in all these regards.

Some variations, discontinuous and of genetic origin, are so extreme as to jeopardize the existence of the variant individual, and render improbable the persistence of the variation (Fig. 6). The most familiar example of an extreme, selectively disadvantageous variation is albinism. It has been reported in 25 species of snakes from North America alone (Hensley, 1959), but none of these has produced an albinistic population in nature. Nevertheless, such populations are readily bred in captivity; and a wild population of albinistic *Elaphe climacophora* has developed at Iwakuni, Japan, partly in consequence of ecological isolation, but mainly as a result of artificial selection by local residents who regard white snakes as sacred (Choate, 1963). Thus even an extreme variation, normally disadvantageous, under exceptional circumstances could be the start of a polychromatic phase. As a general rule, however, the rarer of two pattern phases in one species is apt to be the usual pattern in some other species. Such characters as white venter, vertebral light stripe, unicolor dorsum, blackish suffusion, dorsal saddles, etc., each occurs in some one species only as a variant, but each also occurs as a norm in many other species.

Grotesque, often asymmetric patterns, as in a *Farancia* figured by Etheridge (*op. cit.*), or a vitiliginous *Crotalus* shown by Gloyd (1958), must be highly disadvantageous, to judge from their rarity. Extremely aberrant patterns are found much more often among juvenile snakes than among adults, as Blanchard (*op. cit.*) long ago found to be the case in the kingsnake genus *Lampropeltis.* E. R. Dunn (1942) and later authors have shown that among snakes generally, there is apt to be selection against even some slight variations of pattern and scalation; and it may be that certain seemingly minor variations are accompanied by disadvantageous peculiarities of behavior or physiology. In several neonatal snakes some obvious anatomical abnormality has been found to accompany a highly aberrant pattern (Fig. 7).

Although little is known of ophidian genetics, many cases of polychromatism, in animals other than snakes, are quite reminiscent of the situation in these reptiles; and it seems probable that but a single biological phenomenon is involved. For example, in the mouse, the genetics of which has been intensively studied, certain color variations are known to be associated with selectively disadvantageous conditions, such as peculiarities of gait, anemia or other blood disorders, ankylosis of the caudal vertebrae, microphthalmia, and abnormalities of the reproductive system.

The "burnsi" (unspotted dorsum) dominant mutant of the usually spotted frog *Rana p. pipiens* is mostly localized in a small area; the phases are inherited in mendelian fashion although with modifiers that sometimes limit the expression of the unspotted pattern (Moore, 1942; Volpe, 1960). Similarly, the striped phase of *Lampropeltis getulus californiae* is mostly localized in a small area; the striped and ringed phases are believed to be inherited in mendelian fashion but with modifiers that sometimes limit the expression of the lineate pattern (L. C. Dunn, *op cit.*). The "kandiyohi" (mottled dorsum) dominant mutant is localized in *R. p. pipiens,* is of rare and scattered occurrence in some other *Rana,* but is the norm in *R. areolata* (Anderson and Volpe, 1958; Moore, 1943, Volpe, 1955); just as the saddled (as opposed to ringed) pattern is rare and scattered in *Micrurus fulvius,* is localized in a British Honduras population of the closely related *M. affinis,* and is the norm in another relative, *M. bernadi.*

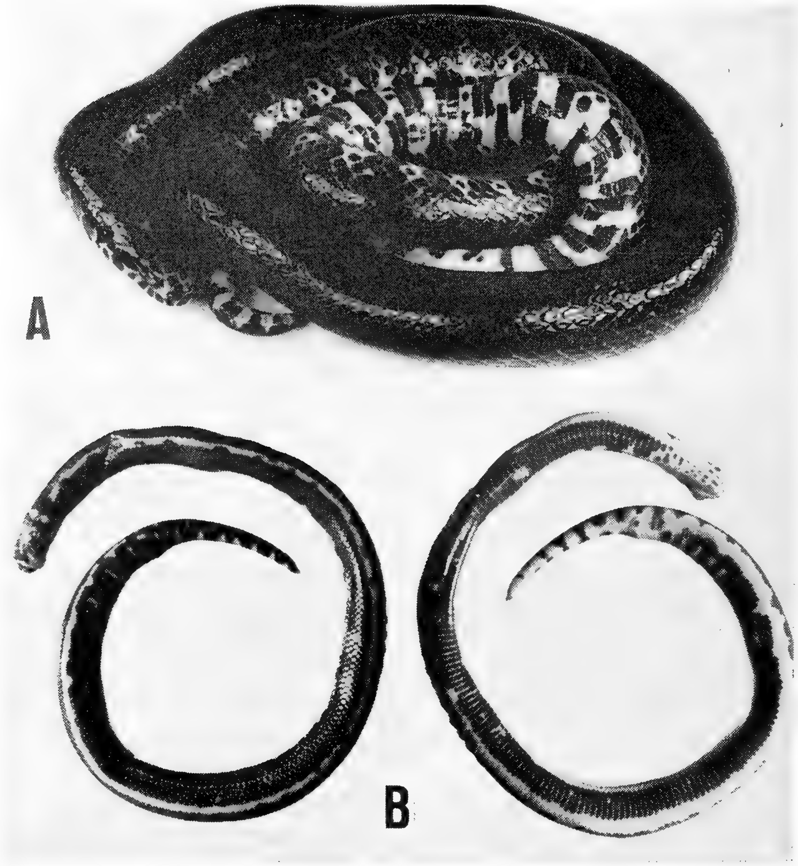


Fig. 7. An extreme pattern variant associated with an anatomical abnormality in *Farancia a. abacura* from central Florida. The normally patterned individual (A) is black except for red ventral areas which extend onto the sides. In an aberrant hatchling (B), there is a vertebral red stripe with notched edges, a light nuchal collar, narrow light bars on the hind part of the body, and a mid-ventral black stripe with light borders. The spectacle of each eye is enlarged and bulging.

The dichromatism, reddish vs. blackish, occurs not only in snakes but in such diverse groups as primates, felines, rodents, hawks, owls, lizards, toads, salamanders, and beetles.

A certain polymorphic butterfly mimics a distasteful species, but only in one pattern phase, the numerical ratio of this phase being highest in areas where the model occurs (Carpenter, 1920). In another butterfly, two polymorphic variants each mimic a different model (Ford, 1940).

Roughly comparable is the situation in *Ninia s. sebae*, a harmless snake which closely resembles the venomous *Micrurus affinis*. The mimic, at least in British Honduras where I have studied it, almost always exhibits transverse dorsal markings of red, yellow, and black in areas where the model is so marked; but where the model exhibits a reduction of its black and yellow rings to dorsal saddles, the ringed phase of *Ninia* is rare, most specimens exhibiting a reduction of the black and yellow equaling or exceeding that of the *Micrurus*. Goldschmidt (1945) speaks of the important relationship between mimicry and polychromatism.

Of course, this is not to say that snakes will yield no new information about polychromatism. These reptiles may exhibit peculiarities not often found in other animals. Thus, little is known of the forces regulating the numerical ratio of one polymorphic alternative to another. Ford (*op. cit.*) believed that polymorphic alternatives would very rarely be of equal selective value; but Mayr (1942) held that in many animals, alternative patterns are likely to be selectively neutral. Snakes should provide excellent material for an analysis of selective forces operative upon polychromatic pattern phases. For example, a striped pattern is found as a normal condition mainly in snakes that are (1) slender and very active; (2) dwellers in open places, or grassy ones; (3) arboreal among vines, twigs, and small branches; (4) primarily aquatic; or, rarely, (5) primarily subterranean; while a transverse pattern characterizes sluggish to moderately active snakes, of moderate to heavy build and living a primarily terrestrial existence in wooded areas. The eastern subspecies of *Lampropeltis getulus* belong in the latter category, and in these kingsnakes one would expect natural selection to militate against a fully lineate pattern. I am not familiar with *L. g. californiae* in the field; but Klauber (1939) found that, in this subspecies, the percentage of lined individuals was higher in captive-hatched broods than in nature, and that the lined phase was to some degree excluded from certain habitats where the ringed phase flourished. Both these findings imply that the lineate pattern is selected against in parts of California. The genetics and natural history of the kingsnake are so poorly known that one could not suggest why the striped phase has not vanished completely; fortunately, Fisher (1930) has provided a theoretical explanation for the persistence of a disadvantageous polymorphic variant.

The emphasis in herpetological literature (*e.g.*, Smith, 1952a) upon hybridization, or at least upon a recombination of former isolates with drift-induced differences, as a theoretical explanation of polychromatism in snakes, apparently stems from difficulty in understanding how a mutant color pattern, not especially advantageous selectively, could spread other than in isolation. That such spread is possible without isolation has been shown by Fisher (*op. cit.*); Kojima and Kelleher (1962) provide a more recent analysis of the topic. Of course, this is not to rule out entirely the isolation-drift-recombination sequence as a theoretical explanation for some pattern variation in snakes; but it does not seem often to have been invoked by students of polymorphism in general.

SUMMARY

A kingsnake, *Lampropeltis getulus californiae,* in southern California may be either ringed or striped, both phases sometimes occurring in a single brood. The situation is generally conceded to be one of dichromatism in a single species, but has also been ascribed to hybridization of two distinct species differing only in pattern. Dichromatism has been reported in several other snake species of the southwestern United States, and it has been contended that something in the past environment of that region has been egregiously conducive to the development of dichromatism in these reptiles.

However, it is pointed out that dichromatism is but the simplest form of polychromatism, a geographically widespread phenomenon among snakes and among many other organisms. The condition in *Lampropeltis getulus* finds many parallels, and the western United States harbors no unusually high percentage of polychromatic snakes.

Neither the distribution nor the relative abundance of a pattern variant will *per se* rule out its consideration as an example of polychromatism. Pattern variants in snakes are to be considered polychromatic unless they are of a continuous, gradational nature, or are of environmental origin. Even an extreme variation, such as

albinism, has at least the potentiality of initiating a polychromatic phase, although this is likely to take place only under exceptional circumstances.

Geneticists, taxonomists, and students of animal groups other than snakes, have often investigated polymorphism (of which polychromatism is a common form). These workers have provided a framework of fact and theory into which it is often possible to fit some of the facts regarding pattern variants in snakes. Of course these reptiles may also provide new information about polymorphism, and especially about the forces that determine the numerical ratio of polychromatic alternatives in nature.

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Quarterly Journal of the Florida Academy of Sciences

Vol. 26 September, 1963 No. 3

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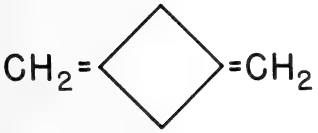
EVIDENCE FOR TRANSANNULAR INTERACTIONS IN TETRASUBSTITUTED 1,3-CYCLOBUTANEDIONES

J. E. Fernandez and A. A. More

Interactions between non-bonded atoms in the same molecule have received considerable notice in recent years. Butler (1960, 1962) has invoked such interactions to account for the "alternating intra-intermolecular cyclic polymerization mechanism". Other workers have attempted to demonstrate such interactions between atoms opposite each other in small ring compounds. Caserio et al. (1958) failed to observe any ultraviolet absorption attributable to 1,3 π-interaction in 1,3-dimethylenecyclobutane (I). 3-Methylenecyclobutanone (II) was prepared but in this case, too, 1,3 π-interaction could not be established (Caserio and Roberts, 1958).



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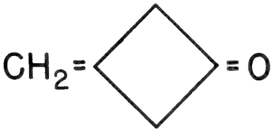
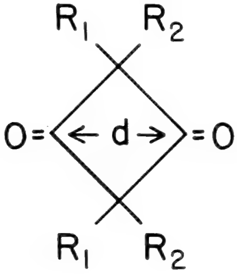


II

LaLancette and Benson (1961) were the first to demonstrate experimentally the existence of a weak 1,3 π-interaction in some derivatives of 2,2,4,4-tetramethylcyclobutanedione by measuring bathochromic shifts in the ultraviolet spectra. We now wish to report additional evidence supporting this interaction.

We have examined the ultraviolet spectra of the five tetrasubstituted 1,3-cyclobutanediones (Eastman Chemical Products, Inc., Kingsport, Tenn.) shown in Table 1.

LaLancette and Benson (1961) state that the cause of the small bathochromic shift in the band near 290 mμ is as yet unresolved since it may be due either to intramolecular charge transfer between the two carbonyl groups, or to the known sensitivity of n —> π transitions to polar environments (Goodman and Shull, 1954). In the present series of 1,3-cyclobutanediones the bathochromic shift increases with increasing size of R_1 and R_2 in both ethanol and cyclohexane solvents. The extent of transannular interaction should be enhanced by large R groups which through mutual repulsion (Ingold, 1921; Dunitz and Schomaker, 1952) decrease the distance *d*. The expected increase in absorptivity was also observed in all compounds except V.



The anomalous behavior of V can be explained by solvent effects: In this compound the butyl groups are large enough to interfere with solvation of the carbonyl groups; therefore, a change in solvent polarity would have less effect on this compound than on the others. This hypothesis is supported by the small differences observed in e_{max} of V on changing from ethanol to cyclohexane. All the other derivatives were affected markedly by the solvent change.

This research was conducted while the junior author was an Undergraduate Student Participant sponsored by Education grant No. G21888, National Science Foundation Undergraduate Science grant.

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TABLE 1

Ultraviolet Spectra of Cyclobutanediones

Absorption maxima in ethanol*

	Compound		λ_{max}		λ_{max}		λ_{max}		λ_{max}	
	R_1	R_2	mμ	e_{max}	mμ	e_{max}	mμ	e_{max}	mμ	e_{max}
I	CH_3	CH_3	227	151	284	18	296	25	306	27
II	CH_3	C_2H_5	230	149	287	26	300	32	310	36
III	CH_3	n-C_3H_7	230	200	285	30	299	45	311	55
IV	C_2H_5	C_2H_5	232	293	288	50	302	60	312	68
V	C_2H_5	n-C_4H_9	233	214	289	30	304	40	314	45

Absorption maxima in cyclohexane*

	Compound		λ_{max}		λ_{max}		λ_{max}		λ_{max}	
	R_1	R_2	mμ	e_{max}	mμ	e_{max}	mμ	e_{max}	mμ	e_{max}
I	CH_3	CH_3	227	183	284	27	297	30	304	34
II	CH_3	C_2H_5	230	202	286	29	301	36	307	40
III	CH_3	C_3H_7	230	210	287	29	301	40	307	46
IV	C_2H_5	C_2H_5	234	208	289	30	303	42	315	49
V	C_2H_5	C_4H_9	234	227	289	27	304	37	315	46

* Determined with a Beckman DU spectrophotometer using 1-Cm. quartz cells.

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CHELONIBIA IN THE NEOGENE OF FLORIDA

Arnold Ross

The present study is the second in a series on the late Tertiary and Pleistocene turtle-barnacles of Florida. The first paper (Ross, 1963b) considered the genus *Platylepas* Gray; the present report treats of the genus *Chelonibia* Leach. This study is based upon specimens obtained from the U.S. Geological Survey, the Florida State Museum collections at the University of Florida, and from the American Museum of Natural History, New York.

Chelonibia is represented in the Florida fossil fauna by two species, one variety, and one specimen of questionable identity. No new species are recorded. The collections here assembled contain 14 specimens ranging in age from late Miocene to Pleistocene. A discussion of the Recent species occurring in Florida waters was presented by Pilsbry (1916).

The specimens described and figured herein have been deposited in the Florida State Museum collections at the University of Florida (F.S.M.) and the United States National Museum (U.S.N.M.).

Order THORACICA Darwin, 1854

Family **Balanidae** Gray, 1825

Subfamily Chelonibiinae Pilsbry, 1916

Genus *Chelonibia* Leach, 1817

Chelonibia Leach, 1817, Jour. Phys. Chim. d'Hist. Nat., vol. 85, p. 68. Genus without originally designated type species; first species assigned to genus: *Chelonobia* [*sic*] *savignii* Leach [= *Chelonibia testudinaria* (Linnaeus), 1758]; therefore, *ipso facto* type species by subsequent monotypy (Leach, 1818, p. 171) and by subsequent designation of Pilsbry (1916, p. 263).

Chelonobia (error for *Chelonibia* Leach, 1817): Leach, 1818, Encyclopedia Britannica, suppl. to ed. 4-6, vol. 3, no. 1, p. 171 [see discussion of original spelling below].

Coronula: Lamarck, 1818, in part, Histoire naturelle des animaux sans vertèbres, vol. 5, p. 387, for *Coronula diadema* (Linnaeus), *Coronula balaenaris* (Gmelin), and *Coronula testudinaria* (Linnaeus) [reference to *Coronula testudinaria* only].

Coronula: Ranzani, 1818, in part, Opuscoli scientifici, vol. 2, pp. 85-86, for *Coronula testudinaria* (Linnaeus) and *Coronula patula* Ranzani [reference to species only]. (Republished *in* Memorie di Storia Naturale, 1820, pp. 50-51.)

Coronula: Say, 1822, in part, Jour. Acad. Nat. Sci. Philadelphia, vol. 2, p. 325, for *C*[*oronula*] *dentulata* Say [reference to species only].

Coronula: de Blainville, 1824, in part, Dict. Sci. Nat., vol. 32, pp. 379-380, for *Coronula bisexlobata* de Blainville, *C*[*oronula*] *testudinaria* (Linnaeus), *C*[*oronula*] *balanarum* [*sic*] (Spengler), *C*[*oronula*] *diadema* (Linnaeus), *C*[*oronula*] *tubicinella* (Lamarck), and *C*[*oronula*] *patula* Ranzani [reference to *Coronula testudinaria* and *Coronula patula* only]. (Republished *in* Manuel de malacologie et de conchyliologie, 1825, pp. 600-602.)

Astrolepas (*ex* Klein MS) Gray, 1825, Ann. Philos., new ser., vol. 10, no. 2, p. 105, for *A*[*strolepas*] *testudinaria* (Linnaeus), *A*[*strolepas*] *rotundarius* Gray, and *A*[*strolepas*] *laevis* Gray. Type species, here designated: *Astrolepas testudinaria* (Linnaeus) [= *Chelonibia testudinaria* (Linnaeus), 1758].

Asterolepas (error for *Astrolepas* Gray, 1825): Reichenbach, 1828, Zoologie oder Naturgeschichte Thierreichs, vol. 1, p. 89.

Chelonobium (error for *Chelonibia* Leach, 1817): Burmeister, 1834, Beiträge zur Naturgeschichte der Rankenfüsser, p. 5.

Chenolobium (error for *Chelonibia* Leach, 1817): Burmeister, 1834, Beiträge zur Naturgeschichte der Rankenfüsser, p. 8.

Coronula: Sowerby, 1839, in part, A conchological manual, p. 30, for *C*[*oronula*] *testudinaria* (Linnaeus), *C*[*oronula*] *balaenarum* (Spengler), and *C*[*oronula*] *diadema* (Linnaeus) [reference to *Coronula testudinaria* only].

Coronula: Chenu, 1843, in part, Illustrations conchyliologiques, unpaginated, pt. 3, pl. 1, pts. 18-19, pls. 2, 3, for *C*[*oronula*] *sulcata* Chenu, *Coronula diadema* (Linnaeus), *Coronula balaenaris* [*sic*] (Spengler), *Coronula testitudinaria* [*sic*] (Linnaeus), and *Coronula californiensis* Chenu [reference to *Coronula sulcata* and *Coronula testudinaria* only].

Chenolobia (error for *Chelonibia* Leach, 1817): Rothpletz and Simonelli, 1890, Zeitschr. Deutsche Geol. Gesell., vol. 42, p. 724; Gruvel, 1902, Expéditions scientifiques du "Travailleur" et du "Talisman," p. 29.

Chetonobia (error for *Chelonibia* Leach, 1817): Tarasov and Zevina, 1957, Zool. Inst. Akad. Nauk S.S.S.R., p. 158.

Definition. Barnacles possessing an asymmetrical, hexamerous, thick shell and exhibiting incomplete concrescence of the rostrum and rostro-lateral compartments. The sutures of the composite rostral plate are clearly discernible internally, but externally only where the shell is worn. The parietes are porous, but may be secondarily filled, and they bear septa, the basal margins of which are serrate. The "sheath" occupies the complete internal surface of the shell, but growth ridges occur only on the upper one-third or less. Along the basal margin of the sheath of each compartment there are either sutural or medial and sutural semicircular channels. The basis is flat and membraneous. The elongated-oblong opercular valves do not completely fill the orifice. The scutum and tergum are articulated by a strong chitinous ligament.

The labrum has a median notch on each side of which there is a long row of teeth. The III, IV, V, and VI pair of cirri are remarkably long. Cirri IV, V, and VI consist of numerous short segments, each segment having two pairs of long spines and little tufts of shorter spines between the longer ones.

Distribution and Habitat. Chelonibia has a world-wide distribution in tropical and warm temperate seas. Recent representatives of this genus have been reported from the Hawaiian Islands, Galapagos Archipelago, western and eastern Mexico, United States, Yucatan, Honduras, Cuba, Jamaica, Puerto Rico, St. Thomas, Venezuela, Brazil, Gambia, Congo, Mediterranean Sea, India, Viet Nam, Ceylon, Australia, and the Japanese Archipelago.

Manatees (*Trichechus*), turtles (*Caretta, Thalassochelys, Eretmochelys*), brachyuran crabs (*Callinectes, Portunus, Menippe*), horseshoe crabs (*Limulus*), and gastropods (*Busycon*) serve as substrata for this group.

Remarks. The species of *Chelonibia* form perhaps one of the better taxonomically known groups although, unfortunately, nothing is known about the general biology of these barnacles. At the present time seven species, one subspecies, and three varieties are recognized.

The earliest probable reference to a turtle-barnacle is by Ulyssis Aldrovandi (1606). This species (*C. testudinaria*), ranging stratigraphically from middle or upper Miocene to Recent (Withers, 1953), however, is credited to Linnaeus (1758). *Chelonibia caretta*, described by Spengler (1790; type locality unknown), is reported only from lower Miocene deposits of Pemba Island, Zanzibar Protectorate (Withers, 1928). The third species referred to this group, *C. patula*, was described by Ranzani (1818) from Recent specimens occurring in the Adriatic Sea. *Chelonibia patula* has been cited in the fossil record of Europe and is here reported from the late Miocene of Florida. *Chelonibia patula dentata* Henry is a contemporary west Mexican form of this species. *Chelonibia manati* Gruvel (1903), from the Congo, is known only from Recent specimens. Pilsbry (1916) described two varieties of this species, *crenatibasis* and *lobatibasis;* the latter from Florida waters, the former from an unknown locality. The remaining three species referred to this genus are based solely on late Tertiary specimens: *C. capellinii* de Alessandri (1906) from the middle Miocene (Helvetian) and Pliocene (Astian) of Italy, *C. hemisphaerica* Rothpletz and

Simonelli (1891) from the Pliocene of Grand Canary, and *C. depressa* Seguenza (1876) from the Pliocene (Astian) of Sicily.

Many taxonomists have failed to note the correct spelling of the generic name. The original orthography is *Chelonibia* (Leach, 1817) where as in a later paper by the same author (Leach, 1818) it is *Chelonobia,* the difference being merely a change in the connecting vowel. There is no evidence from the original publication of an inadvertent error, and furthermore, the original spelling does not contravene any mandatory articles of the International Code of Zoological Nomenclature. Therefore, the original spelling is here adopted unequivocably. No attempt was made to ferret out and list in the above generic synonymy all of the misspelled citations of *Chelonibia* inasmuch as they would fill several pages.

Since Linnaeus first described *C. testudinaria,* type species of the genus *Chelonibia,* no subsequent worker has redescribed or figured the type specimens. It appears questionable that Darwin ever saw any of the Linnean cirriped types because no mention of them is found in any of his monographs. Darwin does, however, acknowledge several conversations with Sylvanus Hanley concerning the Linnean cirriped collections. Hanley, the first taxonomist to review the Linnean collections, stated (1855, p. 18), "The very bad condition of the majority of the Cirripedes in the Linnean cabinet, and the absence of appended numerals to the specimens, prevent much aid being derived from an examination of the types."

Recently, Dodge (1952) reviewed the barnacles described by Linnaeus and stated (p. 24), "The specimens in the collection are in bad condition and bear no identifying names or numbers," thus reaffirming Hanley's earlier observations. Mr. S. P. Dance of the British Museum (Natural History) has informed the author that "A specimen, labelled by Hanley, *Lepas testudinaria,* is included [in the Linnean Society of London collections] but is devoid of any markings or of any other evidence proving it to be Linnean" (letter of January 9, 1963).

It is well known that Linnaeus marked a name or a number on each shell described from his collections, corresponding to their position in either the 10th or 12th edition of the "Systema." Smaller shells were placed in tin boxes and the boxes likewise marked in his own hand. The question now arising is whether the sole specimen of *C. testudinaria* in the Linnean Society of London collections is the one described personally by Linnaeus or one placed there by someone else prior to Hanley's study. The dubious source of the Linnean barnacles that Hanley examined may be the reason why Darwin and subsequent workers have neither mentioned nor figured *C. testudinaria.*

Aurivillius (1894) briefly described the specimens identified by Linnaeus in the "Museum Ludovicae Ulricae" catalogue (Linnaeus, 1764), but as Dodge (1952) and earlier workers have indicated, none of the species described in this work, which are now housed at the University of Upsala, Stockholm, bear the probative notations of Linnaeus.

The criteria used by Hanley, Dodge, and other taxonomists for positive identification of Linnean specimens has been the aforementioned markings and specimen containers. Inasmuch as these workers, as well as Mr. S. P. Dance, indicated that the isolated specimen of *C. testudinaria* is devoid of these markings, it is the author's opinion that this specimen is not the holotype. Designation of a neotype is currently being undertaken by the writer.

Chelonibia patula (Ranzani), 1818

Figs. 1 *a-d*

Coronula patula Ranzani, 1818, Opuscoli scientifici, vol. 2, p. 86, pl. 3, figs. 25-28, Recent, Adriatic Sea.

Chelonibia patula; Withers, 1929, Ann. Mag. Nat. Hist., ser. 10, vol. 4, p. 569, pl. 11, figs. 8-12, lower Miocene, Péloua, France; upper Miocene, Kalksburg, Austria.

Chelonibia patula; Withers, 1953, Catalogue of fossil Cirripedia in the Department of Geology, vol. 3, Tertiary, pp. 57, 58, 61, 62, 69, 75, lower Miocene, France; middle Miocene, Italy; Pliocene, Italy; upper Miocene, Austria.

This species is represented in the present collections by two specimens, one of which is a left lateral or carino-lateral compartment. The second specimen is a portion (right rostro-lateral compartment) of the composite rostrum. No significant differences can be noted between these and Recent specimens, and thus no light is shed on the phylogeny of this group.

Chelonibia patula is easily identified by the light fragile shell, thin outer lamina, and relatively few and thin longitudinal septa. The interseptal spaces, which are not secondarily filled, extend to

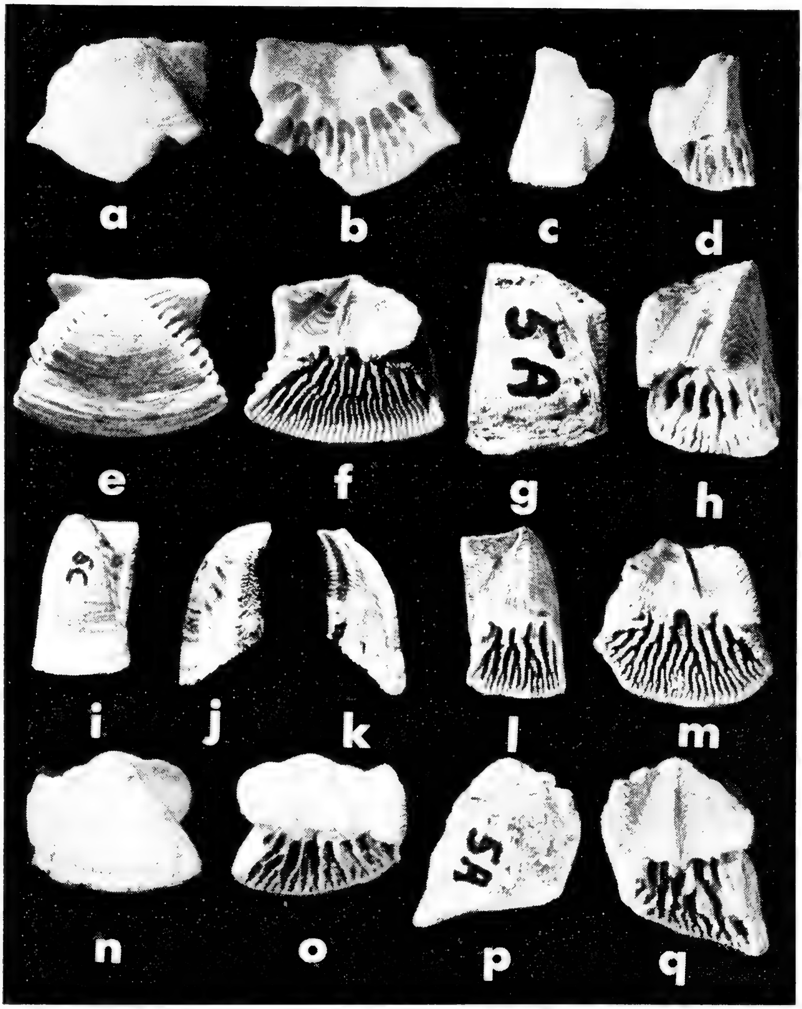

Fig. 1. *Chelonibia patula: a, b,* external and internal views of left lateral or carino-lateral, F.S.M. No. 1320; *c, d,* external and internal views of right rostrolateral, F.S.M. No. 1321. *Chelonibia testudinaria: e, f,* external and internal views of right lateral or carino-lateral, U.S.N.M. No. 648509; *g, h,* external and internal views of right rostro-lateral, F.S.M. No. 1322; *i, j, k, l,* external, radial, alar and internal views of right rostro-lateral, F.S.M. No. 1323; *m,* internal view of left lateral or carino-lateral, F.S.M. No. 1324; *n, o,* external and internal views of left lateral or carino-lateral, F.S.M. No. 1325; *p, q,* external and internal views of right lateral or carino-lateral, F.S.M. No. 1326. All figures approximately X2.

the apex of the parietes. The basal margin of the sheath has only one broad medial arch.

The sutural face denticulation of the rostro-lateral compartment, where articulating with the rostrum, consists of numerous, parallel, downward-opening V-shaped ridges, the inner arm of which is the shortest. The same denticulation occurs on Recent specimens of this species.

Chelonibia caretta, which has not been found in the Florida fauna, may be distinguished from this species and *C. testudinaria* by the absence of interseptal cavities, sutural channels or arches only, and parietal septa which are not continuous from the periphery to the sheath, but are divided into moderately short, separate portions or merely points.

Locality and Horizon. State Road Department borrow pit (N.E. ¼ S.E. ¼ sec. 24, T. 38 S., R. 24 E., Arcadia Quadrangle) along Florida Highway 760, approximately 1.6 miles east of the junction of U.S. Highway 17 and Florida Highway 760 at Nocatee, De Soto County, Florida, Tamiami formation, late Miocene, Arnold Ross collector, September, 1959.

Chelonibia testudinaria (Linnaeus), 1758

Figs. 1*e*-*q*, 2*a*-*g*

Lepas testudinaria Linnaeus, 1758, Systema naturae . . ., 10th ed., p. 668, Recent, type locality unknown.

Chelonobia [*sic*] *testudinaria;* de Alessandri, 1906, Paleont. Italica, vol. 12, p. 314, pl. 18, figs. 6a-b, 7a-b, Pliocene, Orciano (Toscana), Italy.

Chelonibia testudinaria; Withers, 1953, Catalogue of fossil Cirripedia in the Department of Geology, vol. 3, Tertiary, pp. 62, 75, Pliocene, Italy; middle or upper Miocene, Cuba.

Chelonibia testudinaria; Ross, 1963a, The Compass, vol. 40, no. 4, p. 229, Pleistocene, Florida.

Chelonibia testudinaria; Ross, 1963b, Quart. Jour. Florida Acad. Sci., vol. 26, no. 2, p. 156, Pleistocene, Florida.

Ten specimens in the collections are assigned to this species. Three of these are portions (two right rostro-lateral and one left rostro-lateral compartment) of the incompletely fused rostral plate. The remaining specimens here represented are a carina, four right and two left lateral or carino-lateral compartments.

This species is distinguished from other *Chelonibia* by the thick and strong parietes with teeth or notches on both sides of each suture. It should be noted here that some specimens do not

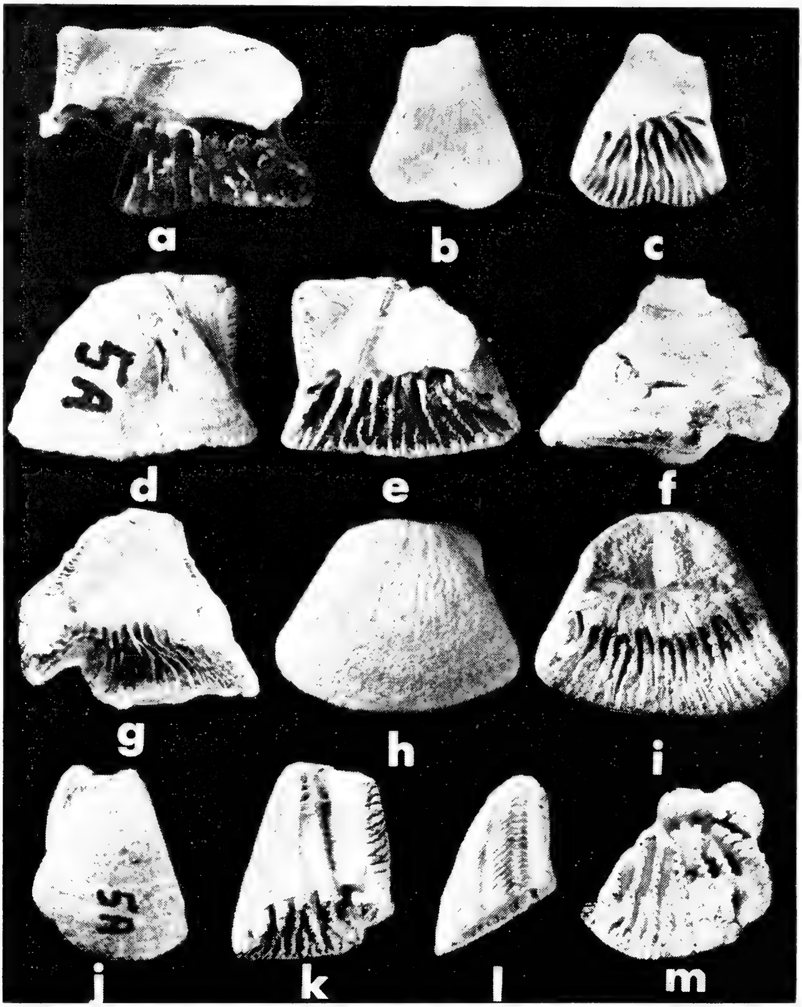

Fig. 2. *Chelonibia testudinaria: a,* internal view of right lateral or carino-lateral, U.S.N.M. No. 648510; *b, c,* external and internal views of left rostro-lateral, U.S.N.M. No. 648511; *d, e,* external and internal views of right lateral or carino-lateral, F.S.M. No. 1327; *f, g,* external and internal views of carina, F.S.M. No. 1328. *Chelonibia* sp.: *h, i,* external and internal views of right lateral or carino-lateral, F.S.M. No. 1329. *Chelonibia testudinaria* cf. *C. testudinaria* var. *solida: j, k, l, m,* external, internal, alar and basal views of left rostro-lateral, F.S.M. No. 1330. All figures approximately X2.

possess these teeth or notches, and identification must therefore be based upon the longitudinal septa and the number of channels in the basal margin of the sheath. The numerous longitudinal septa extend from the outer lamina inward, alternately, to a varying degree, i.e., there may be primary septa which span the complete basal margin, secondary, extending two-thirds the distance, tertiary, extending one-third or less the distance, and marginal, the shortest septa along the periphery. The interseptal spaces penetrate about two-thirds or less the height of the shell. The basal margin of the sheath possesses both sutural and medial channels. The sutural dentition of the rostro-lateral and rostral compartments of this species is similar to that of *C. patula.* The only significant difference is that instead of there being one inverted "V" there are several connected crests and troughs extending the width of the sutural face.

Locality and Horizon. Drainage ditch on Florida Highway 20 and 100, about 6 miles west of Bunnell, Flagler County, Florida, Pamlico formation, Pleistocene, J. E. Lewis collector, March, 1958.

Spoil banks next to Canal C-23 (U.S. Geological Survey Cenozoic locality 22846), St. Lucie County, Florida (sec. 24, T. 37 S., R. 37 E., Okeechobee 4 N.E. Quadrange), about 2.4 miles north of the Florida East Coast Railroad, Pamlico formation, Pleistocene, Druid and Ethel Wilson collectors.

Spoil banks adjacent to Rim Ditch Canal (U.S. Geological Survey Cenozoic locality 22805), St. Lucie County, Florida (N.E. ¼ sec. 29, T. 36 S., R. 39 E., Fort Pierce S.W. Quadrangle), on the southwest side of the canal, approximately 175 yards northwest of the Florida East Coast Railroad and about 2 miles southeast of the intersection, at bridge 27, of Shinn Road and Rim Ditch Canal (Shinn Road crosses U.S. Highway 70 about 11 miles southwest of Fort Pierce), St. Lucie County, Pamlico formation, Pleistocene, Druid and Ethel Wilson collectors, December, 1960.

Spoil banks of canals and north bank of North Fork (of Alligator Creek), west of U.S. Highway 41 (U.S. Geological Survey Cenozoic locality 22454), at Sea Lanes subdivision, Punta Gorda, Charlotte County, Florida (N.E. ¼ and N.W. ¼ N.W. ¼, sec. 20, R. 23 E., T. 41 S., Punta Gorda Quadrangle), Caloosahatchee formation, Pleistocene, Druid and Ethel Wilson collectors, December, 1960.

Chelonibia sp.
Figs. 2*h-i*

One specimen, a right lateral or rostro-lateral compartment is too poorly preserved to permit specific identification. The external ornamentation, where not obliterated, consists of equidistantly spaced, moderately broad, convex riblets. The elongated cavities between the longitudinal septa are, apparently, secondarily filled, except for a narrow zone approximately midway between the outer and inner surfaces. These cavities extend upward about two-thirds the distance toward the apex of the compartment.

This specimen appears to be an intermediate stage between *C. testudinaria* (*sensu stricto*) and the following variety.

Locality and Horizon. Spoil banks adjacent to Harvey Pond Canal, near intersection of Florida Highways 78 and S 721, Glades County, Florida. Caloosahatchee formation, Pleistocene, William K. Emerson collector, August, 1960.

Chelonibia testudinaria cf. *C. testudinaria* var. *solida* Withers, 1929

Figs. 2*j-m*

Chelonibia testudinaria var. *solida* Withers, 1929, Ann. Mag. Nat. Hist., ser. 10, vol. 4, p. 568, pl. 11, figs. 5-7, lower Miocene, Lorient, France.

Chelonibia testudinaria var. *solida;* Withers, 1953, Catalogue of fossil Cirripedia in the Department of Geology, vol. 3, Tertiary, p. 57, lower Miocene, France.

The variety *solida* was characterized by Withers (1929) as having ribbed walls, the interseptal spaces secondarily filled, and both sides of the parietes lacking notches or teeth. One compartment in the present collections, a left rostro-lateral, agrees with the diagnosis of this variety with two exceptions. The interseptal spaces on the radial side are not totally filled whereas those on the opposite side are. Secondly, there is some intimation of very poorly developed external parietal teeth.

In the author's opinion the varietal term *solida* is not worthy of recognition since preliminary studies on Recent specimens of *C. testudinaria* (*sensu stricto*) indicate that there is a variable degree of secondary interseptal filling, and development of parietal teeth or notches. The author cannot, unfortunately, presently provide ample justification for synonymizing this variety owing to the lack of sufficient fossil material.

Location and Horizon. Drainage ditch on Florida Highway 20 and 100, about 6 miles west of Bunnell, Flagler County, Florida, Pamlico formation, Pleistocene, J. E. Lewis collector, March, 1958.

ACKNOWLEDGMENTS

The author is indebted to Mr. S. P. Dance of the British Museum (Natural History) for information concerning the Linnean balanomorph Cirripedia. Mr. J. E. Lewis kindly granted the author permission to use specimens from his thesis site in advance of the completion of his study.

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EARLY MIOCENE SALAMANDERS AND LIZARDS FROM FLORIDA

Richard Estes

The sediments of the Thomas Farm, Gilchrist County, Florida, enclose the remains of a diverse early Miocene vertebrate fauna, and since their discovery in 1931 have produced the only significant North American mid-Cenozoic record of vertebrate evolution east of the Mississippi River. A list of the vertebrate fauna and references may be found in Olsen (1962).

Some lower vertebrate fossils were recovered in early phases of collecting. These included *Alligator,* the turtles *Geochelone* and *Pseudemys,* and a few snakes. The snakes were described by Vanzolini (1952) along with a lizard jaw referred by him to a new species of *Peltosaurus, P. floridanus.* There is substantial doubt that this species is valid or that the fossil originally came from the Thomas Farm; this will be discussed below. Other snake material has been described by Auffenberg (1963).

The application of washing techniques for the recovery of microvertebrate remains has increased the representation of the fauna markedly. Among the lower vertebrates, the sirenid salamander *Siren hesterna* was described by Goin and Auffenberg (1955). Frogs are also abundant: *Rana, Bufo, Gastrophryne, Scaphiopus, Hyla,* and an extinct hylid *Proacris* have been recorded (see Holman, 1961, for references).

Additional material collected by the washing technique (see McKenna, 1962, for a discussion of this method) has been recently made available to me by the Museum of Comparative Zoology, Harvard University; Florida State Geological Survey; and the University of Florida. Additional records to the herpetological fauna are described below. The new material of frogs and snakes is being studied by J. Alan Holman.

Acknowledgments and Abbreviations

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The following abbreviations are used: M.C.Z.—Museum of Comparative Zoology; U.F.—University of Florida; F.G.S.—Florida Geological Survey.

CLASS AMPHIBIA

ORDER URODELA

Family Salamandridae

Notophthalmus robustus, n. sp.

Holotype: M.C.Z. no. 3384, dorsal vertebra.

Referred specimens: M.C.Z. nos. 3383, dorsal vertebra; 3385, first vertebra; nine other unnumbered specimens. U.F. nos. 6503, two dorsal vertebrae; 3597, dorsal vertebra; two unnumbered vertebrae. F.G.S., one unnumbered vertebra.

Diagnosis: A *Notophthalmus* differing from the Recent species in having more robust vertebrae, in which the neural spines are relatively low, and the rib-bearers relatively short and stubby.

Description: The type specimen and the other vertebrae are robust in general proportions. The maximum length of centrum in the type specimen is 2.0 mm. This is the largest of the vertebrae, though they are all approximately the same size. The centrum is opisthocoelous (pseudocoelous of Soler, 1950; see Estes, 1963, for a discussion of this subject), and the small, projecting condyle is set apart from the body of the centrum by a prominent constriction. The short, stubby rib-bearers are connected throughout their length by a sheet of bone, and the ventral rib-bearer connects anteriorly to the centrum by a well-developed or slight ventral lamina, depending on its position in the vertebral column. The zygapophyses are relatively small and are placed close to the centrum. The heavy neural arch is relatively low, and is capped by a flat-topped, sculptured, and pitted deposit of dermal bone that extends anteroposteriorly about two-thirds of the total length of the vertebra. On most of the vertebrae this ornament is badly broken, but in the type and a few others it is well preserved. In all but the type it is of rather narrow side-to-side extent. The neural arch and dermal ornament are deeply notched posteriorly.

The first vertebra or "atlas" has a well-developed intercotylar process projecting anteriorly between the small oval cotyles, and the neural arch is expanded into a broad canopy over the neural canal anteriorly.

Discussion: Among Recent Salamandridae, only *Notophthalmus* and *Cynops* have neural spines capped by dermal bone having the same pattern as is seen here. *Cynops* is now restricted to Asia, and lacks the extensive pitting on the dermal cap of the neural spines found in *Notophthalmus* and the fossils. These fossils do not at all resemble the only other New World salamandrid, *Taricha,* from western North America, which lacks the dermal ornament on neural spines except on some anterior vertebrae. The fossil form differs from the several recent species of *Notophthalmus* (limited today to eastern North America) in having relatively more robust vertebrae, a condition that results in shorter, stubbier rib-bearers and a relatively lower neural spine. *N. robustus* is more different from the Recent species than they differ from each other, but the amount does not exceed interspecific variation in some other salamandrids. Most if not all of these differences can be traced to the more robust ossification in the fossil specimens. Fossil forms closely related to modern species often have more robust proportions than their descendants (see Goin and Auffenberg, 1955, for *Pseudobranchus;* Estes and Wassersug, 1963, for *Bufo*), and there is no particular reason why *Notophthalmus robustus* or related forms could not have given rise to the modern populations.

Family SIRENIDAE

Siren hesterna Goin and Auffenberg, 1955

Referred specimens: U.F. no. 6590, a broken dorsal vertebra.

Comments: This specimen differs from the material described by Goin and Auffenberg (1955) only in having a narrower angle (of about 100°) between the aliform processes. Their type specimen had a very wide angle (about 123°) between the aliform processes. Both specimens still greatly exceed the angular divergence between these processes known to occur in other fossil and Recent species of *Siren*.

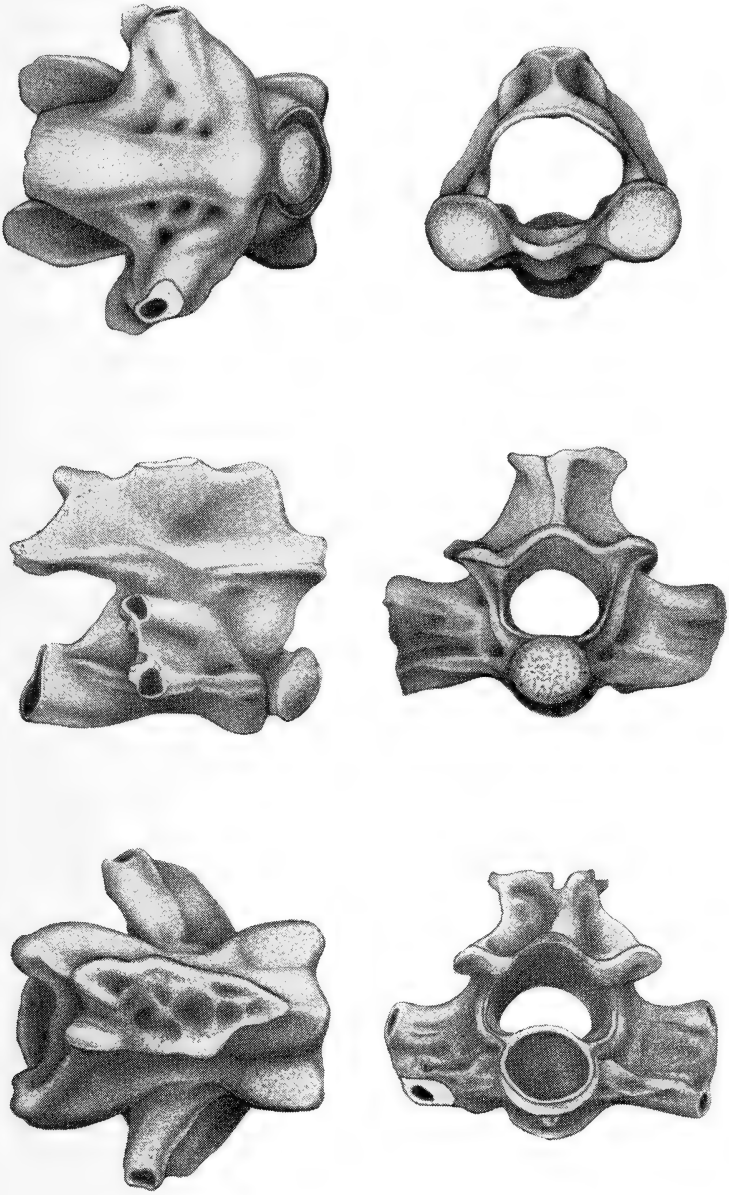

Fig. 1. *Notophthalmus robustus,* n. sp., ventral, right lateral, dorsal, anterior, and posterior views of dorsal vertebra, M.C.Z. no. 3384, type; upper right, anterior view of first vertebra, M.C.Z. no. 3385; all specimens X 20.

Family BATRACHOSAUROIDIDAE

Batrachosauroides dissimulans Taylor and Hesse, 1943

Referred specimen: U.F. no. 7802, a first vertebra ("atlas").

Description: The maximum width of the specimen across the cotyles is 14.3 mm, and maximum length of centrum at its midpoint is 7.5 mm. The tip of the neural spine is broken so that no height measurement is possible. The two deeply concave cotyles are suboval, and separated by a small, ridged intercotylar process which has only a small anterior projection. Several foramina are present on the concave ventral surface of the centrum. The neural arch is robust, and the posterior zygapophyses are well developed. The posterior cotyle is a deeply concave conical hollow. No ridges or laminae are present, and the bone is a solid, rounded, heavily ossified element.

Discussion: Batrachosauroides dissimulans is based on a large salamander skull from the Middle Miocene of the Texas Coastal Plain (Taylor and Hesse, 1943). Auffenberg (1958) described Lower and Middle Miocene vertebrae from the same region, referred them to *Batrachosauroides*, and established a new family for the genus. Auffenberg's reference of these vertebrae to *Batrachosauroides* is undoubtedly correct. The Thomas Farm specimen differs in no fundamental way from any of the six available simliar elements from Texas. Auffenberg figured one of these Texas specimens (*ibid.*, fig. 1), but the figure is too diagrammatic to give any real idea of the contours of the specimen. The cotyles of this specimen are not as circular as he shows them, nor as regular on their surfaces. In reality, they approximate the suboval condition seen in the Florida specimen and duplicated in the rest of the Texas specimens.

The presence of *Batrachosauroides* in the Thomas Farm deposits is an interesting new record for this fauna. However, it is not surprising to find common herpetological taxa in the Texas and Florida localities, in view of the similarity of mammalian faunas, probable warm-humid environment, and latitude. Additional material of this interesting genus is now under study, and I hope to include a more comprehensive look at the relationships of this animal in a later paper.

CLASS REPTILIA

ORDER SAURIA

Family IGUANIDAE

Leiocephalus sp.

Referred specimens: M.C.Z. nos. 3378, fragment of right dentary; 3379, anterior tip of left dentary; 3380, fragment of jaw with two teeth. Nine jaw fragments, some with teeth, one fragment of right dentary showing association of teeth with edentulous dentaries of the type figured. Questionably referred are a number of dorsal and caudal vertebrae, a right scapulocoracoid, slightly broken, and a right innominate bone. U.F. no. 7803, fragmentary right dentary; six tooth-bearing fragments, and a premaxilla. Questionably referred are U.F. no. 5132, dorsal and caudal vertebrae and a distal end of a right humerus; U.F. no. 5745, four right and two left dentary fragments; and a premaxilla. F.G.S., four tooth-bearing fragments; two fragments of right, and two fragments of left dentaries; a badly broken right maxilla, which has the longest complete tooth row of any referred specimen. Questionably referred are two dorsal and two caudal vertebrae.

Description: The mandible is robust, and the Meckelian groove completely and smoothly fused for almost its entire length. The pleurodont teeth have tall, slim, and straight-sided shafts, except for a slight flaring toward the crown. The latter is flattened linguo-labially into a narrow tricuspid fan-shaped structure, the central cusp largest. Each side cusp is prominently separated from the main cusp by a wide groove, which fades out at the base of the crown. These grooves lack an associated ridge, seen in many such lizard teeth, which extends from the apex of the lateral cusp to the base of the crown. The anterior teeth are unicuspate, some with slight anterior and posterior crests, paralleling the formation of lateral cusps in the more posterior teeth. On the labial side of the dentary, a clearly marked but shallow trough near the posterior end of the tooth row marks the position of a coronoid overlap on the dentary.

Discussion: The admittedly fragmentary material associated here and referred to a Recent genus may appear a slim basis for such a conclusion. However, the association of the tooth fragments with the edentulous jaws is based not only on the one specimen which shows these components in association, but for each specimen, on the characteristic pattern of pitting at the tooth bases, shape of tooth bases, spacing of teeth and similarity of preservation. In addition, the Museum of Comparative Zoology houses the best collection of iguanid skeletons available anywhere at the present time; it was prepared as a result of the generosity of the National Science Foundation. I have also been fortunate in having access to unpublished manuscripts by Richard Etheridge on *Leiocephalus* and *Anolis,* and by Dennis Staton on the construction of the iguanid mandible; I have profited a great deal by discussion of iguanid morphology and relationships with both of these gentlemen. Etheridge has suggested that the South American species of *Leiocephalus* are generically separate from the West Indian group. Among the many characters which he has used to separate the two groups is the consistent presence of flared, fan-shaped tooth crowns in the island forms; straight-sided columnar teeth in the South American species. This generic separation is followed here and indicated (until a new generic name is available for the South American species) by preceding each use of the generic name with the locality.

The fossil material can only be compared, on the basis of closure of the Meckelian groove and the form of the teeth, with observed species of the following living genera: *Brachylophus, Basiliscus, Plica,* West Indian *Leiocephalus, Liolaemus, Corythophanes,* and *Tropidurus.* Detailed tooth form, and presence of cuspate anterior teeth eliminate *Brachylophus.* Complete fusion of Meckelian groove for much of the length of the dentary eliminates *Basiliscus.* The lack of a hyperpleurodont dentition (teeth reaching to or near the base of the dentary) excludes *Plica.* The lack of anteroposterior thickenings of the tooth shafts below the lateral cusps, and the relatively greater height of the teeth precludes comparison with *Tropidurus* and *Corythophanes.* Other forms not comparable with the fossil on the basis of non-flared tooth crowns are *Proctotretus, Stenocercus, Uranoscodon,* South American *Leiocephalus,* and *Urocentron. Hispaniolus pratensis,* which agrees closely with the fossils, is probably to be included in West Indian *Leiocephalus,* fide Etheridge. Thus, *Liolaemus* and West Indian *Leiocephalus* are the only genera which can be compared with the fossils on the basis of tooth shape and Meckelian groove closure, and most spe-

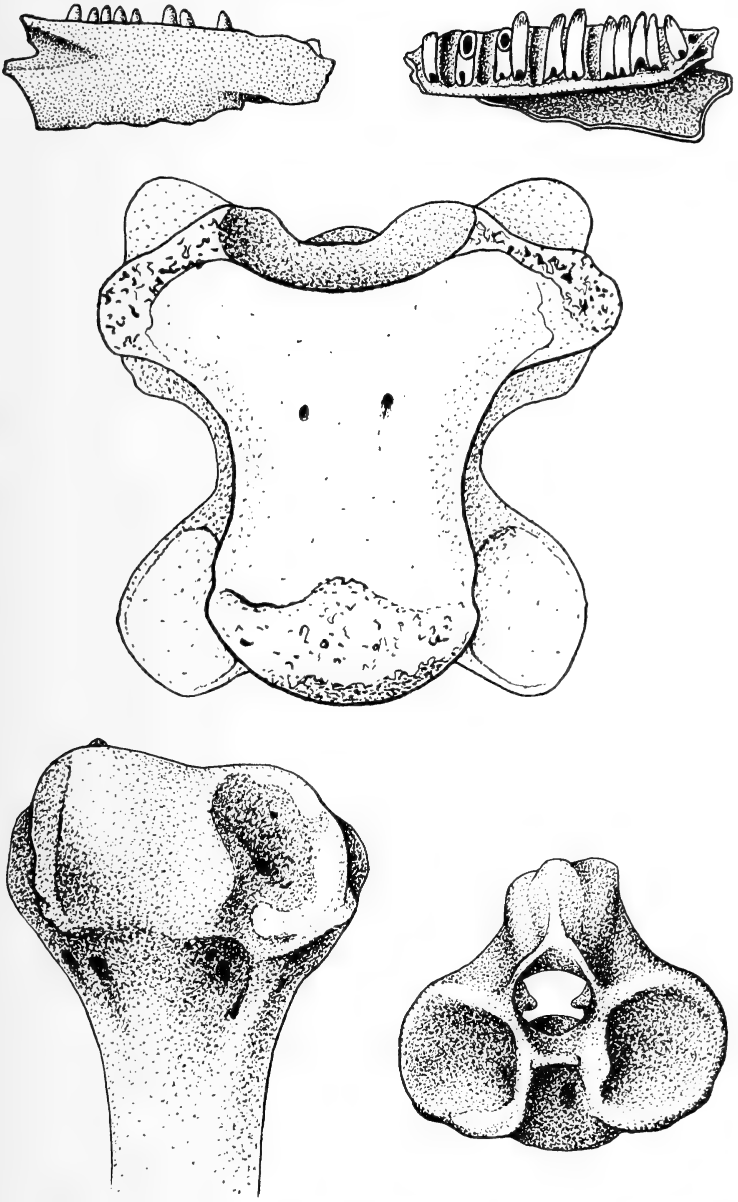

Fig. 2. Above, unidentified genus and species of Gekkonidae, labial and lingual views of right dentary fragment, M.C.Z. no. 3382, X 10. Center, unidentified genus and species of Anguidae, ventral view of dorsal vertebra, U.F. no. 1664; below left, the same, posterior view of distal end of right femur, U.F. no. 7806, both specimens X 6. Below right, *Batrachosauroides dissimulans,* anterior view of first vertebra, U.F. no. 7802, X 3.

cies of *Liolaemus* may be eliminated by the lack of flared tooth crowns.

Another character important in identification of the fossils is the presence of a posterodorsal shallow groove on the labial side of the dentary, shown in U.F. no. 7803 (fig. 3). This groove is covered in life by an anterior extension of the coronoid. Since this extension is present in *Liolaemus* and West Indian *Leiocephalus,* as well as a number of other iguanid genera, some discussion of the occurrence of this character is necessary.

The process is prominent, long, and slender in all of the "anoline" genera, and overlaps from one to as many as three of the posterior teeth. However, no "anoline" possesses fan-shaped teeth, and this group is excluded from further consideration here. Many of the so-called "iguanine" genera also possess this process; among these, *Dipsosaurus, Amblyrhynchus, Conolophus, Sauromalus, Brachylophus, Cyclura,* and *Iguana* all have a broad, wedge-shaped coronoid extension, rather than the long, dagger-like one seen in the fossils. In addition, all of these genera have quite different tooth shapes, much increased cuspation, short deep jaws, or a combination of these which serve to distinguish them from the fossils. Juvenile *Ctenosaura* have teeth very similar to those of the fossils, and also show an overlap of as many as three teeth of the posterior dentary row by the coronoid extension, as in the fossil. However, this much overlap occurs only in the largest specimens of *Ctenosaura,* many times larger than the fossils. No overlap of teeth by the process is present in juveniles of size comparable with the fossils, and in any case, the coronoid extension in *Ctenosaura* is primarily of the broad, wedge-shaped type mentioned above.

Enyalioides, Morunasaurus, and *Hoplocercus,* "iguanines" which have a dagger-shaped coronoid extension, all differ from the fossil in having open Meckelian grooves (broadly open, with large splenial, in the latter two). In tooth form, *Enyalioides* has a more fan-shaped crown with a tendency to multiply cusps beyond three, while the latter two lack fan-shaped teeth entirely.

Among the remaining iguanids, grouped essentially as "tropidurine" and "sceloporine" types, only West Indian *Leiocephalus* and *Liolaemus* possess a coronoid extension of any type. In these two genera, this process extends a variable distance anteriorly. In fifteen available species of *Liolaemus* it usually overlaps two teeth at the posterior end of the row, but may either overlap three or

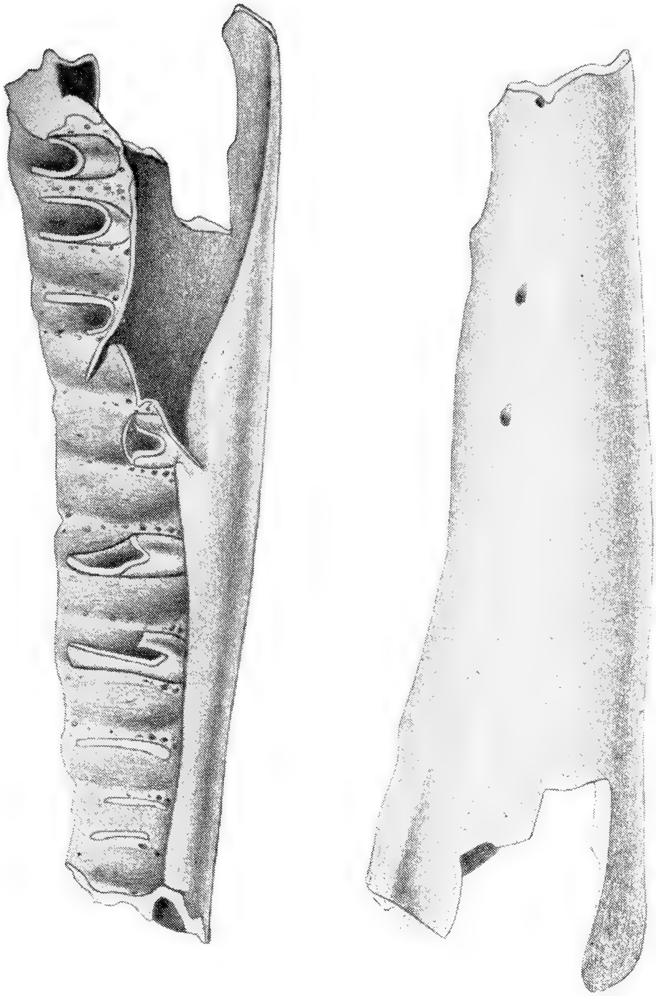

Fig. 3. *Leiocephalus* sp., lingual and labial views of right dentary, U.F. no. 7803, X 10.

none at all. In West Indian *Leiocephalus* it may be much better developed, and in *L. c. carinatus* may overlap the last five dentary teeth, though again two is the most frequent condition. A small amount of breakage obscures the true outline of the posterior end of the tooth row in U.F. no. 7803, but it is clear that at least three and perhaps four teeth were overlapped by the coronoid extension. If the latter is the case, it is another condition suggestive of West Indian *Leiocephalus,* but unfortunately this cannot be determined at this time.

However, several other considerations make West Indian *Leiocephalus* a more probable choice than *Liolaemus.* First, only one species of *Liolaemus, L. platei,* has teeth showing as pronounced a crown flare as in all West Indian *Leiocephalus. Liolaemus annectens, L. multiformis,* and *L. nigromaculatus* have weakly flared teeth, less so than in the fossil specimens and West Indian *Leiocephalus.* The other species lack flared teeth. Second, *Liolaemus* tends to have a relatively short dentary when compared with West Indian *Leiocephalus* and the fossils. Though the fossil dentaries are all broken anteriorly, their length and slenderness are still immediately apparent. Third, the Meckelian groove is open in eight of the species of *Liolaemus* available to me, and while the other seven show a fused condition, in no case is this as complete or as antero-posteriorly extensive as in West Indian *Leiocephalus* and the fossils.

On zoogeographic grounds the choice of West Indian *Leiocephalus* or *Liolaemus* becomes a West Indian vs. a South American one. Although little if anything links Florida faunistically to the West Indies during the Miocene, or for that matter at any other time, I believe that the close proximity of Florida to the Antilles makes it as likely a linkage in this case as one to South America, which was also separated from North America at this time and for some time previously.

In summary, a number of individually rather inconclusive morphological characteristics combine to strengthen confidence, I believe, in the premise that West Indian *Leiocephalus* is the most probable group to which the fossils may be referred. Since the type species of *Leiocephalus* is *L. carinatus* from Cuba, the generic name will remain with the island forms and with these fossils.

Unidentified IGUANIDAE

A number of specimens, described below, indicate that other iguanids are present in the Thomas Farm fauna. These are here referred to three unnamed species A, B, and C. By analogy with Recent iguanids, the differences between these three species suggest (insofar as the scanty material permits) that they belonged to three different genera, none of which can be identified at the present time.

Unidentified genus, species A

Referred specimens: M.C.Z. no. 2590, two teeth in a small fragment of maxilla; a single unnumbered tooth.

Description: The specimen has relatively short-crowned teeth, with rather plump bases. The main cusp is quite large and projects strongly from the occlusal surface of the tooth, and is flanked by relatively weak side cusps. The single tooth is similar, but has a more swollen base and relatively smaller main cusp.

Discussion: The label in the box in which M.C.Z. no. 2590 was found identifies the specimen as *Anolis* (?) sp., and it does resemble some of the anoles, as well as some other iguanids, in details of tooth shape; especially the combination of rather plump-based teeth with a strongly projecting main cusp. If the two specimens come from individuals of the same species, they represent different areas in the tooth row, the single tooth probably being from near the posterior part of the series. The specimens are clearly distinct from the West Indian *Leiocephalus* specimens described above, but do not warrant more precise identification.

Unidentified genus, species B

Referred specimen: U.F. no. 7804, a single fragment of left dentary.

Comments: The specimen represents an iguanid with an open Meckelian groove, and is thus distinct from the West Indian *Leiocephalus* described above. Minor differences in attachment and spacing of teeth and in the pattern of pitting at the bases of the teeth also distinguish the specimen. If the teeth described above as species A could be shown to belong to the anoles (all of which have closed and fused Meckelian grooves) then this jaw would represent a third iguanid in the Thomas Farm fauna. On the other hand, the only evidence which indicates at this time that A and B might belong together is that of parsimony. There appears to have been a difference between A and B in crown height of teeth, but as this is inconclusive they are separated here principally to indicate the potential diversity of the iguanids in this fauna.

Unidentified genus, species C

Referred specimens: U.F. no. 7805, anterior end of left dentary; an unnumbered sacral vertebra.

Description: The fossil dentary is from an individual several times larger than those representing the fossils referred to West Indian *Leiocephalus*. The Meckelian groove is closed and fused. The tooth crowns are broken and worn away, and their bases are relatively closely spaced. The area where the teeth attach to the jaw is smooth, and lacks the regular pattern of tiny foramina seen in West Indian *Leiocephalus*. The tooth shafts are deeper at their bases than in West Indian *Leiocephalus*, and their lingual faces are straight, rather than having the slight concavity seen in the latter. The vertebra is of iguanid type, and has a strong zygosphene-zygantrum articulation.

Discussion: The thickness of the teeth at their bases resembles the condition seen in iguanids having broadly leaf-shaped multicuspate teeth (e.g. *Iguana*, *Cyclura*, etc.). The best character separating this form from West Indian *Leiocephalus* is the difference in pattern of tiny foramina at the tooth attachment area. The greater size probably also differentiates this form from the latter, but in the absence of other more clear-cut characteristics, is of doubtful validity. The vertebrae referred to West Indian *Leiocephalus* also have zygosphenes and zygantra; thus size alone allows reference of the large vertebra to species C.

Summary of Thomas Farm Iguanidae

The presence of West Indian *Leiocephalus* or of a very closely related form is well documented. Fragmentary specimens allow the speculation that as many as three other iguanid species (probably belonging to three different genera) were present: species A, based on teeth having resemblances to some of the anoles; species B, based on a dentary having an open Meckelian groove; and species C, a large form perhaps related to one of the large *Iguana*-

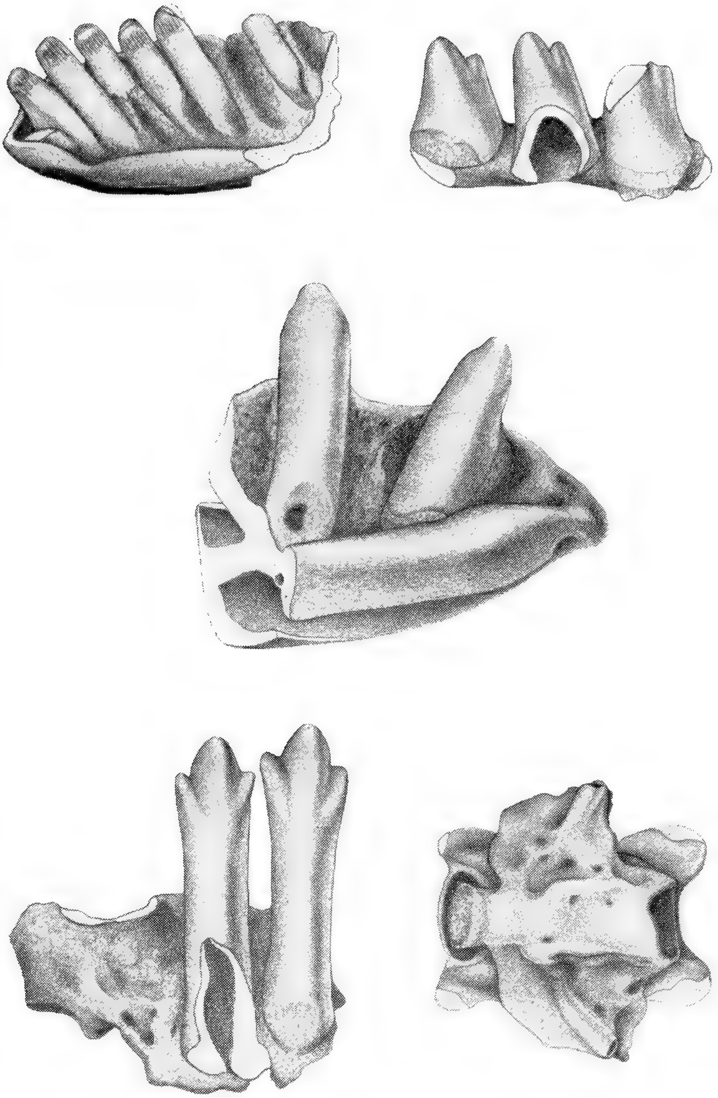

Fig. 4. Above left, *Eumeces,* sp., lingual view of anterior end of right dentary, M.C.Z. no. 3377. Above right, *Cnemidophorus* sp., lingual view of tooth-bearing fragment, probably from posterior part of maxillary or dentary series, M.C.Z. no. 3381. Center, *Leiocephalus* sp., lingual view of anterior tip of left dentary, M.C.Z. no. 3379; below left, the same, lingual view of jaw fragment bearing two teeth, M.C.Z. no. 3380. Below right, *Notophthalmus* sp., ventral view of dorsal vertebra, M.C.Z. no. 3383. All specimens X 20.

like genera. The physical possibility exists that species A and B may be synonymous, since one is based on teeth, the other on a dentary. Yet no evidence exists at this time for either alternative. I believe that species C is distinct, but without knowledge of the tooth crown pattern a firm decision cannot be made.

Family GEKKONIDAE

Unidentified genus and species

Referred specimen: M.C.Z. no. 3382, posterior tooth-bearing fragment of right dentary.

Description: The fragment bears spaces for sixteen teeth, of which eight are complete. These teeth are simple, pointed cones, lightly striated at their tips. They are rather irregularly spaced and variable in height and individual contour. At the posterior end of the tooth row there is a tiny facet for a lingual process of the coronoid. Just medial to the tooth row, the dentary is broken, with loss of the medial edge of the *sulcus dentalis.* Labially the bone is smooth, and the remains of a foramen are present anteroventrally. Posterodorsally there is a deeply-incised notch for the labial extension of the coronoid.

Discussion: The combination of numerous, small, slightly irregular, conical teeth and the deeply-incised notch for a labial extension of the coronoid is characteristic of most of the geckos. This fossil is nearly identical with Recent and fossil individuals of many different genera. The striations are variable and infrequently occurring in most modern forms, but when they do occur they are found only on the posterior teeth. I believe that there is little doubt that this fossil represents a gecko, but the lack of distinguishing characteristics in dentaries of most Recent forms precludes more specific identification.

Family SCINCIDAE

Eumeces sp.

Referred specimens: M.C.Z. no. 3377, anterior end of right dentary; two other unnumbered fragments of left dentary, one unnumbered fragment of right dentary, and two tooth-bearing fragments.

Description: The dentary fragments all show an open Meckelian groove and a slight *sulcus dentalis*. The teeth are columnar; closely and regularly spaced. The crowns are blunt, and their external surface is smooth, lingually curved, and bluntly obtuse. Most of the crowns show some evidence of wear on the tips. The inner surface of the crowns is concave and coarsely striated. The striations are short and come to an abrupt end at the base of the crown.

Discussion: The crown pattern of obtuse smooth labial side and prominently striated lingual surface, in combination with the regular and close spacing of the teeth, is unique to some species of *Eumeces*. Within the group there seem to be no strong geographical patterns as far as the various types of tooth crown patterns are concerned; these specimens resemble species from California, the Ryukyu Islands, and Kansas as much as they do the ones living in Florida today. *Eumeces* has already been recorded from the late Pliocene of North America (Taylor, 1941) and this fossil extends the record of this diverse and widely spread genus back to the early Miocene.

Family TEIIDAE

Cnemidophorus sp.

Referred specimens: M.C.Z. no. 3381, tooth-bearing fragment, probably from the posterior part of maxillary or dentary series. U.F., unnumbered fragment of right maxilla; unnumbered anterior end of right dentary. F.G.S., two tooth-bearing fragments; two fragments of right dentary; some doubtfully referred caudal vertebrae.

Description: The teeth are short near the rear of the jaw, as indicated by the figured specimen, but increase in height toward the front as indicated by the other specimens. The tooth bases are slightly swollen, and the shafts taper to the crown. The latter is bicuspid on all specimens, with the anterior cusp the smaller. Implantation is subpleurodont. The wide shelf under the tooth-bearing process indicates that the figured teeth come from the posterior part of the dentary or maxillary series. A referred dentary from the University of Florida collection is slender, pinched or narrowed near its anterior end, and has a narrowly open Meckelian groove.

Discussion: The so-called microteiids may have either bicuspid or tricuspid teeth in the posterior series, but none of them have the slender, narrowed dentary seen in the fossils, nor do any of the other lizards which possess bicuspid teeth. Among the more primitive teiids, only *Ameiva* and *Cnemidophorus* have bicuspid teeth of this sort in the posterior series associated with the slender dentary. *Callopistes* has similar teeth, but they differ in having the main cusp very much larger than the tiny anterior cusp, and the jaw shape is quite different. The other genera either have tricuspid posterior teeth or a dentition otherwise modified toward a crushing type. *Ameiva* and *Cnemidophorus* (through the taxonomy of the species usually referred to the latter is hopelessly snarled) show little to differentiate them as full genera. It has been stated (Burt, 1931) that the "retractile" tongue distinguishes *Ameiva,* but I am not certain that this is consistent or of sufficient importance for generic separation. Certainly they are very closely related, as closely as *Diploglossus* and the now synonymous *Celestus,* which were long separated on a character of no greater significance.

A practically complete representation of species of *Ameiva* and *Cnemidophorus* has been examined with respect to the presence of tricuspid or bicuspid teeth and associated characters. Among the species now grouped as *Ameiva,* bicuspid teeth occur only in the West Indian species (most consistently in the Lesser Antillean forms), though some island species, e.g. *A. exsul,* have tricuspid teeth in the posterior part of the series. No South or Central American *Ameiva* was found to have bicuspid teeth. Teeth of *Cnemidophorus* may be bicuspid or tricuspid posteriorly; some species seem to have consistently one condition or the other, in others there is considerable intraspecific variation. In addition, there seems to be no consistent geographic grouping; the two conditions appear indiscriminantly in South, Central, or North American populations. Identification of these fossils with *Cnemidophorus* rather than with *Ameiva* is primarily on the basis of zoogeographic probability. Since the primary affinity of the Thomas Farm fauna is with North America, it is perhaps more probable that the affinities of the fossils would lie with forms that are known to have been in North America as far back as the early Pliocene (Taylor, 1941 and an unpublished record from the Valentine formation in Nebraska) and that seem to have their affinities with the modern North American *Cnemidophorus.* However, the presence of West Indian *Leio-*

cephalus in the Thomas Farm fauna demonstrates that we cannot be sure that these fossils are not related to the bicuspid island ameivas.

Family ANGUIDAE

Unidentified genus and species

Referred specimens: U.F. no. 1664, complete dorsal vertebra; U.F. no. 7806, complete right femur; three other unnumbered vertebral fragments and the distal half of a left femur.

Description: The dorsal vertebra is robust, has a relatively low neural arch, small neural canal, broad zygapophyses, and lacks zygosphenes or zygantra. The centrum has concave sides when viewed ventrally, and two tiny subcentral foramina are present. The condyle is slightly abraded, but there is a slight constriction between the centrum and the wide, flattened condyle itself. One of the unnumbered vertebrae is one-half of a caudal, lacking zygosphenes, and showing clearly the presence of caudal autotomy. The other vertebrae are broken but conform to the figured specimen.

The femur has a wide, flared head, which is well separated from the trochanter major. The shaft is relatively short, and the distal articular end strongly flared. There is a well-developed popliteal fossa. The ligamentary pit between the tibial attachment surfaces is deep and irregularly shaped.

Discussion: The general shape of the vertebrae, with the low neural arch, small neural canal, and slight constriction between condyle and centrum (not to be confused with the precondylar constriction of varanoids) are characteristically anguid. The breadth of the condyle and the strongly concave ventral sides of the centrum distinguish these vertebrae clearly from those of *Peltosaurus,* in which the condyle is quite narrow and the sides of the centrum relatively straight, as in *Gerrhonotus.* In these two characters and in general aspect the fossils resemble the vertebrae of *Heloderma* (and to a slight degree those of *Ophisaurus* as well, though the ventral surface of the centrum is not flattened as in that genus, and the femora, if correctly referred, indicate a limbed form). Hoffstetter (1957, fig. 6) figures a similar vertebra for *Eurheloderma gallicum,* but it is less extreme than this specimen in centrum shape. The caudal vertebra indicates an autotomous condition of the tail, an anguioid rather than a varanoid characteristic. This caudal was referred on the basis of size, general form, and lack of zygosphenes. The only other large lizard known in the Thomas Farm fauna is a large iguanid (discussed above as unidentified genus, species C) which has strong zygosphene-zygantrum articulations on all referred vertebrae.

The femur also resembles that of *Heloderma* in the widely flared head and distal condyle. The short, stubby shaft of the bone indicates an animal with relatively short legs; a condition common in larger anguioids. The ligamentary pit between the tibial articulations may eventually prove to be useful in separating genera of anguids, when enough material has accumulated so that the pattern of variation can be understood. At this time, all that can be said is that the pattern differs from the condition seen in large *Diploglossus* and fossil *Glyptosaurus*. Recent *Gerrhonotus* is too small to make any meaningful comparison, as are the other Recent anguids, and the femur of *Peltosaurus* is unknown.

In summary, these fossils, if they belong together, seem to indicate a large, limbed anguid showing some similarities to *Heloderma*. The shape of the vertebrae are quite distinct from those of *Peltosaurus*, and in any case, the record of *P. floridanus* Vanzolini is open to question, as discussed below.

A NOTE ON THE STATUS OF *Peltosaurus floridanus*

Vanzolini (1952, p. 457), in describing the type specimen of *Peltosaurus floridanus* (M.C.Z. no. 1799), stated that the lateral dentary process of the coronoid reached farther forward than it did in *Glyptosaurus* or in other species of *Peltosaurus*. In species of both of these two genera, the lateral dentary process of the coronoid reaches to about the level of the last dentary tooth, and this is also true of M.C.Z. no. 1799.

The color of the bone of M.C.Z. no. 1799 is a pale and uniform cream, and a fine-grained, greyish-white matrix adheres in places. Stanley J. Olsen has confirmed that this matrix is unlike that of the Thomas Farm deposits, and that the natural unweathered color of Thomas Farm fossils is dark brown; M.C.Z. no. 1799 is not at all weathered. On the other hand, preservation and matrix closely resemble specimens from the Oligocene White River Formation, in which *Peltosaurus granulosus* is found. It seems probable that this specimen was actually from the White River Formation and was mistakenly placed in the box containing the specimens described by Vanzolini before he received them.

In view of this, and the absence of the distinguishing characteristic cited by Vanzolini, *Peltosaurus floridanus* is here placed in the synonymy of *P. granulosus* Cope. It is possible that the latter or a related form might occur in the Thomas Farm fauna (though I consider it improbable, and the large anguid noted above seems clearly unrelated to *Peltosaurus*), but at the present it seems best to remove the record from the faunal list.

ENVIRONMENT OF THE THOMAS FARM

The most generally accepted interpretation of the Thomas Farm deposits is that they represent the filling of a sinkhole in a porous, eroded, limestone terrain. Lack of fish remains appears to preclude connection with major stream systems, though it does not preclude small streams and ponds as part of the internal drainage pattern of the sinkhole. The presence of *Siren*, an aquatic salamander, has been thought to imply a relatively permanent source of water, but there are so few specimens that it is possible to explain the occurrence of this animal as an introduction by a predator (though I consider this unlikely). However, the abundant frogs, *Pseudemys*, and alligators indicate a pond or pool environment, so that it is fairly clear that some source of relatively permanent water was available.

Sirens live today in primarily quiet, stagnant waters, and are often found associated with vegetation mats in these localities. Recent *Notophthalmus* has such broad geographic spread and ecologic tolerances that no statements about the fossil form are warranted. Though both larvae and mature adults of this genus are aquatic, there is often a terrestrial eft stage, and at this time it is not possible to distinguish late larvae, efts, and adults on the basis of vertebral characters. The habits of *Batrachosauroides* are unknown. The absence of extensive bony crests, ridges, and keels on vertebrae of this form probably indicates that there was no extensive diversification of muscle masses usually associated with an attenuated body form, reduced limbs, and aquatic habit. However, the skull (Taylor and Hesse, 1943) indicates at least a partially larval or neotenic form, and modern analogues are invariably aquatic.

The lizards described here have (with one exception) wide ecologic tolerances and widespread geographic occurrence (*Eumeces, Cnemidophorus*), or are too poorly known for comment (all others except West Indian *Leiocephalus*). Island species of *Leiocephalus* occur today mainly in open country, and though most of the species are found in dry locations, some may also occur in damp areas.

Some of the fossil mammals (e.g. kangaroo rat, badger), insofar as these more rapidly evolving forms can be used for ecologic interpretation, also indicate relatively dry, open country, while others (e.g. the browsing horses) indicate forested situations. Thus the spectrum of habitat types found in this one deposit is broad, ranging from the relatively clear-cut aquatic habit of *Siren* and the pondside frogs, through forest dwellers, to inhabitants of dry open areas. This situation is most plausibly interpreted as a sinkhole with internal drainage (probably spring-fed, since connection with other drainage systems would be indicated by the presence of fresh-water fishes) which, as a result of the available water, drew to it animals from diverse habitats. To attract large numbers of both browsing horses and other animals adapted for dry, open country, it was probably in an ecotone between the two habitats. Perhaps there were dense thickets, or forested areas capping limestone bluffs, at the foot of which, under the massive overhanging limestone blocks, were found pools suitable for water holes. These pools supported aquatic and pondside vertebrates and might have been on the margins of more open dry country, thus attracting many plains types. The adjacent forested area would provide access for the browsers, and overhanging limestone cliffs would provide suitable habitat for the many bats also represented in the deposit. Auffenberg (1963) has interpreted the deposit as a linear fissure in the underlying limestone, in which the vertebrate remains were deposited. This fissure, which was certainly a large one, was probably part of a depression in locally-developed karst topography, as Auffenberg has suggested. The disarticulated nature of all of the Thomas Farm fossils would imply that the bones remaining after maceration were subsequently washed into the fissure, rather than the latter being a primary trap for the animals.

AFFINITIES OF THE FAUNA

Of the eleven herpetological taxa identified in this paper, it is possible to apply generic names to only six. Of these six, four (*Siren, Notophthalmus, Eumeces, Cnemidophorus*), occur in Florida today, one (*Leiocephalus*) is of West Indies affinities, and one (*Batrachosauroides)* is extinct but associated in the fossil record with other warm-humid faunas.

Similarity to the Recent Floridan fauna is heightened when the other reptiles (*Alligator, Pseudemys, Geochelone*) and amphibians (*Bufo, Rana, Gastrophryne, Hyla, Scaphiopus*) are considered. The extinct *Proacris* is the only frog not occurring there today. Thus at least twelve Recent herpetological genera have been in Florida since the early Miocene.

It is to be expected that other modern elements will be found as more material becomes available. If the large anguid vertebrae described above could be shown to pertain to *Heloderma* (as their morphology suggests) this would be an interesting intermediate record of helodermatids more closely linking the Eocene-Oligocene *Eurheloderma* of France and *Heloderma matthewi* from the Oligocene of Nebraska to the Recent distribution of this genus.

The presence of a modern West Indian type of *Leiocephalus* in the Florida Miocene is one of the few resemblances of the terrestrial vertebrate faunas between the two areas. It must not be taken, however, as evidence for land connection of any sort. At present, without greater knowledge of fossil distributional patterns and lacking greater faunal similarity between the two areas, it must be interpreted as a sweepstakes occurrence.

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OLIGOCENE BIRDS FROM SASKATCHEWAN

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ALTHOUGH more than 40 species of vertebrates are now recorded from the Cypress Hills Formation in Saskatchewan (Cope, 1891; Lambe, 1908; Russell, 1934, 1936, 1938, 1940), until now no birds were known. During the summers of 1960 and 1961 field parties from the Saskatchewan Museum of Natural History collected over 40,000 vertebrate fossils in the Cypress Hills, including the remains of three undescribed genera of birds reported herein.

According to Russell (1948), the formation is of early Oligocene age and on the basis of numerous mammalian genera is equivalent to the lowest part of the Chadron Formation of South Dakota. The sediments were deposited by rather swift streams emptying into temporary lakes. The presence of a crocodile and a boid snake suggests tropical or semitropical conditions in southwestern Saskatchewan during the early Oligocene.

The birds reported in the present paper occurred in a matrix of conglomeratic sandstone and sands with included clay pellets, along the north branch of Calf Creek, 10 miles northwest of Eastend, Saskatchewan, in Legal Subdivision 4, section 8, township 8, range 22, W. 3rd meridian; elevation, 3600 feet.

Family ODONTOPHORIDAE Gould. New World Quails

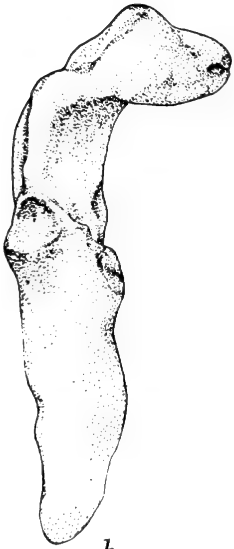
Nanortyx, new genus

Type of genus. Nanortyx inexpectatus, new species.

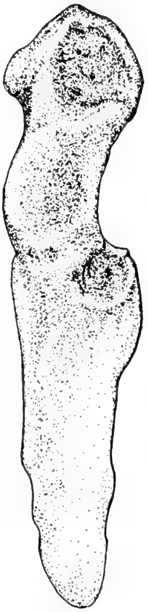
Diagnosis. Tarsometatarsus resembles that of *Lophortyx* Bonaparte but differs in having anterior surface of metatarsal III flat rather than rounded and in being only slightly elevated above metatarsals II and IV. Differs from other New World quails as above and also in having (1) shaft, proximal to distal foramen, proportionately shallow as compared to width; (2) bridge between metatarsals III and IV nearly level with their anterior surface; (3) metatarsal IV straight and thin in lateral view; (4) wing of trochlea of metatarsal II reduced.

Etymology. From Greek, *nanos,* a dwarf, and *ortyx,* masculine, quail.

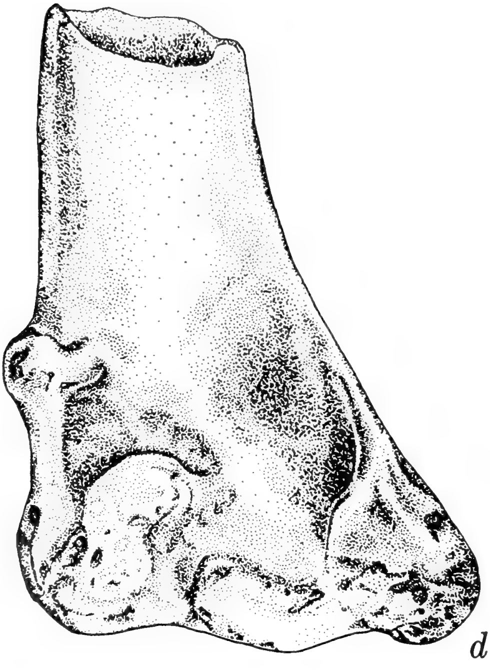
a



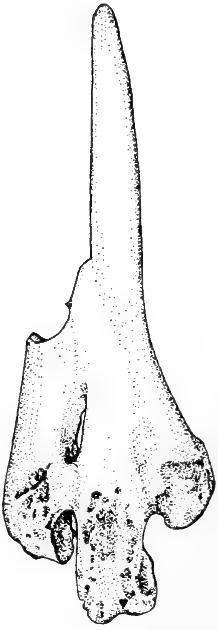
b



c



d



e

Nanortyx inexpectatus, new species

Holotype. Distal end of right tarsometatarsus, Saskatchewan Museum of Natural History, no. 1417 (plate 1, fig. *e*). Collected by Bruce McCorquodale, A. E. Swanston, and Robert D. Weigel, August 1961.

Description. Trochleae slightly worn, otherwise well preserved. Width across trochleae less than in *Lophortyx, Oreortyx* Baird, *Callipepla* Wagler, and *Cyrtonyx* Gould. Greatest width across trochleae, 5.2; width of shaft 1 mm proximal to distal foramen, 3.1; thickness of shaft 1 mm proximal to distal foramen, 1.3; length of fragment, 15.0 mm. The small foramen that perforates the bridge between metatarsals III and IV opens directly into the distal foramen. This condition was noted for *Lophortyx, Colinus* Goldfuss, and an unidentified quail from the Middle Oligocene of Colorado (Tordoff, 1951).

Referred material. Distal end of right tarsometatarsus, SMNH 1418, middle trochlea worn, extreme distal tips of inner and outer trochleae missing. Characters as in type.

Humeral end of right coracoid with head missing, SMNH 1419 (plate 1, fig. *a*). Fragment 12.0 mm long; least width of shaft, 1.6 mm. Differs from other odontophorids in smaller size and in having (1) intermuscular line much reduced; (2) procoracoid projecting posteriorly rather than medially; (3) anterior surface of shaft rounded rather than angular; (4) antero-dorsal border of glenoid facet reduced. The humeral ends of 2 additional worn quail coracoids (SMNH 1422, 1424) probably belong to this species.

Etymology. Latin *inexpectatus,* unlooked for. This is the earliest record of the New World quails.

Family SCOLOPACIDAE Vigors. Sandpipers

Paractitis, new genus

Type of genus. Paractitis bardi, new species.

Diagnosis. Coracoid agrees with scolopacids in lacking coracoidal fenestra. Closest to *Actitis* Illiger but differs from this and

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Plate 1. Birds from the Cypress Hills Formation. Figs. *a, e: Nanortyx inexpectatus,* n.g., n.sp., referred coracoid, length as preserved, 12.0 mm, and holotype tarsometatarsus, length, 15.0 mm. Figs. *b-c: Paractitis bardi* n.g., n.sp., holotype coracoid, internal and lateral views, length, 9.0 mm. Fig. *d: Neococcyx mccorquodalei,* n.g., n.sp., holotype humerus, greatest width, 6.2 mm.

other genera in having (1) coraco-humeral depression nearly round and proportionately large; (2) posterior border of coraco-humeral area at right angles to shaft; (3) ventral border of brachial tuberosity at right angles to shaft; (4) triosseal canal more deeply excavated; (5) anterior border of glenoid facet less produced, scapular facet large. Shaft below procoracoid stocky, as in *Lymnocryptes* Kaup.

Etymology. Greek, *para,* beside, and *actites,* masculine, a shore dweller.

Paractitis bardi, new species

Holotype. Humeral end of left coracoid, SMNH 1412 (plate 1, figs. *b-c).* Collected by McCorquodale, Swanston, and Weigel, August 1961.

Description. Head and neck slender. Length of fragment, 9.0; least width of shaft below procoracoid, 1.4; greatest width at humeral end, 3.7 mm.

This is the first record of the family from the Oligocene of North America. The three species of the extinct genus *Palaeotringa* Marsh (1870, 1872), from the Paleocene of New Jersey, are all much larger than *Paractitis bardi.*

Etymology. The species is named after Fred Bard, director of the Saskatchewan Museum of Natural History, in recognition of his efforts to preserve the whooping crane.

Family CUCULIDAE Vigors. Cuckoos

Neococcyx, new genus

Type of genus. Neococcyx mccorquodalei, new species.

Diagnosis. Humerus similar to living cuculids. Muscle attachment in area of ectepicondylar prominence extending onto palmar surface proximal to external condyle, as in *Crotophaga* Linnaeus, *Guira* Lesson, and *Coccyzus* Vieillot. Differs from these and other cuckoos in having (1) entepicondyle reduced; (2) ridge extending proximally from ectepicondyle to ectepicondylar prominence less angular; (3) area of attachment of anterior articular ligament flat; (4) ectepicondyle rounded and less produced; (5) intercondylar furrow shallow; (6) anconal surface of shaft at level of ectepicondylar prominence flat rather than rounded. About the size of *Coccyzus americanus* (Linnaeus), but internal condyle smaller and olecranal fossa shallower.

Etymology. From Greek *neos,* new, and *coccyx,* masculine, cuckoo.

Neococcyx mccorquodalei, new species

Holotype. Distal end of right humerus, SMNH 1420 (plate 1, fig. *d*). Collected by McCorquodale, Swanston, and Weigel, August 1960.

Description. Greatest width of distal end of humerus, 6.2; width of shaft proximal to ectepicondylar prominence, 3.4; thickness of shaft at same point, 2.2 mm.

This is the first Tertiary cuckoo from North America, although two genera are known from the Tertiary of France. *Necrornis palustris* Milne-Edwards (1871) of the Middle Miocene is represented only by leg elements and is thus not directly comparable with *Neococcyx.* The Upper Eocene or Lower Oligocene *Dynamopterus velox* Milne-Edwards (1892) and *D. boulei* Gaillard (1938) are nearly three times the size of *Neococcyx mccorquodalei. Dynamopterus* differs additionally in having the ectepicondyle and internal condyle proportionately larger, and the ectepicondylar prominence weakly developed (Milne-Edwards, 1892; Lambrecht, 1933).

Etymology. The species is named in honor of Bruce McCorquodale for his contributions to the vertebrate paleontology of Saskatchewan.

ACKNOWLEDGMENTS

I am grateful to Bruce McCorquodale, curator of paleontology at the Saskatchewan Museum of Natural History, for allowing me to study the avian specimens from the Cypress Hills. I am indebted to Pierce Brodkorb of the University of Florida and Horton H. Hobbs, Jr., of the United States National Museum for the loan of recent skeletal material. The drawings were made by Sue Lohnes and Dona Rae Goldsworthy.

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A POSSIBLE FISH-KILLING YELLOW TIDE IN CALIFORNIA WATERS

James B. Lackey and K. A. Clendenning

Red tides are not uncommon along the California coast in the vicinity of San Diego. These discolorations of the water seem to be due principally to dinoflagellates, although diatom blooms could as easily impart the reddish color to the water, and probably do at times. In the summer of 1959, a red tide was reported from Baja California which proved to be due to a ciliate, *Mesodinium rubrum.* Little attention is attracted to blooms of green organisms. They rarely kill fish. A green euglenid, probably *Eutreptia,* was supposed to have caused a fish kill off the Malabar coast of India (Hornell, 1917). Green water caused by *Prymnesium,* not green itself, has likewise been incriminated in fish kills.

The literature on fish kills caused by, or associated with, blooms of microorganisms is quite voluminous. Hutton (1956) has reviewed the published work dealing with the notorious Florida Gulf coast organism, *Gymnodinium breve,* which may produce local kills, or may affect an area 200 miles long and 30 miles wide (Lackey and Hynes, 1955) in water from 3 feet to 50 feet deep. Many other references could be cited relative to blooms in many parts of the world (U. S. Fish and Wildlife Service, 1961), but there have been few instances of reported fish kills along the California coast.

Few of the recorded cases have been sufficiently studied to identify the killing substances or mechanism. In the case of *Gymnodinium breve,* a neurotoxin is supposed to be the lethal agent (Collier, personal communication, 1963), but is still not isolated. But this is one of the few cases wherein a non-parasitic microorganism has definitely been incriminated. Industrial wastes have accounted for the majority of fresh water fish kills (loc. cit.) with agricultural poisons second. Generally oxygen depletion is suspected when a kill occurs, but since the suspected killer is frequently a photosynthetic organism, the case is not often proved unless an investigation is made while the kill is in progress. Barlow and Myren (1961), discussing the oxygen resources of tidal waters, found that the oxygen consumption was greater than its production by photosynthesis in the Forge River, a tidal stream, at a time when the phytoplankton population was near its zenith. If this is a common occurrence, it could solve more than one dilemma in regard to fish kills, and definitely incriminate oxygen depletion as a mechanism, and not necessarily the production of a toxin by a specific organism.

THE FISH KILL IN MISSION BAY

In July, 1961, a minor fish kill was reported in Mission Bay, California. The first dead fish were noticed at Asher Cove, a bathing beach; subsequently it was learned that some fish had died across the Bay in De Anza Cove, also a bathing beach. A variety of fish were killed, but not in large numbers did deaths occur except during 24 hours. Nevertheless, considerable talk and some apprehension was aroused; the tendency was to ascribe it to sewage contamination, and the health authorities were asked repeatedly if the beaches were safe. A quick check showed no chance of sewage having entered the Bay.

MICROBIOTA OF THE KILL AREA

While the kill was still in progress one of us (Clendenning), made a trip to the area and secured water samples to determine what organisms were present. These were refrigerated and examined the following day. The organisms were examined alive, after concentrating by centrifuging for 5 minutes at 2200 rpm. A Zeiss microscope with magnifications of 100X and 440X was used for counting which was done by the drop method (Am. Public Health Assn., 1960).

Table 1 shows the organisms present in Asher Cove at the time of the kill. There are several unusual features about this list. First, the number of species is only about one-half the number found in most of the summer samples in this area. Second, 13 of the 22 listed species are photosynthetic organisms (2307 per ml). While there were 1098 non-photosynthetic zooflagellates, and 10 ciliates per ml, they were mostly organisms about 5 to 12 microns in diameter. The outstanding fact is that 50.68 per cent of the total number of organisms were *Gymnodinium flavum.* The number found in Asher Cove was the highest encountered anywhere in the Bay or its environs this summer. This pale yellow dinoflagellate, about 40 microns in diameter, contains some melanic granules, but is not strongly colored. Nevertheless the water was pale yellow-brown in color, hence the term "yellow tide."

TABLE 1

Population of Asher Cove water, June 24, 1961, at time of fish kill

Organism		No/ml
Chlorococcales		
Green cells, mostly *Chlorella* sp.		120
Euglenophyceae		
Notosolenus sp.		6
Chrysophyceae		
Chrysococcus cinctus		60
Chrysochromulina spp.		60
Dinoflagellata		
Ceratium falcatiformis		51
Ceratium furca		27
Ceratium minuta		3
Dinophysis rotundatum		5
Gymnodinium flavum		1776
Gymnodinium minor		12
Gymnodinium variable		120
Gymnodinium spp.		84
Oxytoxum milneri		5
Peridinium divergens		1
Bacillariae (Diatoms)		
Detonula sp.		60
Nitzschia closterium		12
Zooflagellata		
Colorless cells (mostly *Oicomonas)*		480
Bodo sp.		12
Kephyrion ovum		600
Ciliata		
Stenosemella nivalis		1
Tintinnopsis everta		5
Tintinnopsis minuta		4
No. species ± 22	No. organisms/ml	3504

The organism was described by Kofoid and Swezy (1921) and at that time they described it as a bloom-former in the vicinity of La Jolla for a month in the summer of 1914. Apparently it has not been seen since, for very competent observers such as E. Balech failed to record its presence. Nevertheless, it was widespread around La Jolla in the summer of 1961. Table 2 gives a rough idea of this distribution. Number per ml fluctuated widely. Thus on the day following the fish kill, there were only 1104/ml in Asher Cove water, while across the sandspit there were 936/ml off the Mission Bay Yacht Club. It also showed wide variation in numbers at the surface and the 50-foot depth for a given station.

TABLE 2

Occurrence and numbers per ml of *Gymnodinium flavum* in San Diego waters, summer of 1961

Date	Sample from	Stations*											
		6	7	8	10	11	12	13	14	15	16	17	18
6–18	Top								0				
	Bottom								4				
6–21	Top	525											
	Bottom	471											
6–22	Top	336			0	0			0	0			
	Bottom	0			147	1			4	3			
6–28	Top	99	0										
	Bottom	105	2										
7–3	Top	12											
	Bottom	0											
7–10	Top	14							0	0	0	2	0
	Bottom	0							144	160	234	160	183
7–11	Top	631		0				0	0				
	Bottom	996		90				37	55				
7–12	Top	110	2676		411	156	12						
	Bottom	72	384		67	52	44						

**Stations*

6—Ballast Point
7—Point Loma
8—Scripps Institution Pier
9—La Jolla Kelp Bed, North End
10—Convair Gantry
11—Sunset Cliffs Park
12—Ocean Beach
13—Bird Rocks
14—Mission Bay Entrance
15—Oceanarium
16—Terra del Fuego
17—Crescent Bay
18—Flood Control Channel

DISCUSSION

Evidence that *Gymnodinium flavum* is a fish killer is presumptive. First, the only fish kill brought to attention in two summers' work in this area occurred where the organism attained its maximum density. Second, it is difficult to envisage an oxygen depletion in the area where the kill occurred. There are several reasons why oxygen depletion may be ruled out. The areas are not contaminated by sewage or other wastes; the general area is shallow, subject to wave action, and good circulation, temperatures were not excessive; and the algae and protozoa present were not those characteristic of anaerobic situations, but rather, one of photosynthetic activity. While no dissolved oxygen tests were run, even if the kill might have been due to oxygen depletion, this is probably the organism having the largest biomass, so it would be indirectly the killer. Finally, much larger populations of rather similar organisms occurred in Mission Bay during the summer, but no fish died. It is therefore concluded that *Gymnodinium flavum* was the cause of the limited but general fish kill in Mission Bay in the summer of 1961.

The organism is not one which might clog the gills of fish. Two dead fish were examined, and their gills showed no abnormal appearance. The most logical conclusion is that a toxin produced by *Gymnodinium flavum* is the killing agent. Cells of this species, after formalin preservation, give rise to large quantities of long threadlike materials, which tend to be straight, like acicular crystals, but which are flexible and of unknown composition. Nothing comparable has been observed by us for any other dinoflagellate. The crystals were not extruded when the formalin was first applied but appeared within 24 hours. They are strongly reminiscent of certain alkaloids. Should another bloom of this species appear, the nature of these artifacts would be worth investigation.

It is noteworthy that the bloom lasted for a month. Numbers were never comparable to those of some other known dinoflagellate blooms. *Gymnodinium breve,* for example, has attained populations of 20,000/ml or greater, whereas the highest number encountered here was 2676/ml at Point Loma on July 12 in the surface water. If any fish were killed there at this time, they were not noticed. The two small kills observed in Mission Bay were minor. But if huge numbers of the organism built up in the Bay, which has a small tidal exchange compared to Point Loma, the situation could become quite serious. Altogether, the rarity of the organism in time, its tendency to bloom when it does appear, its probability of being a fish killer, and the peculiar artifacts it yields on formalin preservation indicate that this merits further investigation.

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MOVEMENT AND DISPLACEMENT IN THE RICE RAT

Dale E. Birkenholz

Little has been added to the knowledge of certain aspects of the biology of the rice rat (*Oryzomys palustris*) since Hamilton (1946) reviewed the published data and commented on its paucity. Negus *et. al.* (1961) have conducted the most intensive field study on *Oryzomys,* focusing their attention on the ecology and population dynamics. Prior to Negus's work, patterns of movements appear to have been the least studied aspect of the biology of *Oryzomys.* Svihla (1931) marked and liberated two males; one individual was retaken 50 feet away the next day. None of four animals marked by Erickson (1949) was retaken. Pournelle (1950) reported 6 of 19 animals retaken, one immature animal traveling 270 feet and another a minimum of 222 feet overnight. Harris (1952) listed maximum recapture distances averaging 245 feet for six rice rats. The home range of 23 males averaged 0.81 acres, 12 females 0.51 acres (Negus, *et al.,* 1961). They recorded maximum movements of 1000 and 2000 feet for two adult males.

Materials and Methods

From late November 1959 to October 1960 I live trapped in a marshy grassland near Gainesville, Florida, to obtain information on the population structure, movements, and home ranges of the rice rat and to measure possible interactions between this species and the cotton rat (*Sigmodon hispidus*) which occupied the same area.

The gridded area, 600 by 800 feet in size, provided a naturally delimited piece of moist pasture land that was surrounded on three sides by marsh. It was trapped four days each month with Sherman traps 3 by 3 by 12 inches in size. Traps were located in rows 50 feet apart parallel to the shorelines and 100 feet apart in the rows perpendicular to the shoreline. Captured animals were sexed, examined to determine molt and other physical characters, and toe-clipped. They were weighed each time captured beginning in January.

Description of Study Area

The area studied consisted of marshy pasture on the periphery of Paynes Prairie, a large prairie located six miles south of Gainesville. The topography is nearly flat, and the demarcation between land and water tenuous. Pasture grasses (mostly *Andropogon* spp.), an assortment of sedges (*Carex* spp.) and rushes (*Juncus* spp.), and various annual weeds composed the principal vegetation on the drier ground. Beds of *Panicum hemitomon, Hydrotrida caroliniana, Pontederia lanceolata,* and the sedges and rushes developed along the edge of the ponds and provided dense cover which the rice rats preferred. The larger clumps furnished elevated platforms where most nests and feeding platforms were built.

Habitat conditions changed during part of the study period. When the study began in November 1959, most of the gridded area could be trapped. The water level remained fairly stable until mid-March, when it rose briefly. It then dropped gradually during the spring. The entire area could be trapped during the summer until late August when heavy rains flooded nearly the entire plot. However, heavy grazing by cattle reduced the cover in the summer, and the rice rats shifted their activities to the emergent vegetation in the adjacent marshes. The stable water conditions during the first part of the study provided an opportunity to study habitat associations and preferences.

POPULATIONS

Unmarked rice rats were taken on the last day of trapping in only one month, hence most probably were trapped in four nights. Of 39 animals captured, 23 (59 per cent) were males and 16 (41 per cent) were females. Individuals were considered as adult after the post-juvenile molt was completed (usually between 30 and 40 grams). External examination, along with necropsy of collected specimens, indicated that most males were fertile at this time. All females in this category were infertile. Hamilton (1946) declared that young rice rats are half-grown at 40 grams. On the above criteria, young animals made up one-fourth of the population during the winter months. Of the adult animals present, 75 per cent of the males and 25 per cent of the females were in breeding condition.

Weights indicated that young animals predominated in this population. The average weight of ten males was 46.2 grams (range 32 to 70 grams); that of six females was 41.3 grams (range 30 to 50 grams). No rice rats weighing less than 30 grams were taken. I assume that the young begin to wander from the nest about this time and are then available to trap.

MOVEMENTS

The validity of movement activity calculated from recapture data has often been discussed and evaluated. Brant (1962) concluded that traps spaced 50 and 100 feet apart intercept an animal's movements too infrequently in some cases to give a true measure of their activity. The trapping on Paynes Prairie indicated that the movements of rice rats were restricted, and hence the above criticism may apply here. In one sense the more widely spaced traps may actually be of advantage. Small mammals may become trap-prone and enter the same trap repeatedly. Several rice rats were taken in the same trap on consecutive nights, a behavior shown in many live-trapping studies. A high proportion of this type of activity would give an impression of restricted movement, just as widely spaced traps would be more likely to intercept and measure movements of the wide ranging individuals in a population. However, the home range values calculated below may best be used from a comparative standpoint, since the trap spacing in this study has been used commonly in other studies.

Thirty-nine animals were trapped a total of 107 times. Since many animals moved mainly along the shore lines, their recaptures, when plotted, showed more of a linear distance than a two-dimensional area. In these cases the distances between consecutive captures may give a more realistic measure of the habitat used and are shown in Table 1. Recaptures are shown according to the time elapsed since the last capture, those listed in the column titled 1-day being trapped on successive days, those in the 2-day column two days apart. Animals retaken the following months are listed in the 30-day column, and those two months later in the 60-day column.

Most average distances between consecutive recaptures increased with time (Table 1), but the maximum distances between captures at the 1 and 2-day intervals did not. The recaptures within one trapping period (1 and 2 days) should reflect wandering from a single homesite; hence the difference between the 1 and 2-day intervals may indicate that the rice rats vary their travel patterns from night to night and use different parts of the home range on different nights. However, the number of 2-day intervals is small.

TABLE 1

Distances between consecutive captures of *Oryzomys palustris* *

	1 day	2 days	30 days	60 days
Number of Recaptures	35	6	18	1
Average distance in feet between consecutive captures	95	139	220	60
Range	0–450	0–300	20–550	

* Paynes Prairie, Florida, January to September 1960.

The distance between consecutive recaptures from one trapping period to another could more conceivably result from a shift in home range or activity. This may account for some additional increase in the 30-day period. However, some rats moved as much as 450 feet in one night, a distance that approaches the intervals moved in one month.

Home ranges were calculated by the inclusive boundary method, in using from 3 to 10 recaptures in a 4-day to a 5-month period while water levels were fairly static. The ranges of nine individuals averaged 0.62 acres (extremes 0.12 to 1.80 acres). The average home range of females was slightly higher than that of males (0.72 to 0.56 acres), but the sample is small. Home ranges did not increase greatly in size when calculated from data obtained from longer periods of time, and this may indicate that the size shown here represents a single home range. Also, had water levels fluctuated greatly the animals would have been forced to shift home sites, thus biasing home range values.

INTERSPECIFIC RELATIONSHIPS

Rice rats are found in dry fields to an elevation of 1000 feet or more (Hamilton, 1946) but are more characteristic of wet regions. In the Gainesville area they are common along marsh and lake borders and on Paynes Prairie are most abundant in the grassy vegetation surrounding the ponds and sloughs. They sometimes use the abandoned houses of *Neofiber alleni,* often some distance from land and in water up to 24 inches deep. In most habitats, however, rice rats are closely associated with the cotton rat. Hamilton (1946) noted this association, and Svihla (1931) also commented on it. The respective habitats of the two species overlap considerably.

Eighty-seven per cent of the *Oryzomys* and 53 per cent of the *Sigmodon* captured during the study were from stations within 100 feet of the pond or marsh margins. However, the relative abundance of the two species at these stations changed between trapping periods. In November, when the study area was trapped for the first time, the borders were dry, although inundated earlier in the fall. During this month nine rice rats were taken here, while no *Sigmodon* were captured. In January five rice rats were taken, all in the same habitat as in November. Also, six cotton rats were captured, three of them in the marshy border. With respect to the capture sites, the two species were now sharing a common habitat to a high degree. In February, four *Oryzomys* were captured, all from the wet border. Six cotton rats were taken, three in the drier center portion of the study area and three from the same habitat as the rice rats. In March, of 19 rice rats taken, 16 came from the wet margins. Five of 7 cotton rats were trapped here. Water levels were slightly higher, but substantially the same habitat existed. Thus, to this time, the border zones were moist and contained dense grassy cover, and the percentage of *Sigmodon* in the catch increased each month.

In mid-March, heavy rains raised water levels so that two to three inches of water stood in the border zone. Trapping in early April indicated a decided change in the relationships of the two rodent species. Nineteen *Oryzomys,* 15 from the border strip, were taken 30 times in this trapping period, and no *Sigmodon* were taken. Had water levels been receding prior to this rise, one might suspect that the resulting drier substrate had become increasingly favorable for cotton rats, which were moving into this suitable habitat as it developed. However, water conditions from November to March were static, and in this period cotton rats became more numerous than rice rats.

The evidence is too scant to indicate whether the shift in the catch is a result of withdrawal or avoidance tendencies on the part of *Oryzomys* and whether overt friction existed. The shift may result from the seemingly greater tendency for *Sigmodon* to explore and establish new territories. This tendency may also partially account for the species' wide habitat tolerance. Within five days after rising water levels produced scattered pools of water, rice rats again were most abundant in the border zone, and the cotton rats disappeared. The population of rice rats presumably had not declined during these months since more were taken in March and April than in the preceding months.

SUMMARY

Movements and interspecific relationships of *Oryzomys* were studied from November 1959 to October 1960 in marshy grassland near Gainesville, Florida. The home ranges of 12 individuals averaged 0.62 acres (range, 0.12 to 1.80 acres). The average distance between consecutive captures was 95 feet in one day, 139 feet in two days, and 220 feet after 30 days. When moisture conditions remained static, the number of *Sigmodon* taken in the marshy border zone gradually increased in comparison with the number of *Oryzomys* trapped. This increase may indicate a greater predilection to explore and colonize new territories by *Sigmodon*.

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DIGESTIBILITY OF NUTRIENTS BY RABBITS

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Although the rabbit is widely used as a laboratory animal in research and is produced commercially for food, much less is known about its nutrition than that of the rat or the larger species of farm animals. Knowledge of the digestibility of nutrients by any species is useful in understanding their nutrition and in formulating experimental and practical diets. The digestibility of nutrients in a number of feeds has been determined with rabbits and comparisons made with the digestibility by ruminants in efforts to make use of the rabbit as a laboratory animal for ruminant nutrition studies (Hawkins, *et al.,* 1957; Richards, *et al.,* 1962).

Much of the digestibility data obtained with rabbits represent values for individual feeds; yet it is recognized that the degree of digestibility may vary depending in part upon the presence in the diet of nutrients from various sources. Since most rabbit rations are prepared from mixtures of ingredients, it is desirable to measure the digestibility of the nutrients in a complete ration. The purpose of the present paper is to review briefly the available data on nutrient digestibility by rabbits and to present data on the digestibility of nutrients in a complete ration by two ages of rabbits.

All segments of the alimentary tract of the rabbit are functional in the digestive process. Alexander and Chowdhury (1958) have shown that, in addition to enzymatic digestion in the stomach, some fermentation takes place in this organ and other work has shown that the lactic acid produced may be utilized by the rabbit (Drury and Wick, 1956). Other fermentation products of the lower intestinal tract are made available to the rabbit in the normal practice of coprophagy (Kulwich, *et al.,* 1953; Huang, *et al.,* 1954), and coprophagy permits greater digestibility of nutrients (Thacker and Brandt, 1955; Huang, *et al.,* 1954).

Since the rabbit is herbivorus and normally consumes fairly large amounts of crude fiber, the digestion of this nutrient is of importance. Most studies have indicated that crude fiber is not as completely digested by rabbits as by ruminants, but there is less difference in the digestibility of other nutrients. Considerable variability has been observed in the digestion of crude fiber of different feeds by rabbits, and the fiber in green, succulent feeds was found to be more digestible than that in dried forage (Aitken and Wilson, 1962). It has been generally assumed that much of the digestion of crude fiber takes place in the cecum; however, Herndon and Hove (1955) have successfully removed the cecum from rabbits and observed that digestion of cellulose was not significantly altered.

Rabbit rations normally contain relatively small amounts of fat, yet digestibility studies have shown that this nutrient is highly digestible. Thacker (1956) fed purified diets containing 5 to 25 per cent fat and observed an apparent digestibility of 97 per cent or better at all levels. Considerable variability has been noted in the digestibility of fat in natural feeds (Aitken and Wilson, 1962) but fat digestion in most feeds was relatively high.

A number of other studies concerning nutrient digestibility by rabbits have been reviewed in a report by Aitken and Wilson (1962).

EXPERIMENTAL

New Zealand White and Dutch rabbits of both sexes were used in these studies. Digestion coefficients were determined in two age groups—young animals (5 to 8 weeks old), and adult rabbits.

The diet was a complete commercial pelleted ration which by analysis contained, in per cent: protein, 16.01; ether extract, 2.09; crude fiber, 10.95; nitrogen free extract, 55.96; and energy, 3839 Calories per kilogram. During a one-week preliminary period and the experimental period, rabbits were fed a constant daily amount of feed based upon body weight. The amount for young rabbits permitted normal weight gains; the amount for adult animals was limited to that which permitted slight weight gain. During the 7-day fecal collection period, rabbits were confined to metabolism cages which provided separation and quantitative collection of feces, but did not prevent coprophagy.

Chemical analyses for the various nutrients in the feed and feces were made using methods outlined by the Association of Official Agricultural Chemists (1955). Gross energy was determined in an adiabatic bomb calorimeter. Digestion coefficients were calculated by the conventional method (Maynard and Loosli, 1962) as apparent digestibility, since no correction was made for metabolic fecal nitrogen.

Statistical analyses of the data to evaluate differences between age groups were made by the analysis of variance according to Snedecor (1956).

RESULTS AND DISCUSSION

Digestion coefficients for the various nutrients in the complete ration for both ages of rabbits are recorded in table 1. The values for each group represent averages for the number of individual trials in each group. No differences between breeds were observed and data for both breeds were pooled.

TABLE 1

Digestion Coefficients for Nutrients in a Complete Ration by Rabbits

Age	No. Rabbits	Dry Matter	Protein	Ether Extract	N.F.E.[1]	Crude Fiber	Energy
5-8 weeks	12	68.5	78.7**	84.3*	79.8	13.3	67.9
Adult	12	66.9	72.9	80.3	79.7	18.7	67.0

[1] Seven rabbits each group.
*Significantly greater at 5% level.
**Significantly greater at 1% level.

The average fat digestibility of approximately 82 per cent was higher than that for other nutrients. Crude fiber, with a mean coefficient of 16, was least digested. Digestibility of other nutrients for both groups combined was: dry matter, 67; protein, 75; nitrogen free extract, 80; and energy, 67.

Significant differences between ages were noted in the digestibility of protein and fat. Young rabbits digested significantly more ($P<0.01$) protein than adult animals, and the higher digestion of fat by young rabbits was significant at the 0.05 level. Differences between ages for the other nutrients were not statistically significant. The amount of crude fiber digested by the adult rabbits appeared to be greater than for the young, but there was considerable variation among animals in each group, and the mean difference was not significant.

The low digestibility of crude fiber and relatively high digestibility of fat would appear to be of importance in evaluation of the data. Most commercial rabbit rations contain approximately 15 to 20 per cent crude fiber and a much lower quantity of fat, normally 2 to 3 per cent. Some fiber is considered desirable for normal functioning of the intestinal tract, but the poor utilization suggests the desirability of reducing the amount to a lower level consistent with the level needed for normal intestinal function. On the other hand, the relatively high digestibility of and tolerance for fat may suggest the possibility of increasing the fat content in order to provide a greater intake of energy for growing rabbits. Experiments are planned for further study of the effect of varying levels of fat and of crude fiber in rabbit rations.

SUMMARY

Reports of experiments dealing with nutrient digestibility by rabbits have been reviewed. The digestibility of nutrients in a complete rabbit ration by rabbits of two ages was determined. Fat was digested to the greatest degree; crude fiber least. Protein and fat were digested to a significantly greater degree by young rabbits than by adult rabbits.

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PLEISTOCENE BIRDS FROM AMERICAN FALLS, IDAHO

Pierce Brodkorb

An extinct stork, *Ciconia maltha* Miller, is the only bird recorded from the late Pleistocene American Falls lake beds in southeastern Idaho (Howard, 1942). More recently Marie L. Hopkins, with support from the National Science Foundation, has been collecting along the southeastern shore of the American Falls Reservoir in Power County, approximately 10 miles northeast of the town of American Falls. Vertebrate fossils, including several extinct species of mammals, occur in Bed B (Hopkins and Butler, 1961, fig. 3), which has been dated as having an age greater than 29,700 b.p. Miss Hopkins has asked me to determine the birds, which include the seven species listed below and preserved in the Idaho State College Museum.

Ardea herodias Linnaeus. Great Blue Heron. Tarsometatarsus, juv.

Anser caerulescens (Linnaeus). Snow or Blue Goose. Left humerus.

Anas platyrhynchos Linnaeus. Mallard. Left coracoid, left humerus, and left tibiotarsus.

Mergus merganser Linnaeus. Common Merganser. Right tarsometatarsus.

Falco peregrinus Tunstall. Peregrine Falcon. Right humerus.

Bonasa umbellus (Linnaeus). Ruffed Grouse. Right carpometacarpus.

Agelaius phoeniceus (Linnaeus). Red-winged Blackbird. Left coracoid.

These birds all occur locally today, although only the mallard has previously been recorded as a fossil from Idaho (Brodkorb, 1958). All except the grouse frequent aquatic situations.

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ARTIFACTS, FOSSILS, AND A RADIOCARBON DATE FROM SEMINOLE FIELD, FLORIDA

Ripley P. Bullen

The recent use by Martin (1958, p. 397) and Hester (1960) of a late radiocarbon date for the Seminole Field fossil bed in Florida to suggest the possible extremely late survival of Pleistocene animals in Florida requires comment and discussion. Hester (1960, p. 65) gives good reasons for not accepting this date but Martin (1958, p. 399) is less critical. Bullen (1953, p. 105) and Bader (1957, p. 73 note) have cast doubts on this date, but these references are obscure and data are given in neither case. As I excavated some of the material referred to and am familiar with the exact location, it seems appropriate I should explain the situation so that paleontologists will have a good basis for the rejection (or acceptance) of this date.

This paper presents the evidence for and against an association between artifacts made by man, the radiocarbon date from charcoal sample L-211 (Broecker, Kulp, and Tucek, 1956, p. 161), and bones of an extinct fauna at Seminole Field. I hope to show whether or not the association is fortuitous by examining it in the light of archaeology, geology, and paleontology. My remarks in fields other than my own specialty should be viewed as those of an archaeologist rather than those of a geologist or paleontologist. Much of the pertinent field data was collected by me; when not I have so indicated.

One of the major fossil locations of the Seminole Field bed is along the shores of Joes Creek south and southeast of the point where it crosses present day 46th Avenue North, immediately northwest of the city limits of St. Petersburg, Florida. Joes Creek at this point (NE ¼ of SW ¼ of Sect. 6, T. 31 S, R 16 E) was straightened some years ago and in 1952-53 was being made into a drainage canal. Herbert H. Winters, then with the Florida Geological Survey, kept in touch with this work because of the possibility that good fossil material might be encountered.

Late in February 1953, Mrs. Alton R. Turner, who lived beside Joes Creek and realized the importance of any artifacts, found a chipped stone specimen in a fossil-producing zone in the bank of the canal. Taking care only to identify it as having been made by man but not to disturb it, she and her husband covered over the exposed part of the specimen, appealed to County Commissioner James R. Shoecraft to delay dragline operations at this point, and contacted Winters. Winters asked me to collaborate in the excavation of the specimen, which was done March 1, 1953.

Removing the plywood and dirt protection placed by the Turners, we saw the tip of the specimen in the east bank of the canal. It was lying horizontally, pointing outward. Replacing the plywood, we worked downward from the top and by means of a trowelled face, to check any possible disturbance. Dragline operations had completely removed the original ground surface and replaced it by disturbed material. Elimination of all possibly disturbed deposits showed at least 18 inches of undisturbed fine gray-brown sand over the specimen. A brief examination about 10 feet to the south indicated the specimen probably was originally buried by three feet of undisturbed sand, possibly much more, as even at that point the original ground surface was no longer present.

Next the face was worked to both the north and the south to establish a profile (Fig. 1, upper). A narrow fossil bearing zone, 3-4 inches in thickness, extended horizontally from the specimen both to the north and to the south. Rootlets extended downward from the undisturbed superior sands, through the fossil zone, and into the underlying gray-green zone. The specimen was clearly shown to lie in the narrow fossil producing zone (Fig. 2, Profile 1). The overlying undisturbed sands were entirely sterile archaeologically and paleontologically. I did notice a few minute fragments of some shell-like whitish substance and in the top of the fossil zone, about 3 inches above the specimen, some bits of charcoal.

The specimen (Fig. 1, lower) proved to be an Archaic type spear point or knife which was lying horizontally in the fossil

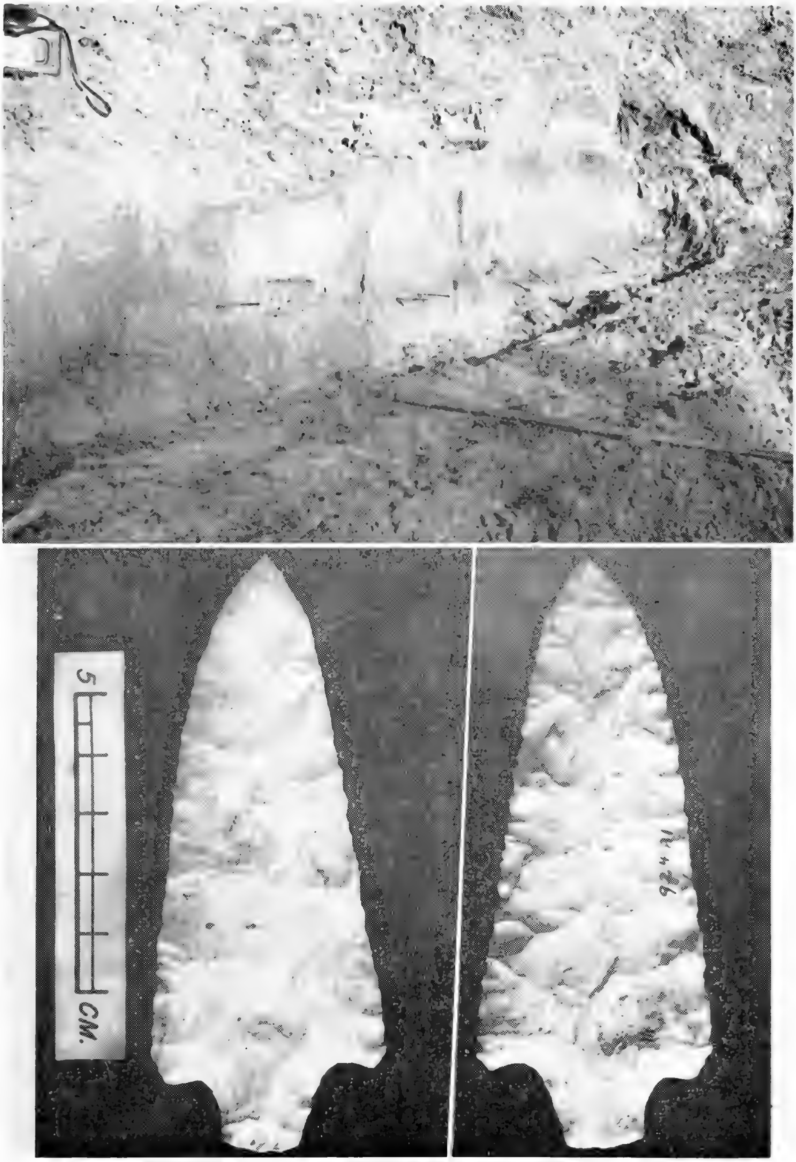

Fig. 1. *Above:* Narrow fossil zone on east side of drainage canal, fossils indicated by sticks. *Below:* Top and bottom sides of stemmed Archaic type point found in the above zone.

zone. At this point the highest fossil was 1 inch directly above the point. Another, consisting of the mid-section of a long bone, was immediately over part of the blade and separated from it by not over ⅛ of an inch. Half an inch above the point was a fossil tooth, while directly over the base was the scute of an extinct armadillo.

Upon removing the point, its cast was clearly defined in the ground which, just below the point, consisted of coarse sand, some

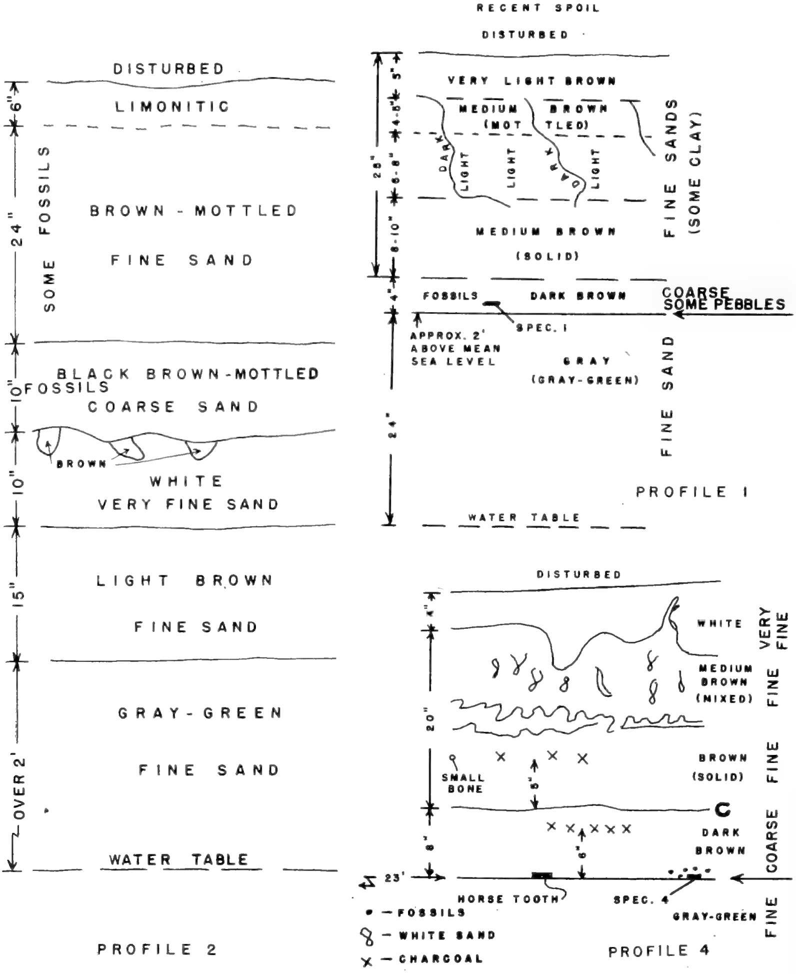

Fig. 2. Profiles 1 and 4 from east side, profile 2 from west side, of drainage canal.

of which was light in color and subsequently found to be pebble phosphate. On the bottom of the specimen and in the cast at the corresponding place was a small deposit of limonitic material. Traces of this may be seen in the illustration (Fig. 2, just above the stem towards the catalogue number).

I have presented considerable detail to demonstrate the spear point to have been found *in situ* in a narrow, fossil-producing zone in direct physical association with bones of extinct animals. This fossil zone was composed of coarse as well as fine sands and was 3 to 4 inches thick. The point lay, horizontally, in the lower part of the zone. Sand deposits above and below this zone were fine grained and did not produce fossils.

The point (Fig. 1, FSM Cat. No. 92481) is of a type typical of the Archaic or late pre-ceramic period of southeastern United States. Made of Florida chert, the specimen is well patinated except for part of its stem which has not undergone as much change as the rest of the specimen, particularly on the side which was downward in the ground. Possibly the stem was protected for a period of time by part of a wooden shaft.

The tip and forward edges are very sharp. Basal grinding has been applied to the stem and extended up the edges of the blades, on both sides, to a point ½ inch forward of the barbs or basal corners of the blade proper.

Another feature of the point is that edges of chipping scars on the face which was uppermost in the ground (Fig. 1, left) are worn, rounded, or dulled, while those on the opposite side (Fig. 1, right) are clearly delineated. Such dulling of the upper surface is what one would expect if the specimen lay for a fairly long time on the surface of a tidal lagoon, or lagoon-like side of a tidal stream, where it would be subjected to mild scouring action by sediments dragged across its surface by water. The finding of coarse sand and fine pebbles beside and immediately below the point would, it would seem, support such a picture as such sorting suggests water action. The alternative that the dulling was caused by sand-blasting is, of course, possible. In either case it lay with one side exposed for a considerable length of time.

Subsequently, Mrs. Turner and others uncovered three additional stone specimens from the same narrow fossil bearing zone. The first of these is a deeply patinated chert flake, 2½ by 1¼ by ¼ inches, with evidence of use in the nature of the removal of minute chips in two places along its edges. The second is an ordinary flake, 1½ by 1 by ⅛ inches, with no signs of use. The third, referred to as Specimen 4 (Fig. 2, Profile 4), is a fragment of the edge of a bifacial chert tool formed by percussion flaking. It is 1¾ by ½ by ¼ inches in size and exhibits but little patination.

These additional specimens were removed by, or their location examined by, Mrs. Turner who sent me profiles of these finds. One of her profiles, that for Specimen 4 has been included in Figure 2. It will be noticed that in this case she delineates the fossil-bearing zone as about 8 inches in thickness. Her Profile 3, not illustrated, shows the fossil-bearing zone decreasing within a few feet, from a thickness of 6 inches to that of 1 inch. Evidently this fossil zone, while everywhere narrow, varied somewhat in thickness.

In the course of her activity at the site, Mrs. Turner found a fairly large deposit of charcoal at the junction of the top of the fossil zone and the overlying brown sand. Its stratigraphic location is indicated on a sketch profile sent me by Winters. It was a short distance south of Specimen 3 (one of the flakes) and about 9 inches higher, judging from Winter's sketch. Fossil fragments are shown a short distance, perhaps 4-5 inches, below this charcoal. I have indicated the stratigraphic but not the horizontal position of this charcoal deposit on Profile 4 by a "C" (Fig. 2). This charcoal was sent to the Lamont Geological Observatory by Winters and there dated as sample L-211.

The original date, based on three runs by the black carbon method was 2600 ± 230 years before 1954 (Winter, letter of May 13, 1954). The published date of 2040 ± 90 years (Broecker, Kulp, and Tucek, 1956, p. 161) was based on the carbon-dioxide method (Kulp, letter of August 18, 1956). I mention this difference as some might otherwise think the dates were from two separate samples.

Before discussing this matter, I must present the stratigraphic situation across the canal and also that north of the bridge. All of the work referred to so far was done on the east side of the drainage canal. Shortly after the original find was investigated, Winters and I cut a profile on the west side of this canal, directly opposite and about 30 feet from the location of these artifacts. The result is given as Profile 2 in Figure 2. Here the situation was radically different.

Examination of Profiles 1 and 4 indicates that the narrow fossil zone rested on a gray-green basal zone of fine sand. This basal layer was extremely compact. Across the canal the same basal zone was found but its surface was 14 inches higher. It will also be noted that across the canal the narrow fossil zone was absent but that fossils were found in substantially higher zones, some 2-4½ feet above the basal zone, and over a considerable vertical distance (nearly 3 feet compared with 3 to 6 inches). The fossils across the canal were associated with coarse sand, while the fine sands below were sterile.

About 200 feet north of Profile 1 and north of the bridge, the profile consists of medium reddish-brown sand, about 4 feet thick, which rests on a sandy shell bed of unknown but substantial (over 6 feet) thickness. Shells include clams (*Venus* sp.) and conchs (*Strombus* sp.). Fossil bones occur in the medium reddish sand over the shelly deposit and Winters showed me one instance in which, after partial uncovering, articulation seemed indicated.

One more thing remains to be mentioned. To the north of the location of Profile 1 and between it and the bridge, Winters and I found the filled-in channel of a stream, presumedly that of Joes Creek.

At the present water table in this channel, we found horizontal tree trunks or branches and part of a vertical tree trunk or root. This wood was stained a green color like that of the basal zone. Over this wood were gray and mottled tan sands, which underlay black and brown sands. I was able, to my satisfaction, to trace the narrow, dark brown, fossil and artifact producing zone part way down the side of this old stream bed.

Further to the south, Winters found another filled-in, old stream channel. The top of the gray-green basal sand, between these channels, did not form a level plane. Near the location of Profile 1, this surface sloped downwards towards the north about 6 inches in 12 feet. Twenty-two feet to the south, the dip was reversed and the top of the gray-green sand was about 7 inches lower than at Profile 1. The high point was between the two old channels. These channels could not be found on the west side of the canal (where the surface of the gray-green sand was higher). Apparently, our work on the east side of the drainage canal was done within an ox-bow or meander zone of an old stream. At some time this stream had eroded the top of the gray-green basal zone.

DISCUSSION

There is no doubt that the stemmed point and the other chert specimens were in a narrow zone which also contained fragments of fossil animal bones and pebble phosphate (Fig. 2, Profiles 1 and 4). It is also evident that the charcoal sample, L-211, came from the very top of this zone or the very base of the succeeding zone, and the formation of the fossil zone antedates the deposition of the charcoal, although any such interval might be extremely short.

The question remains: does the location of the artifacts in the narrow fossil zone indicate contemporaneity in life between man and the animals represented by these fossils and, if so, is the date of charcoal specimen L-211 applicable? My answer to both these questions is an emphatic no.

In the first place it is hard for me to imagine that a variety of Pleistocene animals could have died in one place to be covered over by sands and have their remains found in such a narrow zone. Many but not all of the fossils were rounded nubbins. Surely some large bones, reasonably whole, would have been found if these animals died where found and their bones had not been transported at least a little distance.

Next, let us consider the stemmed point or knife. The early pre-history of Florida may be indicated as follows (Bullen, 1958, p. 35):

Orange Period		Fiber-tempered pottery
	2000 B.C.	
Late Preceramic Archaic		Large, stemmed points and scrapers
	5000 B.C. (?)	
Early Preceramic Archaic		Beveled and notched points with ground bases
	7000 B.C. (?)	
Paleo-Indian		Suwannee (Clovis related) points with ground bases
	9000 B.C. (?)	

The stemmed point from Profile 1 is typologically typical of the Late Preceramic Archaic of Florida and of southeastern United States.

Such points do not have ground base edges except extremely rarely. Presence of this feature, an apparent holdover from the previous period, would date our point as extremely early in the Late Preceramic Archaic or *circa* 5000 B.C. The other stone specimens offer no possible dating information. As far as I am aware, stemmed points of this type have never been found in association with an extinct fauna.

The date of sample L-211, about 2000 years ago, is 3000 years more recent than any other suggested date for the extinction of the remnants of a Pleistocene fauna (Martin, 1958, p. 397; Hester, 1960, p. 59). To be accepted, it would seem that such a date would need to be extremely well documented. Such is not the case. It disagrees with data from Archaic Indian middens of Florida and elsewhere, none of which have produced food bones from Pleistocene animals, although they date to at least 5000 B.C. (Griffin, 1952, p. 366). It also disagrees by some 4000 years with a logical date for the stemmed point. At the most the date can only apply to the end of the period of deposition of the narrow fossil and artifact zone. It will be of interest to some of our readers to realize that by 2000 years ago, the date of Sample L-211, Florida Indians had been making pottery for about 2000 years or since 2000 B.C. (Bullen, 1961; 1963).

Data have been presented outlining the topographic situation at four locations besides Joes Creek, as follows: 1, the east side of the canal where artifacts were found (Fig. 2, Profiles 1 and 4); 2, the west side of the canal where much thicker deposits were found (Fig. 2, Profile 2); 3, north of the bridge where fossil bearing sands rest on a sandy shell deposit; and 4, a fill-in channel of Joes Creek between the bridge and the artifact location. The presence of pebble phosphate in the narrow fossil zone and its presence also in the higher fossil bearing zone across the canal (Fig. 2, Profile 2, fourth zone from the bottom) appears to be significant. The reader will remember these are the only two places where coarse sand was found. The following is a brief resume of what seems to me to be a possible explanation of the phenomena.

The sandy shell zone to the north of the bridge had an early development. Winters, who worked extensively at the site after our original investigation, told me that this zone fingered out to the south and inter-digitated with fine sand. Apparently, this was some form of sand bar phenomenon. Later the ocean retreated, and a marsh developed on top of the sandy shell deposit and the adjacent interdigitated sand. This marsh may have been drained by an incipient Joes Creek. Animals frequented the marsh. Some died there, and their bones became covered over by the accumulating deposits.

Apparently, the ocean advanced again, reworked some of the fossils, mixed them with coarse sand and pebble phosphate, and redeposited them as indicated in the upper part of Profile 2. After the ocean again retreated, Joes Creek cut its deep channel. The present level of the water in Joes Creek, i.e. in the drainage canal, is 2-3 feet below the top of the basal gray-green zone of Profile 2. It rises and lowers with the tides. At times of high water, Joes Creek removed the top foot of the gray-green basal sand layer and undercut the deposits at its bend south of the present bridge and east of the present canal. These deposits, I assume, were like those shown in Profile 2. As they collapsed, the finer sediments were removed, thus leaving behind the heavier pebble phosphate, eroded fossils, and chert artifacts to form the narrow fossil zone shown in Profiles 1 and 4.

The point may have been lying on the original surface and its upper surface sand-blasted before the sediments collapsed, or repeated scourings during the formation of the narrow fossil zone may have smoothed its upper surface. The latter seems the more likely hypothesis as the dulled surface was upward when excavated. As the period of the formation of the narrow fossil zone ended, charcoal sample L-211 was deposited *in situ*. It may have come from an Indian campfire, but of this there is no indication. Subsequently, as time passed, the narrow fossil zone was buried by fine sands, presumably by wind action.

The above hypothetical reconstruction may have many flaws but some such sequence must have occurred to account for the collection in one narrow zone of pebble phosphate, remnants of fossil animals, and the human artifacts. These different materials appear to have originated in three different time periods.

It may be expected that sometime in the future a site will be uncovered in Florida that will produce good evidence of the contemporaneity of man and some of the extinct animals. When this occurs I predict the geological situation will be permissive, the paleontological situation logical (whole bones, partially articulated or in a midden deposit), and the archaeology in agreement with that of the rest of the country (Suwannee or Clovis-like points). None of these conditions were realized in the work at the drainage canal near Joes Creek and the date from charcoal sample L-211 should be entirely disregarded, except as a date when fine sands started to cover a reworked fluvial deposit.

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LANTERN MORPHOLOGY OF THE EOCENE ECHINOID *WEISBORDELLA CUBAE* (WEISBORD)

R. J. Scolaro and Arnold Ross

The echinoid jaw apparatus or lantern is comprised of approximately 40 calcareous plates, of which only the pyramids and teeth are usually preserved in fossils. The pyramids and teeth are sufficiently calcified portions of the lantern, and as such should be more common than the literature suggests. Spreng and Howe (1963), in their study on Paleozoic regular echinoid lanterns, noted that the lantern is rarely preserved or often difficult to recognize since it is seldom complete. A thorough search of the literature dealing with Mesozoic echinoids suggests that lantern preservation is also poor. Illustrations in the literature on Tertiary echinoids indicate that lantern ossicles are preserved, but unfortunately they are not described. Several taxonomists (Jackson, 1912; Moore, Lalicker, and Fischer, 1952) have pointed out the importance of the lantern as being diagnostic at the ordinal and subordinal levels, yet there is a dearth of published data on this structure insofar as the fossil record is concerned.

Preliminary studies undertaken by the authors and based upon the Florida State Museum collections at the University of Florida indicate that several species in the Florida Tertiary fauna are frequently preserved with a number of lantern ossicles intact. The present study describes and illustrates, for the first time, portions of the masticatory structure of the late Eocene clypeastroid *Weisbordella cubae* (Weisbord).

In the present study the morphological terminology employed essentially follows that proposed by Loven (1892) and Jackson (1912).

The specimens here described were collected from a quarry in the Ocala limestone (Eocene) on the south side of Florida Highway 24, about 4.2 miles southwest of the junction of U. S. Highway 441 and Florida 24 at Gainesville, Alachua County, Florida.

Morphology

The lantern apparatus in living echinoids is a complex of calcareous plates and muscles which serve to crush and grind food

(Hyman, 1955). The procumbent pyramids of *W. cubae* form a comparatively flattened stellate pentagon, the diameter of which exceeds the height. Each pyramid is typically V-shaped with alae that project sharply outward and become narrowly acuminate distally. The posterior pyramid (5) is the largest, the anterior pair (2 and 3) smaller, and the posterio-lateral pair (1 and 4) smallest.

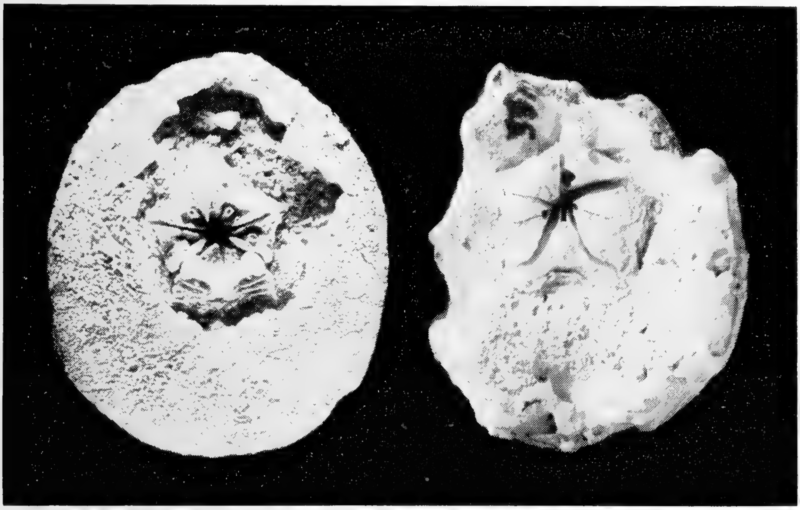

Fig. 1. Dorsal (left) and ventral (right) views of lantern apparatus of *Weisbordella cubae*. Specimens oriented with anterior end towards top of page. Hypotypes, Florida State Museum Nos. 910 (left) and 357 (right). Actual width of specimens 28.7 (left) and 28.2 (right) mm.

The ventro-lateral edges of the pyramids are sharply ridged. The ventral surface is irregularly undulating, with only moderate relief, and gradually slopes toward the median crest. Generally, there are one or two deep fossae, on the ventral surface of the pyramid, which fit over the auricles of the perignathic girdle, but in this species they are lacking. Orally a medial groove marks the symphysis of the two hemipyramids or alveoli, but aborally the alveoli are fused with the line of fusion still evident on the dorsal median crest. The initial point of alveolar fusion appears approximately midway between the dorsal and ventral surfaces. One pyramid was broken along the line of fusion in order to view the symphysial face, which was here seen to be smooth. The lateral surfaces of the pyramid are slightly rugose for the attachment of the interpyramidal muscles. On the lateral surface there appears to be no distinct triangular area separating the external and internal alar regions. The outer-aboral face of the pyramid is strongly septate, with the lateral edges of the septa conspicuously denticulate. At the proximal end of the transverse septa there is a moderately deep, ovate fossa, of which the transverse crest forms the aboral limit.

Situated aborally on each alveolus is a small transverse crest. The proximal portions of the transverse crest of each alveolar pair are fused to form a short medial crest, the whole appearing as a Y-shaped structure. An enlargement of the distal end of the transverse crest, the supra-alveolar process, supports the epiphysis. The epiphyses are simple, flat, thin, and roughly elliptical in outline. The interpyramidal faces of the epiphyses are strongly roughened through secondary calcification. The articulating surfaces of the epiphysis and supra-alveolar process are slightly rugose.

No recognizable trace of a rotula can be determined from the present specimens. The compass is lacking in clypeastroids (Hyman, 1955).

A medial sulcus or dental groove is formed at the junction of the proximal ends of the alveoli. The inner walls of the sulcus are strongly septate; the septa lack denticulae. Aborally, the sulcus flares, forming what is referred to as the foramen magnum. The foramina of pyramids 1, 2, 3, and 4 are deep and moderately broad, whereas the foramen of pyramid 5 is approximately one-third broader. Ventrally, an inward extension of the walls forms an open pentagonal slot to maintain alignment of the teeth.

The teeth are slightly arcuate and pentagonal in section. It is difficult to reconstruct the exact attitude of the teeth since they are fused with the pyramids, and the pyramids have shifted from a life position. Their present angle of repose indicates that the teeth were inclined from the vertical at an angle of about 15 to 20 degrees. The upper part of the tooth extends well into the foramen magnum. Extending the length of the inner face of the tooth is a slight concavity. Aborally, the tooth is hollow, and the uppermost surface is inclined downward towards the inner face. There is a U-shaped notch on the inner margin of the dorsal surface. The edges of the teeth are too poorly preserved to determine their true nature. However, the teeth appear to have terminated in a chisel edge rather than in a point.

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AN UPPER MIOCENE FOSSIL LOCALITY IN NORTH FLORIDA

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INTERPRETING the geology of Florida is difficult under the best available conditions. None of the continuous, clearly exposed, vertical sections, so typical of many western states, are present in the relatively flat topography of the State. Stream beds and banks, springheads, and road cuts offer some exposures useful in determining the surface geology of north Florida. However, road cut exposures are generally meager and are usually separated from other outcrops by miles of grassed over land. Close age correlations between several widely separated outcrops are never wholly satisfactory. Age determinations, based largely on lithology, are less than accurate when a fine age limit is desired. Rarely are fossils encountered, of a quantity or quality sufficient to be used as an index in dating the outcrops.

In the fall of 1961, William Yon, geologist with the Florida Geological Survey, was engaged in a field survey of Jefferson County in north Florida (Fig. 1), which will result in a report of the geology of Jefferson County to be published by the Florida Geological Survey.

While mapping an exposed section of a road cut on State Highway 146, located in the SE. corner of sec. 1, T. 2 N., R. 6 E., Yon encountered a fragment of fossil bone in a unit that had been assigned to the Miocene on evidence other than paleontological. The vertebrate fossil locality has been assigned the locality number Jf SE/SE-1-102-6.

A translucent thin section was prepared from the specimen of bone. It was determined that although this fossil scrap represented a mammal it was not of sufficient quality to go beyond this general classification.

In August 1963, Mr. Charles Sever, geophysicist with the Ground Water Branch of the U.S. Geological Survey, collected an upper molar of the Miocene horse, *Merychippus* sp. (Fig. 2, G-H, V-6062) from the same locality. Subsequent trips by Yon, Sever, and the writer resulted in the collection of additional *Merychippus* teeth, and a well preserved second lower molar of the rhinoceros, *Diceratherium* sp. (Fig. 2, K-L, V-6065). This animal is known else-

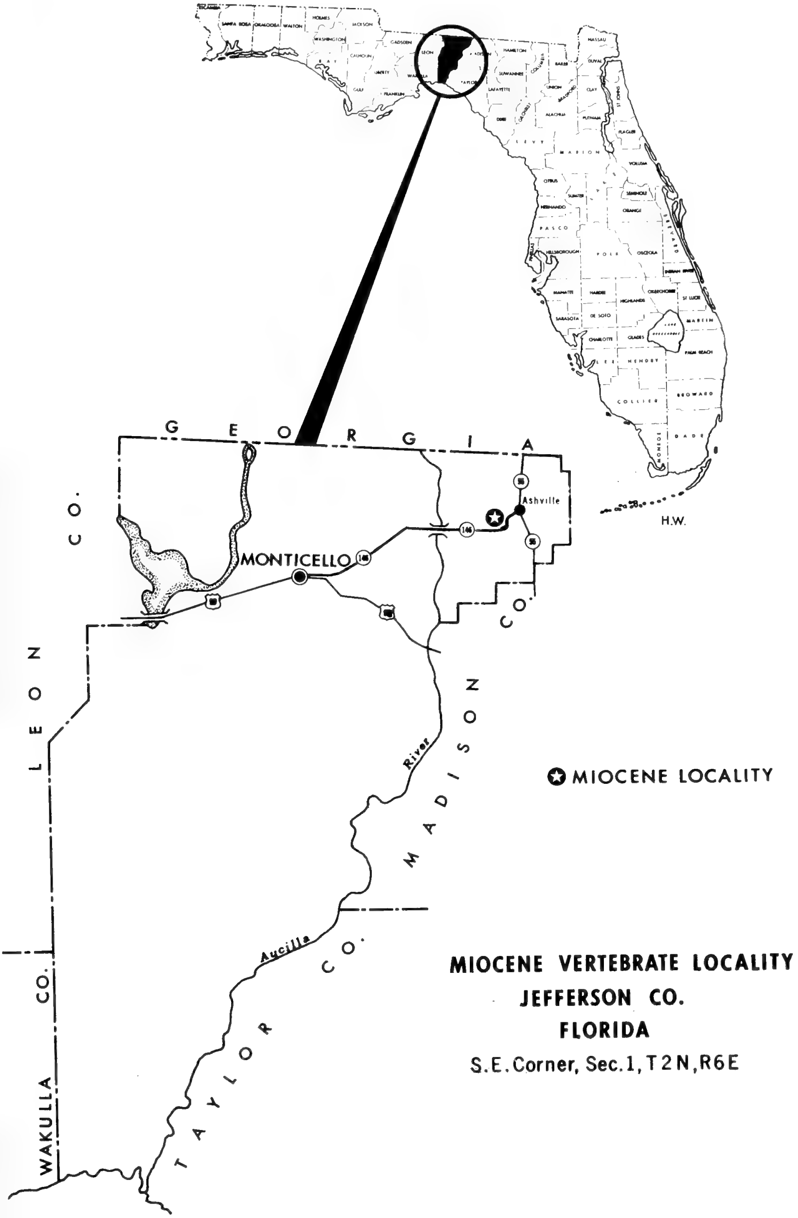

Fig. 1. Location of Miocene locality in northeastern Jefferson County, Florida.

where in the coastal plain from deposits of late Middle Miocene age (Quinn, 1955). Also collected were numerous incomplete postcranial elements of *Merychippus*. Some large and small artiodactyl tarsal bones are present in unit B, having probably weathered out of the overlying unit C (Fig. 3), but are too fragmentary to be assigned to other than a general taxonomic category.

All of the fossils recovered were disarticulated and fragmentary. Much of the bone presents a weathered and crushed appearance. The condition of the terrestrial vertebrate remains suggest that they were perhaps carried offshore by current action and subsequently sank near the margin of a shallow bay or estuary. Certainly the presence of shark and ray teeth (gen. et sp. indet.) in the same deposit seems to bear out this hypothesis. Some previous workers have suggested a Miocene shoreline in the vicinity of the road cut (Cooke, 1945; Puri and Vernon, 1959). T. E. White (1942) and others believe that the Central Florida Dome was cut off from the mainland by the Okefenokee Trough, inundating the Jefferson County locality, to form an island to the south. The mixture of terrestrial and marine vertebrate remains would be the same in either case, with shallow waters covering an area adjacent to a flat coastal plain, where the bones and teeth of grazing land animals could easily become mixed with those of the shallow-water dwellers.

Yon's (personal communication, October 30, 1963) description of the unit (Fig. 3) in which the vertebrate remains occur is as follows:

> "The vertebrate remains occur in Unit C, which is mottled yellow-brown and light gray-green, clayey, angular to subrounded, fine to very coarse grained quartz sand; contains some pea-size and larger quartz pebbles, blebs of yellow-brown clay and light gray clay granules; contact with the underlying clay unit B fairly sharp. Unit C upon exposure to weathering becomes sufficiently lithified to form a small wall along the side of the road cut. On the west end

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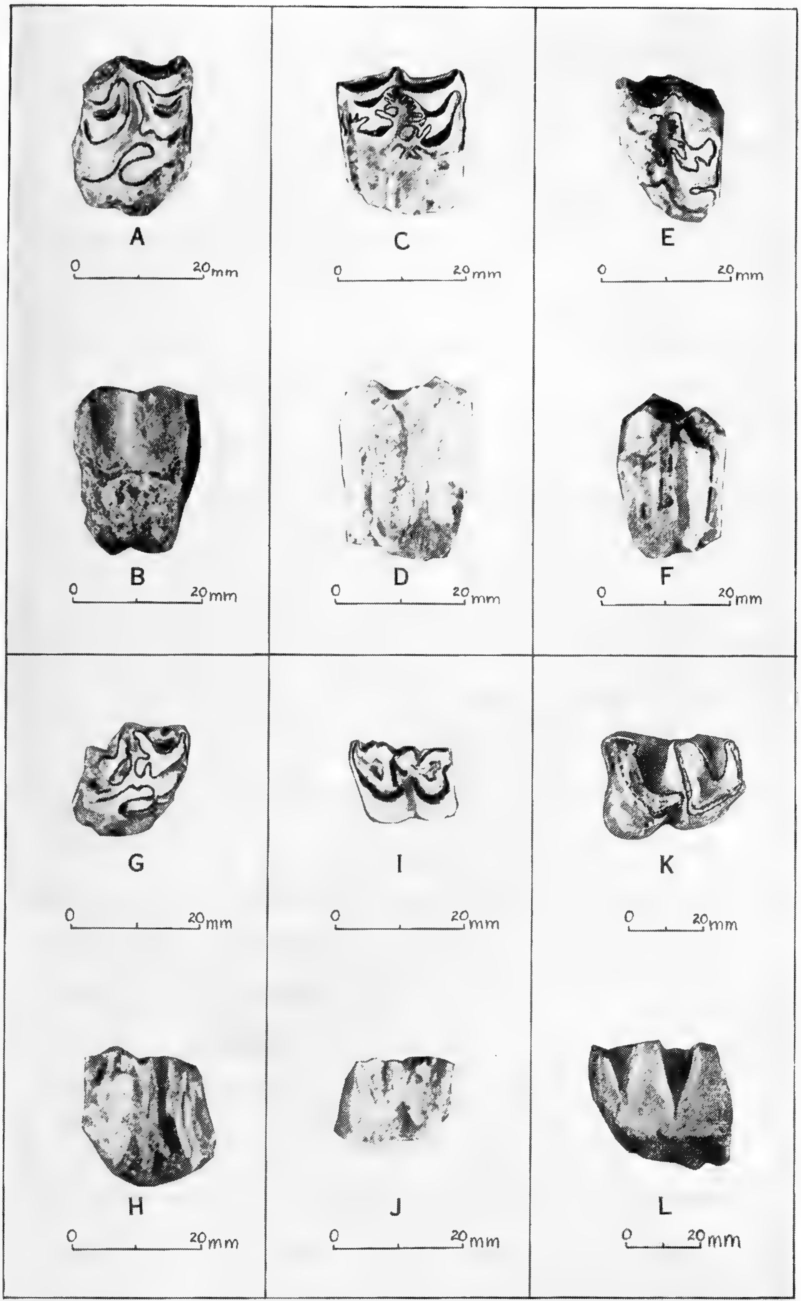
Fig. 2. Upper Miocene mammal teeth from the Jefferson County road cut.

A.-J. *Merychippus* sp.: A, occlusal view; B, labial view of rt. M^1, V-6056; C, occlusal view; D, labial view of rt. M^1, V-6059; E, occlusal view; F, labial view of left P^4, V-6057; G, occlusal view; H, labial view of rt. M^3, V-6062; I, occlusal view; J, labial view of left M_1, V-6058:

K-L. *Diceratherium* sp.: K, occlusal view; L, lingual view of rt. M_2, V-6065.



t. dunaway photo

> of the outcrop, the unit thickens and remains resistant to weathering. The thickness of Unit C is approximately 2 feet."

The occurrence of the remains of the small, three-toed horse *Merychippus* has considerable stratigraphic importance. This animal occurs widely in deposits ranging from the beginning of the Middle Miocene to the end of the Upper Miocene. It was contemporaneous in the Middle Miocene with the more commonly known horse *Parahippus,* which became extinct before the close of the Miocene (Simpson, 1951; Stirton, 1959). The teeth of the two forms generally differ in that *Parahippus* was a browsing form with low-crowned molars, having no cement; whereas *Merychippus* was a grazing animal having high-crowned molars, with cement being present in the teeth. Isolated postcranial elements of these similar genera are not separable.

The Jefferson County horse teeth, some 30 in number, were compared with a large series of Tertiary horses from the western United States. They agree most closely with *Merychippus* from pre-Valentine (Lower Pliocene) and post-lower Snake Creek (Upper Miocene) beds but are too fragmentary for more than a generic determination. To place a specific name on these isolated teeth would do little but confuse the already complicated taxonomy of Miocene horses.

It is difficult to isolate separate molars so that they fit into the existing concept of Miocene merychippines. This is due, in part, to different specific names being assigned to individual teeth that represent stages of wear from deciduous molars to those of old individuals in the last phase of wear.

The use of a separate protocone is not a reliable feature as a valid diagnostic character for the more advanced Miocene horses. The appearance of an isolated protocone depends a great deal on degree of tooth wear. An unworn molar may have a separate protocone, but continued wear would tend to join the pattern near the base of the tooth, where the protocone is in direct contact with other infoldings of the tooth crown pattern. This was observed in the teeth of Miocene horses in the American Museum.

A new species, *Merychippus gunteri,* was described by Simpson (1930) from a fullers earth pit of lower Middle Miocene age at Midway, Florida, some 50 miles to the west of the Jefferson County locality. In the same paper, Simpson also recorded another species, *M. westoni,* from the Middle Miocene of Newberry, Florida, 85 miles to the south of the locality under discussion. The *Merychippus* teeth from Jefferson County do not belong to either of these two species.

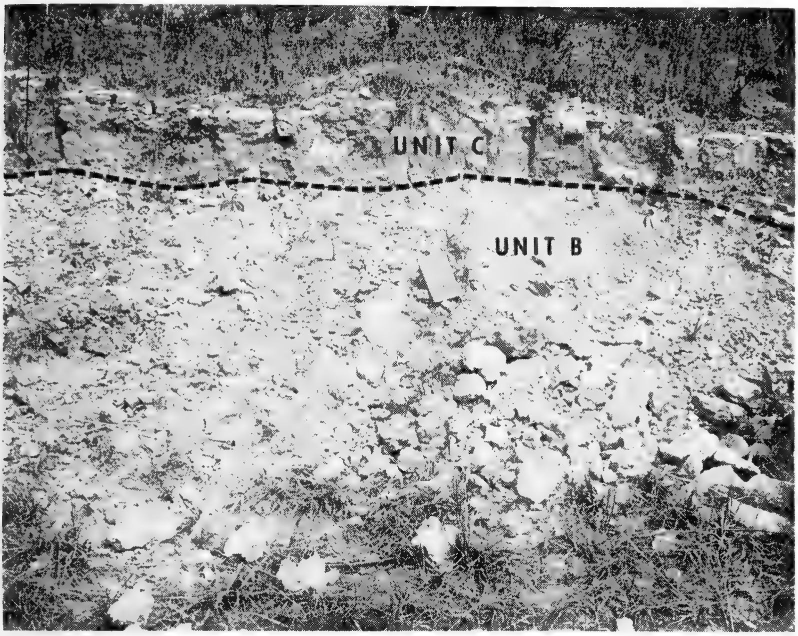


Fig. 3. Section of road cut at Miocene locality, Jf SE/SE-1-102-6. Vertebrate remains occur in unit C. Fossils have also been recovered from weathered slope overlying unit B. Field notebook for scale.

The single molar of *Diceratherium* sp. is larger and more advanced than the compared series of this genus from the western Middle Miocene. This would be expected in an animal from a slightly higher horizon.

Work is continuing at this site, and it is hoped that additional vertebrate material will be recovered, to aid in our interpretation of the stratigraphy of north Florida.

Acknowledgments

I wish to thank Mr. Morris Skinner, Frick Laboratory, and Dr. Horace Wood of the American Museum of Natural History, for their aid in making the final comparisons with material not avail-

able to me here in Florida. Mr. Charles Sever, Ground Water Branch of the U. S. Geological Survey, generously donated to the Florida Geological Survey the vertebrates which he collected. This brief report was prepared with the permission of Dr. R. O. Vernon, State Geologist and Director of the Division of Geology of the Florida Board of Conservation. Mr. William Yon very kindly gave assistance with the interpretation of the geology of the site.

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Quart. Jour. Florida Acad. Sci. 26 (4) 1963 (1964)

THE PLEISTOCENE VERTEBRATE FAUNA OF REDDICK, FLORIDA

H. JAMES GUT AND CLAYTON E. RAY

AN abandoned limerock quarry on property of the Dixie Lime Products Company, located one mile southeast of Reddick, Marion County, Florida (SW ¼, NW ¼, Sec. 14, T. 13 S., R. 21 E.), contains one of the richest vertebrate local faunas in the Pleistocene of North America. The fossiliferous deposits are unconsolidated earths accumulated in a tightly clustered complex of limestone caverns and solution pipes. These deposits now lie exposed in the quarry as a result of the enveloping country rock having been mined away years ago. It is no longer possible to determine the degree of interconnection which might have existed among the various caverns. The deposits seem to be at least penecontemporaneous on the basis of faunal, topographic, and stratigraphic evidence, although there is some indication of minor temporal differences (Auffenberg, 1963b, p. 141).

These deposits have been assigned tentatively an Illinoian age, primarily on the basis of their subjacent relation to the Wicomico (Sangamon?) Terrace and the percentage of extinction in the avifauna.

Each major deposit in the group has been assigned a letter designation in order to maintain the integrity of each unit. Although there has been some duality of designation in the past, that used and mapped by Hamon (in press) has priority and should be followed henceforth. However, the letter designation of each deposit should be prefixed by the Roman numeral I, which designates the quarry in which the deposits are exposed. Thus Reddick IA indicates deposit A in quarry I near Reddick. This system is in use for other similar localities in Florida. Reddick IA, comprising the so-called "Rodent Beds," is the most extensive deposit. It is largely of owl-pellet origin and contains remains not only of small rodents but of many other small vertebrates in great profusion. Reddick IB has yielded numerous remains of vampire bats (Olsen, 1960b) and large carnivores. Reddick IC is particularly rich in well preserved bones of small birds and has been studied primarily by Hamon (in press). Reddick ID has produced mainly the remains of tortoises and large mammals. More detailed statements regarding the stratigraphy and correlation of these deposits can be found in Auffenberg (1963b, pp. 141-142), Bader (1957, pp. 71-73), Brodkorb (1957, pp. 129-130), and especially Hamon (in press), who includes a detailed locality map.

The initial discovery of fossils at Reddick I was made in 1937 by E. J. Moughton, Jr., who brought the site to the attention of the senior author. Together they and other associates have continued to collect there intermittently through most of the intervening years. Beginning in 1951 with the work of Pierce Brodkorb other workers have become increasingly interested in the site, with the result that several major collections now exist. Those known to us are as follows:

Amherst College, Amherst, Massachusetts, Department of Biology. Matrix sample from Reddick IA.

Brodkorb Collection at University of Florida. Limited to avian remains and the major repository for that group.

Carnegie Museum, Pittsburgh, Pennsylvania. Matrix sample from Reddick IA.

Florida Geological Survey, Tallahassee. Large collection of non-avian remains.

Florida State Museum, University of Florida. General collection from all localities, especially rich in poikilotherm remains.

Gut Collection, Sanford, Florida. Large collection of primarily mammalian remains. Fossil birds transferred to Brodkorb Collection and certain critical mammalian specimens to Florida Geological Survey and Florida State Museum.

Museum of Comparative Zoology, Cambridge, Massachusetts. General collection, primarily from Reddick IA.

Tulane University, New Orleans, Louisiana, Department of Zoology. Matrix sample from Reddick IA.

University of Illinois, Urbana, Department of Zoology. Matrix sample from Reddick IA.

Studies in progress based on these collections include analysis of faunal samples by J. E. Guilday at the Carnegie Museum and A. E. Wood at Amherst College; population studies based on mammalian calcanea by H. J. Stains and A. A. Arata of Southern Illinois and Tulane Universities, respectively; taxonomic study of the microtines with special emphasis on *Synaptomys* by Arata; quantitative studies on *Peromyscus* by R. S. Bader of the University of Illinois; evolutionary study of the larger carnivores by B. Kurtén of the University of Helsinki; taxonomic study of *Bison* by J. S.

Robertson of the University of Florida; and continuing studies of the avifauna by Pierce Brodkorb.

Although segments of the mammalian (Gut, 1959; Olsen, 1960b; Ray et al., 1963) and reptilian (Auffenberg, 1958, 1963a, 1963b) faunas have been subjected to recent study, only the avifauna has been analyzed comprehensively (Brodkorb, 1957, 1963; Hamon, in press). The avifauna stands at some 64 species including those being recorded by Hamon (in press). Although Brodkorb (1957, p. 129) asserts that the herpetofauna includes about 50 species, and Auffenberg (1963b, p. 142) indicates that "of the reptile and amphibian fossils taken from this deposit there are but a few species missing from a list comprising the known herpetofauna of the central part of the peninsula at the present time," only a few of these have been explicitly recorded. Since Gut's (1939) initial publication on the site the list of mammals has increased by some 280 per cent to 53 species. Thus the fauna includes no less than 167 vertebrate species.

For various reasons, a comprehensive study of the mammals has never materialized and seems unlikely to do so in the immediate future. On this account, and in view of the considerable current interest in the fauna, it has seemed to us desirable to present a list of the mammals identified thus far, together with a list of the known non-mammalian fauna (exclusive of Hamon's 10 addditions to the avifauna) and a complete bibliography of primary literature on the site. Such a list leaves much to be desired, particularly regarding relative abundance of species. It does not reveal for example that the ocelot is known from a single specimen, whereas the shrews, moles, and some rodents are known from literally hundreds (potentially thousands if the counts were pursued). It is hoped that studies in progress by various workers will remedy this situation.

Many workers have studied and performed the original identifications upon segments of the fauna over a period of some years, so that the function of the present authors is largely that of compilation of published and unpublished records. While we wish to acknowledge the original work and in many cases direct assistance of the following colleagues, we alone are responsible for errors in the present publication: Andrew A. Arata, Walter Auffenberg, Robert S. Bader, Pierce Brodkorb, Sue E. Hirschfeld, J. Howard Hutchison, Björn Kurtén, and Stanley J. Olsen.

LIST OF THE VERTEBRATES

In the following list, extinct species or subspecies are denoted by an asterisk (*), and extinct genera by a dagger (†), in advance of the scientific name.

Class AMPHIBIA

Order **Urodela**

Family SIRENIDAE

Siren lacertina Linnaeus 1766: Great Siren
**Pseudobranchus robustus* Goin and Auffenberg 1955: Mud Siren

Family AMBYSTOMIDAE

Ambystoma, sp. indet.: Salamander

Order **Anura**

Family PELOBATIDAE

Scaphiopus holbrookii (Harlan 1835): Eastern Spadefooted Toad

Family BUFONIDAE

Bufo quercicus Holbrook 1840: Oak Toad
B. terrestris (Bonnaterre 1789): Common American Toad

Family MICROHYLIDAE

Gastrophryne carolinensis (Holbrook 1836): Narrow-mouthed Toad

Family HYLIDAE

Hyla, sp. indet.: Tree Frog

Family RANIDAE

Rana pipiens Schreber 1782: Leopard Frog

Class REPTILIA

Order **Chelonia**

Family TESTUDINIDAE

Pseudemys, sp. indet.: Terrapin

**Terrapene carolina putnami* (Hay 1906): Box Turtle. Extinct subspecies, possibly including some intergrades with *T. c. carolina* or *T. c. bauri.*

Gopherus polyphemus (Daudin 1803): Gopher Tortoise

**Geochelone (Hesperotestudo) incisa* (Hay 1916): Small Land Tortoise

**G. (Caudochelys) crassiscutata* (Leidy 1889): Giant Land Tortoise

Trionyx ferox (Schneider 1783): Soft-shelled Turtle

Order **Squamata**

Family IGUANIDAE

Anolis carolinensis (Voigt 1832): Green Anole

Family TEIIDAE

Cnemidophorus sexlineatus (Linnaeus 1766): Eastern Race Runner

Family SCINCIDAE

Eumeces, cf. *E. fasciatus* (Linnaeus 1758): cf. Five-lined Skink

Family ANGUIDAE

Ophisaurus ventralis (Linnaeus 1766): Common Glass Lizard

Family AMPHISBAENIDAE

Rhineura floridana (Baird 1858): Florida Worm Lizard

Family COLUBRIDAE

Carphophis amoenus (Say 1825): Worm Snake

Diadophis punctatus (Linnaeus 1766): Eastern Ringnecked Snake

Farancia and/or *Abastor,* sp. indet.: Mud Snake and/or Rainbow Snake

Rhadinea flavilata (Cope 1871): Yellow-lipped Snake

Heterodon platyrhinos Latreille 1802: Eastern Hognosed Snake

H. simus (Linnaeus 1766): Southern Hognosed Snake

Opheodrys aestivus (Linnaeus 1766): Rough Green Snake

Coluber constrictor Linnaeus 1758: Black Snake

Masticophis flagellum (Shaw 1802): Coachwhip

Drymarchon corais (Daudin 1803): Indigo Snake
Lampropeltis getulus (Linnaeus 1766): Common Kingsnake
Elaphe guttata (Linnaeus 1766): Corn Snake
E. obsoleta (Say 1823): Rat Snake
Pituophis melanoleucus (Daudin 1803): Pine Snake
Tantilla coronata Baird and Girard 1853: Crowned Snake
Storeria, cf. *S. dekayi* (Holbrook 1842): cf. Brown Snake
Thamnophis sirtalis (Linnaeus 1758): Common Garter Snake

Family ELAPIDAE

Micrurus fulvius (Linnaeus 1766): Eastern Coral Snake

Family CROTALIDAE

Sistrurus miliarius (Linnaeus 1766): Pigmy Rattlesnake
Crotalus adamanteus Beauvois 1799: Eastern Diamondback Rattlesnake

Order **Crocodilia**

Family CROCODYLIDAE

Alligator mississipiensis (Daudin 1803): American Alligator

Class AVES

Order **Colymbiformes**

Family PODICIPEDIDAE

Podilymbus podiceps (Linnaeus 1758): Pied-billed Grebe
**Podiceps dixi* Brodkorb 1963: Grebe

Order **Anseriformes**

Family ANATIDAE

Anas fulvigula (Ridgway 1874): Mottled Duck
A. acuta Linnaeus 1758: Pintail
A. clypeata Linnaeus 1758: Shoveler
Querquedula discors (Linnaeus 1766): Blue-winged Teal
Nettion crecca (Linnaeus 1758): Green-winged Teal
Aythya collaris (Donovan 1809): Ring-necked Duck

Order **Falconiformes**

Family CATHARTIDAE

**Gymnogyps amplus* L. H. Miller 1911: Condor
Cathartes aura (Linnaeus 1758): Turkey Vulture
**Coragyps occidentalis* (L. H. Miller 1909): Vulture

Family ACCIPITRIDAE

Accipiter cooperii (Bonaparte 1828): Cooper's Hawk
A. striatus Vieillot 1807: Sharp-shinned Hawk
Buteo jamaicensis (Gmelin 1788): Red-tailed Hawk
B. lineatus (Gmelin 1788): Red-shouldered Hawk

Family FALCONIDAE

Falco peregrinus Tunstall 1771: Peregrine Falcon
F. sparverius Linnaeus 1758: Sparrow Hawk
**Caracara prelutosa* (Howard 1938): Caracara

Order **Galliformes**

Family PHASIANIDAE

**Colinus suilium* Brodkorb 1959: Quail
†Neortyx peninsularis Holman 1961: Quail

Family MELEAGRIDAE

Meleagris gallopavo Linnaeus 1758: Turkey

Order **Gruiformes**

Family RALLIDAE

Rallus limicola Vieillot 1819: Virginia Rail
Porzana carolina (Linnaeus 1758): Sora
**P. auffenbergi* Brodkorb 1954: Rail
Coturnicops noveboracensis (Gmelin 1789): Yellow Rail
**Laterallus guti* Brodkorb 1952: Rail
**Fulica minor* Shufeldt 1891: Coot

Order **Charadriiformes**

Family CHARADRIIDAE

Charadrius vociferus Linnaeus 1758: Killdeer

Family SCOLOPACIDAE

Tringa flavipes (Gmelin 1789): Lesser Yellowlegs
Capella delicata (Ord 1825): Common Snipe

Order **Columbiformes**

Family COLUMBIDAE

†*Ectopistes migratorius* (Linnaeus 1766): Passenger Pigeon. Exterminated in historic time.
Zenaidura macroura (Linnaeus 1758): Mourning Dove

Order **Strigiformes**

Family TYTONIDAE

Tyto alba (Scopoli 1769): Barn Owl

Family STRIGIDAE

Otus asio (Linnaeus 1758): Screech Owl
Speotyto cunicularia (Molina 1782): Burrowing Owl
Strix varia Barton 1799: Barred Owl

Order **Piciformes**

Family PICIDAE

Colaptes auratus (Linnaeus 1758): Yellow-shafted Flicker
Melanerpes erythrocephalus (Linnaeus 1758): Red-headed Woodpecker

Order **Passeriformes**

Family TYRANNIDAE

Tyrannus tyrannus (Linnaeus 1758): Eastern Kingbird

Family HIRUNDINIDAE

Progne subis (Linnaeus 1758): Purple Martin
**Tachycineta speleodytes* Brodkorb 1957: Swallow

Family CORVIDAE

Corvus brachyrhynchos Brehm 1822: Common Crow
C. ossifragus Wilson 1812: Fish Crow
†*Protocitta dixi* Brodkorb 1957: Jay
Cyanocitta cristata (Linnaeus 1758): Blue Jay

Family TROGLODYTIDAE

Troglodytes aëdon Vieillot 1807: House Wren
**Cistothorus brevis* Brodkorb 1957: Wren

Family PARULIDAE

Geothlypis trichas (Linnaeus 1766): Maryland Yellowthroat

Family ICTERIDAE

†*Pandanaris floridana* Brodkorb 1957: Brown-headed Cowbird
Agelaius phoeniceus (Linnaeus 1766): Red-winged Blackbird
Quiscalus quiscula (Linnaeus 1758): Common Grackle
Sturnella magna (Linnaeus 1758): Eastern Meadowlark

Family FRINGILLIDAE

Pipilo erythrophthalmus (Linnaeus 1758): Rufous-sided Towhee
Passerherbulus henslowii (Audubon 1831): Henslow's Sparrow

Class MAMMALIA

Order **Marsupialia**

Family DIDELPHIDAE

Didelphis marsupialis Linnaeus 1758: Opossum

Order **Insectivora**

Family SORICIDAE

Blarina brevicauda (Say 1823): Short-tailed Shrew
Cryptotis parva (Say 1823): Least Shrew

Family TALPIDAE

Scalopus aquaticus (Linnaeus 1758): Eastern Mole

Order **Chiroptera**

Family DESMODONTIDAE

**Desmodus magnus* Gut 1959: Vampire Bat

Family VESPERTILIONIDAE

Myotis austroriparius (Rhoads 1897): Southeastern Myotis
Lasiurus borealis (Müller 1776): Red Bat
Dasypterus floridanus Miller 1902: Florida Yellow Bat

Family MOLOSSIDAE

Tadarida brasiliensis (I. Geoffroy St.-Hilaire 1824): Brazilian Free-tailed Bat

Order **Edentata**

Family MEGALONYCHIDAE

†*Megalonyx,* cf. *M. wheatleyi* Cope 1871: cf. Wheatley's Ground Sloth

Family MYLODONTIDAE

†*Paramylodon,* cf. *P. harlani* (Owen 1840): cf. Harlan's Ground Sloth

Family DASYPODIDAE

**Dasypus bellus* (Simpson 1929): Armadillo
†*Chlamytherium septentrionalis* (Leidy 1890): Giant "Armadillo"

Family GLYPTODONTIDAE

†*Boreostracon floridanus* Simpson 1929: Glyptodont

Order **Lagomorpha**

Family LEPORIDAE

Sylvilagus palustris (Bachman 1837): Marsh Rabbit
S. floridanus (J. A. Allen 1890): Eastern Cottontail

Order **Rodentia**

Family SCIURIDAE

Sciurus, sp. indet.: Squirrel
Glaucomys volans (Linnaeus 1758): Southern Flying Squirrel

Family GEOMYIDAE

Geomys pinetis Rafinesque 1817: Southeastern Pocket Gopher

Family CRICETIDAE

Oryzomys palustris (Harlan 1837): Marsh Rice Rat
Reithrodontomys humulis (Audobon and Bachman 1841): Eastern Harvest Mouse
Peromyscus (*Peromyscus*) *polionotus* (Wagner 1843): Oldfield Mouse
P. (*P.*) *gossypinus* (Le Conte 1853): Cotton Mouse
P. (*Podomys*) *floridanus* (Chapman 1889): Florida Mouse
P. (*Ochrotomys*) *nuttalli* (Harlan 1832): Golden Mouse
Sigmodon hispidus Say and Ord 1825: Hispid Cotton Rat
Neotoma floridana (Ord 1818): Eastern Wood Rat
Microtus (*Pitymys*) *pinetorum* (Le Conte 1830): Pine Vole
Neofiber alleni True 1884: Round-tailed Muskrat
**Synaptomys* (*Synaptomys*) *australis* Simpson 1928: Bog Lemming

Order **Carnivora**

Family CANIDAE

**Canis* (*Aenocyon*) *ayersi* Sellards 1916: Florida Dire Wolf
Canis latrans Say 1823: Coyote
Urocyon cinereoargenteus (Schreber 1775): Gray Fox

Family URSIDAE

**Tremarctos floridanus* (Gidley 1928): Spectacled Bear
Ursus americanus Pallas 1780: Black Bear

Family PROCYONIDAE

Procyon lotor (Linnaeus 1758): Raccoon

Family MUSTELIDAE

Spilogale putorius (Linnaeus 1758): Eastern Spotted Skunk
Mephitis mephitis (Schreber 1776): Striped Skunk

Family FELIDAE

**Felis* (*Panthera*) *onca augusta* (Leidy 1872): Jaguar
**F.* (*Puma*) *inexpectata* (Cope 1896): Mountain Lion
F. (*Leopardus*) *pardalis* Linnaeus 1758: Ocelot
F. (*Lynx*) *rufus* Schreber 1777: Bobcat
†*Smilodon,* sp. indet.: Sabertooth

Order **Proboscidea**

Family MAMMUTIDAE

†*Mammut americanum* (Kerr 1792): American Mastodon

Family ELEPHANTIDAE

†*Mammuthus,* sp. indet.: Mammoth

Order **Perissodactyla**

Family EQUIDAE

**Equus,* sp. indet.: Horse

Family TAPIRIDAE

**Tapirus veroensis* Sellards 1918: Tapir

Order **Artiodactyla**

Family TAYASSUIDAE

†*Mylohyus,* cf. *M. gidleyi* Simpson 1929: Peccary
†*Platygonus,* cf. *P. compressus* Le Conte 1848: Peccary

Family CAMELIDAE

†*Camelops,* sp. indet.: Camel
†*Tanupolama mirifica* Simpson 1929: Camel

Family CERVIDAE

Odocoileus virginianus (Zimmermann 1780): White-tailed Deer

Family BOVIDAE

**Bison,* sp. indet.: Bison

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ECOLOGY OF FLOATING ALGAL COMMUNITIES IN FLORIDA

Ronald C. Phillips

High productivity is synonomous with a concept of the marine sea grass association. Odum *et al.* (1959) summarized this idea after working on primary productivity of marine grass beds in several geographic locations.

This paper constitutes a report of a relatively inconspicuous but significant community of both plants and animals found within the Florida sea grass association. The dominant algae in the community were blue-greens.

Portions of the community occurred as floating masses. Reports came concerning the feeding of mullet on floating algal masses (locally called "mullet gunk"), especially near Johns Pass, near St. Petersburg. In the Philippines this algal community (locally called "lab-lab") was cultivated as fish food (Rabanal, 1949). Flint (1956) reported the common occurrence of filaments of several blue-green algal species in shrimp stomachs. In my Florida observations community development occurred in areas and at times coincident with the appearance of thousands of small fish. It is assumed that the community aids in supporting this influx of feeders. (I have observed small fish in Puget Sound, Washington, nibbling on blue-green epiphytic on leaves of *Zostera marina* L.).

The following papers list community development of blue-green algae in fresh-water: Minnesota (Buell, 1938), Colorado, (Pennak, 1949), and North Carolina (Phillips, 1958). Two papers mention a large scale development of *Lyngbya majuscula* Harv., a blue-green alga, in marine waters of northwest Florida (Humm, 1956), and Bermuda (Bernatowicz, 1952). I found *L. majuscula* a major component of floating algal colonies in at least two Florida marine areas. In northwest Florida Humm (*op. cit.*) reported that *L. majuscula* became a drifting form. In all cases the basic principle concerning composition and structure of the community was similar.

Description of Communities

These observations were made from 1957-1961, concentrating in the Tampa Bay area and in the Indian River near St. Lucie Inlet.

The ontogeny of these marine communities was identical to that found in fresh-water (Phillips, *op. cit.*). Community growth started as patches of blue-green algal scum over substrate and leaves of attached plants (*Diplanthera wrightii* Aschers. and *Ruppia maritima* L. in this study). Gradually patches coalesced through marginal expansion, and a mat of algae was formed over the bottom. Owing to gelatinous secretions of the algae concerned, individual filaments were bound together, forming a relatively tough surface layer. This layer was composed of living, brilliantly colored blue-green algae, either *Spirulina subsalsa* Oerstedt var. *oceanica* Gom. or *Lyngbya majuscula* Harv., depending on the marine habitat. Below was a layer of dead and dying trichomes of these species, in which protozoa, nematodes, and bacteria were most active. Below this layer mud particles of the substrate were consolidated to the mass. Thousands of diatoms, and many crustacea and phytoplankton were scattered throughout the mass below the surface layer of living algae.

During daylight hours gas was produced by the algal mat. The gas was trapped by the gelatinous mat surface. As gas accumulated portions of the mat swelled, tore away from the bottom, and floated to the water surface. This phenomenon occurred only on windless days as turbulent water broke up the floating colony. Floating colonies were not found early in the morning or late in the afternoon.

Size of the floating masses varied, but usually did not exceed 10 cm. Thickness also varied, but usually ranged from 4-10 mm.

The color of the colony was black. According to Buell (*op. cit.*) phycoerythrin predominates under low light intensity and imposes a black appearance on a blue-green algal mass. In marine areas where these colonies developed, waters were relatively murky owing to the silty nature of the substrate. In North Carolina (Phillips *op. cit.*) colonies were bright green, resulting from a predominance of phycocyanin, characteristic of high light intensity.

DISCUSSION

In two experiments muddy sand substrate was brought to the laboratory from Tampa Bay. *Diplanthera wrightii* Aschers. colonized this substrate in the field. No community development was evident in the field at the time of substrate collection. In both experiments substrate was placed in two 15-gallon aquaria, filled with brackish water also from Tampa Bay. The aquaria were illuminated continuously with two 40-watt fluorescent lights. A constant water salinity of 22-24 o/oo was maintained. Water temperatures were those of the room, 26-27°C.

In one experiment both aquaria were aerated. Within two weeks a blue-green algal mat appeared and covered the substrate in one tank. No development beyond the mat stage was attained. In the other experiment one teaspoon of 10-10-10 liquid fertilizer was added to both aquaria once a week, but only one tank received aeration. In 17 days both aquaria evidenced an algal scum over the substrate and on the aquaria sides. In the tank given aeration there was no algal development beyod the scum stage. In the aquarium given no aeration a definite algal mat developed in 22 days. In 28 days the entire aquarium was filled with this algal growth. Several floating colonies, buoyed up by entrapped gas, developed from the substrate surface mat. A sickening stench of H_2S was detected over a radius of several feet around the aquarium. It appeared that aeration inhibited prodigious algal growth in the laboratory. The dominant alga in the aquarium experiments was *Spirulina.*

In the field colonies formed in shallow water, three feet deep or less, over a muddy sand bottom. Wherever the algal community developed attached sea grasses were found. The algal colonies in the field appeared in late summer, coincident with maximum water temperatures, which rose to 29-34°C. over the shallow flats. From the summer of 1960 through the winter of 1961 a very dense coverage of a blue-green algal mat occurred over *R. maritima* L. in most of Old Tampa Bay. This community consisted in major part of *Spirulina,* with an admixture of *Oscillatoria subuliformis* Kutz. On one occasion *Anacystis dimidiata* Dr. & Daily was found accompanying *Spirulina.*

The dominant alga in the community differed according to the salinity of the habitat. In Tampa Bay annual mean salinity varied from approximately 20.0-25.0 o/oo. In these areas *Spirulina* was dominant. In Boca Ciega Bay near St. Petersburg and in Indian River near St. Lucie Inlet, where mean annual salinity exceeded 27.5 o/oo, *Lyngbya* was the dominant form. The latter was also dominant in the high salinity areas in northwest Florida reported by Humm (*op. cit.*) and at Bermuda (Bernatowicz, *op. cit.*).

In all marine areas where these algal communities were observed, hydrogen sulfide was detected in great quantity. Bernatowicz (*op. cit.*) noted the same phenomenon in Bermuda. In the aquarium experiments a hypodermic needle was inserted into several gas bubbles in floating colonies. Gas was extracted and expelled onto moist pH indicator paper. According to the color change, the pH of the gas was definitely below pH 7.0, probably between 6.0-7.0. It is presumed that the gas in the bubbles buoying the floating mass was H_2S. The brackish water in the aquarium was at approximately pH 8.0, as was water from the natural habitat.

A study of the local effects of the pH phenomenon might help to explain bay and estuarine distribution of plants and animals. In one aquarium experiment sea grass plants in the tank died with the appearance of the algal masses and H_2S. Several factors could account for this, among them exhaustion of nutrients, light shading, or H_2S appearance. An interesting problem is the mechanism that sea grasses possess in nature in buffering the deleterious effects of H_2S, which is always present in the substrate. A more fundamental problem is the origin of the H_2S. A very interesting problem in this regard lies in the role of bacteria in colony activity.

Algal mats influence local habitat conditions in various ways. Mats grow over sea grass leaves, screening off light and adding a mechanical factor of weight to leaves. In addition H_2S is added to the habitat, more than that normally present. These factors are probably inimical to the growth of sea grasses. However, the algal community offsets these negative factors in their probable source of food for many marine animals, by probable addition of nutrients to the water when mats decay, and by possible addition of O_2 to the water in photosynthesis, which may, however, not influence the habitat owing to the presence of a large amount of sulfide ion.

One further observation seems pertinent. At Cats Point Bank in Boca Ciega Bay in January 1958 floating colonies, first thought to be of blue-green algae, proved to be a species of photosynthetic sulfur bacterium, possibly *Chlorobium*. This phenomenon is not understood, as in December 1957 the bottom community and floating colonies at this station consisted of *Lyngbya majuscula*, a form not found at the station in January 1958.

Such algal mats seem to exert a nutritional role in nature. They undoubtedly also hasten the emergence of shallow submerged flats by the deposition of organic detritus. The biomass of blue-green algae produced is large. The deposition of silt by colonies adds to that contributed by the sea grass community itself. Substrates in beds of sea grasses, especially in sheltered areas, are often soft and muddy. Where growth is dense and abundant, the algal community may significantly influence the habitat in many interacting complex ways.

This work was done during my tenure at the Florida State Board of Conservation Marine Laboratory, St. Petersburg. Sincere appreciation is extended to Mr. R. M. Ingle, Director-of-Research, Salt Water Fisheries Division, for his aid and help in this study.

SUMMARY

A community of blue-green algae was observed in several Florida marine habitats. The community in all cases formed over sea grasses. The ontogeny and composition of the community was discussed. Portions of the community floated to the surface as gas, probably H_2S, formed within the algal mass. The algae are significant in that they exert a nutritional role and contribute much organic detritus to the substrate.

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STANDARDIZED CULTURE OF SOME LEMNACEAE

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The Lemnaceae are excellent experimental organisms where there are requirements for small short-lived spermatophytes that are grown aseptically under standardized laboratory conditions.

Five *Lemna* and two *Spirodela* clones have been selected by this laboratory as experimental tools in the study of effect of environment on aging. Because of the importance of environment in life span, it became necessary to find the minimum culture conditions that would yield optimum growth and vegetative reproduction for these organisms. Two clones, G3 and 6746, were obtained from Dr. William S. Hillman at Yale University. Clones 1, 3, 6A, 6B, and 25 were selected from local habitats.

Culture

The culture conditions that were varied were nutrients, sucrose (carbohydrate adjunct), photoperiod, light intensity, temperature, and pH of nutrient solution.

All clones were cultured aseptically using Hillman's method (1961). Two third-generation, first-daughter fronds were transferred to an autoclaved, 50 ml, cotton-plugged, round-bottom centrifuge tube containing 20 ml of nutrient solution and placed in an environmentally controlled growth chamber (microphytotron).

Preliminary experiments have shown that the nutrient supply does not become limiting during a seven day culture period. Most experiments were terminated after seven days. If the plants were cultured for longer periods, they were transferred to new tubes containing fresh nutrient solutions every seven days.

Microphytotrons

Microphytotrons were constructed to control photoperiod, light intensity, and temperature (Fig. 1). The culture chambers are 120 cm wide, 48 cm high, and 41 cm deep, and are double-walled with double glass tops. There are a 2.5 cm air space between the two layers of glass and a 2.5 cm vermiculite-filled space between the two walls of the chamber. Four bottom-hinged doors make up the face of the box. The interior of the box is of white enamel,

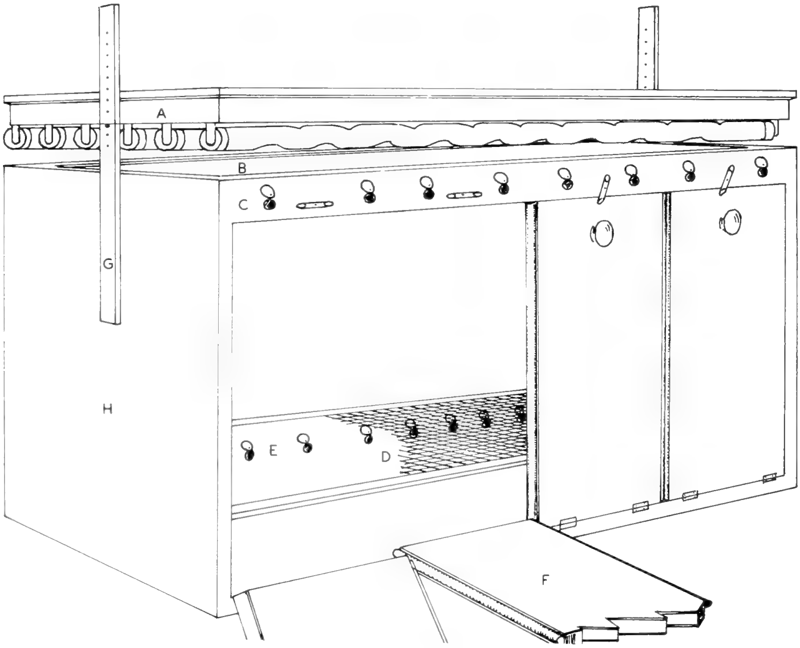

Fig. 1. Isometric diagram of the Boss-Dijkman microphytotron.

A. Light panel 121.5 X 40 cm, consisting of 2.4 cm marine plywood base. Six G.E. F48PG17-CW Power Groove cool white tubes and fixtures with ballast.
B. Double glass phytotron top, panes 2.5 cm apart.
C. Top front vents with covers.
D. Culture table consisting of wooden frame and stiff wire.
E. Bottom rear vents and covers.
F. Door showing inside wood frame, outside plywood covers, inside insulation and rubber tightening rims.
G. Guides for adjusting light intensity.
H. Double phytotron wall, consisting of 2.4 cm thick wooden frame, covered with 0.6 cm thick plywood and plywood insulated inner space.

Two blowers are attached to the back lower vents of the Phytotron, which supplies cool air into the Phytotron. Inside the Phytotron, a blower, heater and thermostat maintain any particular experimental temperature needed. Air-flow through the culture space is regulated by the covers over the bottom and top vents. For photoperiod experiments a removable ventilated light trap is provided over the top of the microphytotron.

has one adjustable wire mesh shelf, one thermostat controlling a 20-watt electric aquarium heater, and 8.5 cm electric fan that circulates air across the heater. Adjustable ventilation holes at the top-front and bottom-rear of the chamber and three 10 cm centrifugal blowers at the bottom-rear of the chamber aid in temperature control.

Six General Electric power groove, 110-watt, 120-cm fluorescent lamps and ten 7-watt incandescent bulbs are placed over the glass top and can be raised or lowered to vary the light intensity up to 2,100 foot-candles.

The microphytotrons are housed in an air-conditioned room at 15-16°C. Chamber temperature may be varied from 21°C to 40°C at a tolerance of ± 1°C. Installation of additional blowers at the rear of the chamber could allow lower temperatures.

NUTRIENT SOLUTIONS

Many of the nutrient solutions cited in Hillman's (1961) monograph on the Lemnaceae were considered or tested, but Hutner's (1953) solution yielded the best preliminary results. Hutner's solution was selected for modification to suit each of the Lemnaceae clones' individual needs.

Hillman noted that most Lemnaceae grow as well or better in a ⅓ strength Hutner's solution. In some of our early work we had also found that a more dilute nutrient solution gave greater yields. A preliminary experiment testing the effects of Hutner's solutions showed that the growth of Lemnaceae was much reduced above the full concentration and below one-fourth concentration of the medium. A second study on the effects of nutrient solutions concentration showed that one-fourth strength Hutner's produced roughly as much as the one-half and full strengths (Table 1).

Various combinations of concentrations of nitrogen, phosphorous, and potassium were tested in a basal one-fourth strength Hutner's solution. Twenty-seven combinations of N, P, and K were used. Each species or clone required a different concentration combination of N, P, and K for optimum growth and reproduction. Three-way tables of the results were prepared to evaluate simultaneously the effects of the various combinations of the three nutrients levels on frond production and fresh weight. Table 2 presents the optimum combinations of the three elements for all the

TABLE 1

Growth and vegetative reproduction of some Lemnaceae at different percentages of unmodified Hutner's nutrient solution*

Clone	100%		50%		25%	
	Fronds	Wt.	Fronds	Wt.	Fronds	Wt.
Lemna perpusilla (6746)	19	21	24	25	26	25
Spirodela oligorrhiza (3)	15	8	12	7	14	8
Lemna minor (6A)	20	33	21	40	25	41
Lemna minima (6B)	10	6	18	14	17	16
Spirodela polyrrhiza (25)	12	32	14	44	14	40

* Eight day culture period, 1,700 foot-candles, 12 hour photoperiod, and 25° C. Nutrient solution buffered at pH7. Fresh weight of fronds in milligrams. Four to six replications were used in each test.

TABLE 2

Optimum combinations of nitrogen, phosphorus, and potassium levels in nutrient solutions for *Lemna* and *Spirodela*

Clone	Optimum macronutrient levels *		
Lemna gibba (G3)	N ¼	P ½	K 1
Lemna minima (6B)	N ¼	P ¼	K 1
Lemna minor (6A)	N ½	P ½	K ¼
Lemna perpusilla (6746)	N ¼	P ½	K ¼
Lemna perpusilla (1)	N ½	P ¼	K ½
Spirodela oligorrhiza (3)	N ¼	P ½	K ½
Spirodela polyrrhiza (25)	N 1	P ½	K ¼

* N 1 = 50.0 mg NH_4NO_3/L nutrient solution.
P 1 = 21.6 mg Na_2HPO_4, 18.4 mg NaH_2PO_4/L nutrient solution.
K 1 = 10.8 mg KCl/L nutrient solution.

clones of *Lemna* and *Spirodela*. Table 3 presents the complete nutrient solution containing full strength levels of nitrogen (N 1) phosphorus (P 1) and potassium (K 1).

TABLE 3

Basic nutrient solution for *Lemna* and *Spirodela* with N 1, P 1 and K 1 levels

Compound	Weight (mg)
$CaCl_2$	41.5
EDTA	125.0
$MgSO_4.7H_2O$	125.0
$ZnSO_4.7H_2O$	16.5
$MnSO_4.H_2O$	3.8
$FeSO_4.7H_2O$	6.2
H_3BO_3	3.5
$Na_2MoO_4.2H_2O$	6.3
$CuSO_4.5H_2O$	0.9
$CoCl_2.6H_2O$	0.2
NH_4NO_3	50.0
KCl	10.8

1. Add distilled water to make approximately 950 ml.
2. Adjust to pH7 with NaOH or HCl.
3. Add phosphorus in form of phosphate buffer (pH7):

Na_2HPO_4	21.6 mg
NaH_2PO_4	18.4 mg

4. Add distilled water to make 1,000 ml.

Hydrogen Ion Concentration

The pH's of nutrient solutions used by many Lemnaceae workers Gorham (1950), Bitcover and Sieling (1951), Landolt (1957) and Hillman (1958) and this laboratory have varied from pH 5.5 to above pH 7. Hillman (1961) noted that the pH optimum depends upon many factors including ammonium or nitrate nitrogen sources and iron sources.

Different pH's were tested with our optimum nutrient solutions and it can be seen that little difference occurred between pH's 6 and 8 (Table 4). All nutrient solutions used by this laboratory are kept at pH 7. Buffer exhaustion is prevented by first adjusting the nutrient solutions to pH 7 with HCl or NaOH, then adding the buffer.

TABLE 4

Nutrient solution pH affecting growth and vegetative reproduction of Lemnaceae *

	pH5		pH6		pH7		pH8	
Clone	Fronds	Wt.	Fronds	Wt.	Fronds	Wt.	Fronds	Wt.
Lemna perpusilla (1)	22	16	26	26	25	29	24	27
Spirodela oligorrhiza (3)	13	17	17	24	20	28	20	26
Lemna minor (6A)	14	27	20	39	20	43	20	42
Lemna minima (6B)	13	12	15	14	17	15	19	16
Spirodela polyrrhiza (25)	8	16	6	15	8	20	7	17

* Eight day culture periods, 1,700 foot-candles, 12 hour photoperiod, 25°C and ¼ strength Hutner's nutrient solution, (unmodified). Fresh weight in milligrams.

PHOTOPERIOD

Hillman (1961) stated that at light intensities below 700 foot-candles the multiplication rate of most of Lemnaceae increases with increasing photoperiod, until it reaches a maximum at a twenty-four hour photoperiod. The interested reader is referred to Clark (1925), Ashby (1929), and Landolt (1957).

Seven-hundred foot-candles may be thought of as a relatively low light intensity for heliophytes such as *Lemna* and *Spirodela.* Photoperiods were tested on seven of the clones at 1,700 foot candles. The results indicated that the two clones of *Lemna perpusilla* show marked increases in growth and reproduction with increased photoperiod. The other five clones increased in growth and reproduction much more slowly with increased photoperiod (Table 5). Total growth values in this experiment are low. Hillman (1961) and Pirson and Göllner (1953) noted the phenomenon of periodicity in growth in the Lemnaceae. We have noticed that reduced growth occurs in some of our clones in November-December.

TABLE 5

Growth and vegetative reproduction of *Lemna* and *Spirodela* at different photoperiods *

Clone		6 hours	9 hours	12 hours	18 hours	24 hours
Lemna	Fronds	3.0	4.0	5.6	12.0	16.6
gibba (G3)	Fresh Wt.	5.6	11.8	15.7	50.8	89.1
Lemna	Fronds	4.3	6.0	7.6	9.0	11.3
minima (6B)	Fresh Wt.	2.3	4.3	5.1	8.1	10.1
Lemna	Fronds	4.3	7.3	12.6	13.6	18.3
minor (6A)	Fresh Wt.	5.8	11.5	17.6	26.3	39.3
Lemna	Fronds	7.0	18.6	19.6	30.0	48.0
perpusilla (6746)	Fresh Wt.	4.1	14.9	22.8	48.7	70.2
Lemna	Fronds	7.0	11.0	14.6	28.6	58.6
perpusilla (1)	Fresh Wt.	4.8	11.1	18.3	46.6	88.0
Spirodela	Fronds	5.5	7.3	10.1	10.1	16.6
oligorrhiza (3)	Fresh Wt.	5.2	8.7	14.5	14.5	29.9
Spirodela	Fronds	3.0	4.6	6.0	10.0	13.6
polyrrhiza (25)	Fresh Wt.	4.3	11.2	17.1	36.1	55.4

* Seven day culture period, 1,700 ft. c., and Hutner's nutrient solution (unmodified).

TEMPERATURE

Ashby and Oxley (1935), Jacobs (1947), and Landolt (1957), as discussed by Hillman (1961), have made temperature studies in relation to Lemnaceae growth. Temperature optima were found to be between 20° and 32° C.

A preliminary experiment showed that the growth and vegetative reproduction of our clones were markedly reduced below 23° C and above 31° C. A second, more refined experiment, as reported here, was carried out to determine the optimum temperature for each clone. Table 6 summarizes the growth and vegetative reproduction of each clone with respect to five different temperatures. It can be seen that all the clones tested have their temperature optima at approximately 27-29° C.

LIGHT INTENSITY

The growth of Lemnaceae under different light intensities has been carried out by a number of workers (Ashby, 1929; Ashby and

TABLE 6

Growth and vegetative reproduction of *Lemna* and *Spirodela* at different temperatures *

Clone		23°	25°	27°	29°	31°
Lemna	Fronds	30	77	90	84	83
perpusilla (1)	Fresh Wt.	65	74	103	93	76
Spirodela	Fronds	31	55	60	76	62
oligorrhiza (3)	Fresh Wt.	79	78	76	90	60
Lemna	Fronds	22	32	34	36	35
gibba (G3)	Fresh Wt.	105	110	115	128	89
Lemna	Fronds	26	27	51	42	34
minor (6A)	Fresh Wt.	67	54	70	59	51
Lemna	Fronds	30	51	63	63	56
minima (6B)	Fresh Wt.	35	49	74	62	46
Spirodela	Fronds	24	36	45	47	36
polyrrhiza (25)	Fresh Wt.	64	60	72	79	75
Lemna	Fronds	22	56	63	69	51
perpusilla (6746)	Fresh Wt.	48	66	80	91	69

* Seven day culture period, 1,700 ft.-c, 12 hour photoperiod, and optimum nutrient solution.

TABLE 7

Growth and vegetative reproduction of *Lemna* and *Spirodela* under different light intensities *

Clone		1,300 A-c	1,700 A-c	2,100 A-c
Lemna	Fronds	19	30	18
perpusilla (1)	Fresh Wt.	29	46	32
Spirodela	Fronds	22	27	23
oligorrhiza (3)	Fresh Wt.	44	46	50
Lemna	Fronds	13	18	23
gibba (63)	Fresh Wt.	45	64	91
Lemna	Fronds	24	29	25
minor (6A)	Fresh Wt.	56	66	66
Lemna	Fronds	20	22	18
minima (6B)	Fresh Wt.	25	26	21
Spirodela	Fronds	16	24	19
polyrrhiza (25)	Fresh Wt.	58	74	80
Lemna	Fronds	25	30	30
perpusilla (6746)	Fresh Wt.	43	59	55

* Eight day culture period, 12 hour photoperiod, 25° C, and optimum nutrient solution.

Oxley, 1935; White, 1936; Hicks, 1934; and Landolt, 1957). Most of the early work, however, was done with incandescent bulbs, which produce a considerable amount of heat. Landolt's (1957) fluorescent light experiments at the low temperature of 24°C showed saturation levels between 200 and 900 foot-candles.

The Lemnaceae clones in our laboratory are able to utilize higher light intensities at optimum growth temperatures between 27-29° C.

Preliminary observations showed that the growth and reproduction rates increased proportionally with increase in light intensity from 420 foot-candles to 1,700 foot-candles. Table 7 indicates the growth and vegetative reproduction rates of the Lemnaceae clones at 1,300, 1,700, and 2,100 foot-candles light intensities. Growth reaches a maximum at approximately 1,700 foot-candles, except in S. *polyrrhiza* and L. *gibba*.

Vegetative reproduction also reaches a maximum at approximately 1,700 foot-candles, except in L. *gibba*.

TABLE 8

Growth and vegetative reproduction of *Lemna* and *Spirodela* with and without sucrose *

Clone		With 1% Sucrose	Without Sucrose
Lemna	Fronds	11	11
perpusilla (6746)	Fresh Wt.	12	12
Lemna	Fronds	13	14
minor (6A)	Fresh Wt.	33	34
Spirodela	Fronds	12	10
polyrrhiza (25)	Fresh Wt.	39	41
Spirodela	Fronds	9	9
oligorrhiza (3)	Fresh Wt.	15	12
Lemna	Fronds	11	9
gibba (G3)	Fresh Wt.	44	32
Lemna	Fronds	18	18
perpusilla (1)	Fresh Wt.	29	26
Lemna	Fronds	14	16
minima (6B)	Fresh Wt.	12	14

* Seven day culture period, 1,700 ft. c., 25° C, and Hutner's solution (unmodified).

Since sucrose in nutrient solutions has been used to promote growth of Lemnaceae under low light intensities, a study was made on the necessity of a carbohydrate supplement at 1,700 foot-candles. Table 8 shows that no appreciable differences in growth and reproduction occurred upon addition of 1 per cent sucrose to the nutrient solution.

LIFE SPAN

The seven Lemnaceae clones that are cultured in our laboratory under optimum culture conditions have different life spans. Table 9 shows that two clones live approximately twenty-one days, while two other clones live approximately 33 days. The other three clones have life spans between these two extremes. Average maximum variations from the life span mean in any particular run is about two days for all clones.

TABLE 9

Life span of *Lemna* and *Spirodela* under optimum culture conditions and 12 hour photoperiod

Clone	Life Span in Days *
Lemna gibba (G3)	29
Lemna minima (6B)	28
Lemna minor (6A)	33
Lemna perpusilla (6746)	22
Lemna perpusilla (1)	26
Spirodela oligorrhiza (3)	21
Spirodela polyrrhiza (25)	33

* Mean of three replications.

DISCUSSION

The Lemnaceae are excellent tools to the researcher who needs a spermatophyte that is small, is cultured aseptically, reproduces quickly, and has a short life span.

The rapidity of growth and vegetative reproduction of the Lemnaceae under optimum conditions allows relatively quick response to change in an environmental factor. Most of the experiments detailed in this paper ran from seven to eight days.

The foregoing data present the optimum requirements for five *Lemna* clones and two *Spirodela* clones, cultured under six General Electric power groove 110-watt, 120-cm fluorescent lamps, with incandescent light supplement from ten 7-watt bulbs. The microphytotrons described readily allow control of gross environment but are not essential unless strict control of temperature and photoperiod are necessary. As would be expected each clone is specific in regard to certain environmental and nutritional factors.

Research in this laboratory is concerned with effects of environmental stress on life span. It was therefore necessary to ascertain, as far as possible, optimum culture conditions of our organisms. One major requirement, however, was the obtaining not only optimum growth and vegetative reproduction conditions but also the minimum quantity of any one factor that gives maximum growth. This information would allow us to study life span effects of environmental factors that produce optimum growth and reproduction but which are in excess of the minimum optimum quantities.

The authors offer aseptic *Lemna* and *Spirodela* clones to interested workers.

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SYNONYMY AND DISTRIBUTION OF THE FROG *GASTROTHECA LONGIPES* (BOULENGER)

COLEMAN J. GOIN

ALTHOUGH *Gastrotheca longipes* (Boulenger) is one of the more spectacular species of this genus, remarkably few data have accumulated concerning it since it was originally described.

While working in the British Museum during the summer of 1959, I had occasion to examine and take notes on the two cotypes. In 1961 I had the privilege of visiting the Instituto Oswaldo Cruz in the company of Dr. Bertha Lutz and had the opportunity of seeing the type of *Gastrotheca viridis* Lutz and Lutz in that institution. Since these two nominal forms are surely conspecific, I present the following synonymy, redescription and notes on the species.

Gastrotheca longipes (Boulenger)

1882 *Nototrema longipes* Boulenger, Cat. Bat. Salientia in the British Museum, p. 418, pl. 27 (type locality: Canelos and Sarayacu, Ecuador); Gadow, 1901, Amphibia and Reptiles, p. 188; Nieden, 1923, Das Tierreich (Anura 1), p. 321.

1939 *Gastrotheca viridis* Lutz and Lutz, Ann. Acad. Bras. Sci., Vol. 11, no. 1, p. 81 (type locality: Serra da Bocaina, a region bordering on the states of São Paulo and Rio de Janeiro, Brazil).

Diagnosis. A rather large *Gastrotheca* with the cranial derm free from the skull, without triangular appendages on the upper eyelids, and with very small dermal appendages on the heels. It is a pale frog (green in life, pale yellow to white in preservative) generally with dark markings in the form of thin postocular stripes, a few scattered round spots on the top of head and dorsum, a transverse bar above the vent, and markings on the lateral sides of the feet and the one or two outer toes.

Description of male cotype. BMNH. 80.12.5.238 [1947.2.31.5]; Sarayacu, Ecuador; collected by Mr. Buckley. Vomerine teeth in two short, transverse series between the small, rounded choanae; tongue two-thirds as wide as mouth opening, broadly rounded, its posterior border slightly free and shallowly notched; snout short, rounded when viewed from above, truncate and slightly sloping

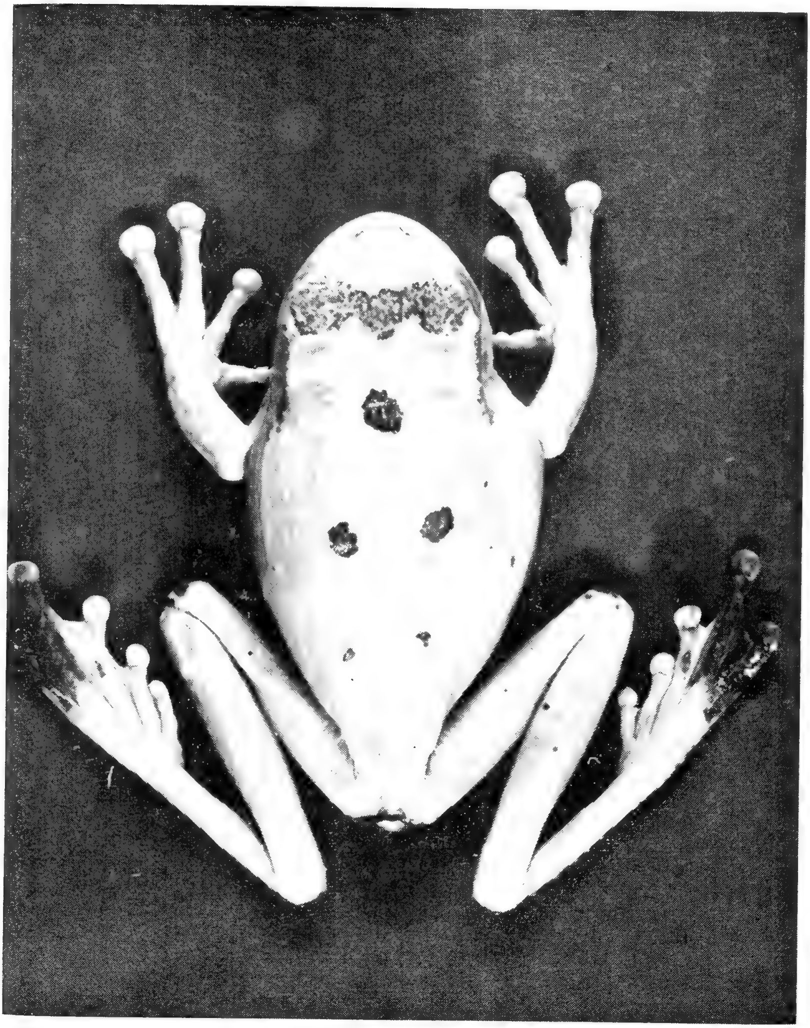

Fig. 1. Dorsal view of *Gastrotheca longipes*, Escuela Politecnica Nacional 2748, adult male from Río Rutuno, Pastaza Prov., Ecuador.

in profile, the upper jaw not extending appreciably beyond lower; nostrils more lateral than superior, not projecting, their distance from end of snout about one-half that from eye, separated from each other by an interval equal to their distance from eye. Canthus rostralis sharply defined, somewhat curved; loreal region concave and nearly vertical, the upper lip not flaring out appreciably below it. Eye medium, not particularly prominent, its diameter twice its distance from nostril; interorbital distance broad, half again as wide as upper eyelid, which is about equal to the distance between nostrils. No superciliary appendage. Tympanum distinct, higher than wide, its greatest diameter about one-half the diameter of eye, separated from eye by about its shortest diameter. Fingers with a trace of web at base, first and second about equal, fourth slightly longer than either, reaching to base of disk of third, which slightly more than covers the tympanic area; no projecting rudiment of a pollex; a small but definite ulnar ridge. Toes slightly more than one-half webbed, the web on fourth toe reaching the base of the penultimate phalanx, fifth longer than third, disk of fourth covering about two-thirds the tympanic area; a distinct oval inner and a very indistinct rounded outer metatarsal tubercle; tarsal ridge present; very small dermal appendage on heel. Body moderately elongate, in postaxillary region a little narrower than greatest width of head; when hind leg is adpressed, heel reaches well beyond tip of snout; when limbs are laid along the side, knee and elbow considerably overlap; when hind legs are bent at right angles to body, heels overlap considerably. No patagium. Skin of upper parts smooth; above the region of the urostyle the skin is fused with the flesh, forming the incipient thecum of the male; there is a definite glandular fold lying above the vent, arranged in the form of a shallow, inverted V; a rather narrow glandular ridge passes above the tympanum; skin of throat and chest smooth, that of belly and lower femur uniformly and finely granular; a very faint trace of a skinfold across the chest; no inguinal gland; vocal sac not apparent. Skin of head not coossified with skull, roof of skull exostosed.

Dimensions. Head and body, 55.7; head length, 18.3; head width, 21.4; femur, 31.8; tibia, 35.1; foot, 45.7; hand 18.8 mm.

Color in alcohol. A very pale frog marked as follows: a little brown stripe between nostrils, a broader one between the eyes, supratympanic fold margined with brown, and five brown spots on back as follows: a single median one just back of the head, a pair just anterior to the sacrum and another smaller pair just posterior to the sacrum. The ulnar and tarsal ridges and glandular fold above the vent are margined in creamy white. There is a creamy white margin to the upper lip, a tiny creamy white spot below each eye, and another slightly larger one posterior to the angle of the jaw on each side. The ventral surfaces are immaculate.

Variation. The discussion of variation below is based on the following specimens examined:

BMNH 80.12.5.238 [1947.2.31.5]. Adult male. Ecuador, Sarayacu (cotype of *G. longipes*).
BMNH 80.12.5.163 [1947.2.31.4]. Adult female. Ecuador, Canelos (cotype of *G. longipes*).
Inst. Oswaldo Cruz. Adult female. Brazil, Serra da Bocaina, on the border between the states of São Paulo and Rio de Janeiro (type of *G. viridis*).
Esc. Polit. Nac. 2745. Adult female. Ecuador, Pastaza Prov., Chicerota, upper Amazon Basin not far from the point where the Rio Bobonaza enters the Rio Pastaza. Alt. 250-270 m.
Esc. Polit. Nac. 2746. Immature. Same data as E.P.N. 2745.
Esc. Polit. Nac. 2748. Adult male. Ecuador, Pastaza Prov., Rio Rutuno (circa 77° 15′ W., 1° 55′ S.). Alt. 340-350 m.
Esc. Polit. Nac. 2749. Adult female. Same data as E.P.N. 2748.
J. A. Peters 3868. Immature. Same data as E.P.N. 2745.

The pattern of this species may be seen in the adult male (Esc. Polit. Nac. 2748) illustrated in Fig. 1. In this specimen the top of each eyelid is marbled in brown, and a brown interocular dark bar extends from the dark spot on top of one eyelid to the dark spot on top of the other. There is a rounded dark spot about the size of the tympanum or a little larger on the back just above the occipital region. A narrow dark brown stripe extends from the posterior corner of the eye above the tympanum to terminate at a point slightly behind and above the axilla. There is a pair of brown spots about the size of the tympanum on the back slightly anterior to the sacrum and another pair of much smaller brown spots between these and the region of the vent. There is a quite pronounced horizontal dark bar above the vent, a few brown specks on each knee, and a brown line extending across each heel, along the lateral side of the tarsus, and on to the dorsal surface of the two outermost toes. Otherwise the specimen is white in preservative.

The male cotype of *longipes* differs in pattern from the male discussed above in having a little brown stripe between the nostrils and in that the line above the vent and along the outer side of the tarsi is not conspicuous.

In the type of *viridis* the interocular bar is incomplete with only a brown spot on the top of each eye. There is a pair of rounded dark spots on the anterior portion of the back; posteriorly there are five or six tiny, more or less paired spots posterior to the sacral hump. Furthermore there are three fairly distinct small brown spots on the dorsal surface of each crus.

Some of the other specimens have patterns that differ from this as follows: In the two fresh adult females in the Esc. Polit. Nac., the larger of the specimens has a pattern essentially as described for the male above except that the dorsal spots are a little more reduced, and the two posterior-most dorsal spots lie in the corners of the opening of the dorsal pouch. In addition a few faint flecks of brown occur along the upper surface of the shanks. The other female, also mature, has the pigment restricted to the line above the vent and the line along the outer margin of the heel, the lateral surface of the tarsus, and with faint markings on the top of the two outermost toes; otherwise she is white.

The two young specimens at hand, Esc. Polit. Nac. 2746 and JAP 3868, have quite distinct interocular bars running from the margin of one upper eyelid across the dorsal surface of the eyelid and top of the head to the margin of the other eyelid, a single anterior median spot on the back, two larger spots just above the sacrum, and the outer margin and dorsal surface of the two lateral toes are covered in brown; otherwise they are immaculate.

There seems to be some sexual differences in size, the female attaining a larger size than the male. The following table gives the head-body, thigh, and crus length in millimeters for the male cotype of *longipes* and the three adult specimens in the Escuela Politecnica Nacional.

	Head-body	Thigh	Crus
BMNH 80.12.5.238, male	55.7	31.8	35.1
Esc. Polit. Nac. 2748, male	72.1	35.0	40.5
Esc. Polit. Nac. 2745, female	80.8	42.5	47.8
Esc. Polit. Nac. 2749, female	88.4	46.0	52.3

Acknowledgments. To the following I am deeply indebted: to Miss Alice G. C. Grandison for the privilege of examining the cotypes of *G. longipes* in the British Museum; to Dr. Bertha Lutz for the privilege of examining the type of *G. viridis* in the Instituto Oswaldo Cruz; to Dr. Gustavo Orces V. for the loan of the specimens in the Escuela Politecnica Nacional; to Dr. James A. Peters for the loan of the specimen in his personal collection; to Mr. Paul Laessle for the photograph for the figure included herein; and to the National Science Foundation for grants in support of my studies on South American tree frogs (G-13325; GB-1339).

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THE BURROW OF THE GOPHER TORTOISE

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FRONTED by its asymmetric apron of subsoil, the cavernous entrance and burrow of the eastern gopher tortoise, *Gopherus polyphemus* (Daudin), has long intrigued naturalists and herpetologists. Auffenberg (1962) postulates that the burrowing habit of the genus *Gopherus* has evolved as an effective manner in escaping subthreshold surface temperatures and is practiced only in areas where winters are sufficiently cold to warrant this type of activity. The literature indicates that the eastern form is the only North American species that consistently digs a long permanent burrow. Relatively little study has been given to the subterranean abode of this chelonian species other than the early work by Hallinan (1923). Hallinan studied 19 burrows in the Lakeland soil series of Duval County in northern Florida.

The present work is a comparative analysis of the burrow systems in three different soil types, Lakeland, Lakewood, and St. Lucie soils. The Lakeland and St. Lucie soil sites studied were located near DeLand, Volusia County, Florida. The Lakewood soil habitat was studied near Silver Glen Springs in the Ocala National Forest, Lake County, Florida. The Lakeland sand supports a plant association dominated by the longleaf pine (*Pinus australis*) and turkey oak (*Quercus laevis*) and is classified as a well drained non-calcareous sand (Bryan, 1960). Both the Lakewood and St. Lucie sands support a plant association of sand pine (*Pinus clausa*) and scrub oaks (*Q. chapmani, Q. myrtifolia, Q. virginiana geminata*) and belong to the excessively drained non-calcareous sands of Florida.

For the manual excavation of 13 burrows, appreciation is here expressed to my students of natural history and ecology. Thanks are also given to Dr. Warren F. Jones, Jr., of Stetson University for his assistance with some of the statistical problems of the study.

MATERIALS AND METHODS

Measurements of 13 excavated burrows (length, vertical depth, angle of declination, and burrow diameter) and their tortoise inhabitants (greatest carapace length, width, and depth) are recorded in Table 1. The tortoises were measured with large wooden cali-

TABLE 1

Gopher tortoise and excavated burrow measurements

No.	Sex	Carapace Length in mm.	Greatest Width in mm.	Greatest Depth in mm.	Burrow Length in inch.	Burrow Depth in inch.	Angle of Decline degree	Entrance Width in inch.	Entrance Depth in inch.	Width at 2 ft. in inch.	Depth at 2 ft. in inch.	Soil Type*
1	F	146	111	62	114	55	30	7.8	4.3	5.3	3.0	L
2	F	159	122	67	178	70	24	8.0	3.8	7.0	3.5	L
3	F	179	139	75	168	63	23	7.8	4.0	7.0	3.3	L
4	M	196	152	86	198	104	32	8.5	4.0	7.0	3.3	L
5	F	177	134	76	139	71	31	7.8	4.0	6.3	3.3	L
6	F	277	218	120	242	67	17	12.5	5.5	9.5	5.5	L
7	F	162	122	70	126	65	31	7.5	3.5	6.0	3.0	L
7†	(F)	(162)	(122)	(70)	106	68	39	(7.5)	(3.5)	6.3	3.3	(L)
8	F	149	113	59	152	70	28	6.0	2.5	5.8	2.5	Lw
9	M	227	167	98	180	110	38	10.0	5.0	8.0	4.3	Lw
10	M	217	161	90	188	92	30	12.0	6.5	9.0	5.0	Lw
11	F	174	127	67	161	77	29	9.3	4.3	7.8	4.0	SL
12	M	181	136	73	168	75	27	8.0	3.8	6.8	3.3	SL
13	F	145	113	62	166	78	28	7.3	3.3	6.5	3.3	SL

* Soil type: L, Lakeland; Lw, Lakewood; SL, St. Lucie.

† Double burrow.

pers to the nearest millimeter. Thirty-eight additional burrows were measured for length using a heavy plastic garden hose. To facilitate the passage of the hose down the burrow, a furniture caster with a two-inch wheel was secured to the end of the hose (Allen, 1961). Usually, the wheel could be heard as it struck the shell of the tortoise. For all 51 burrows, measurements were taken of the exposed subsoil fronting the burrow entrance, the height and width of the burrow entrance, and a second similar measurement two feet down the burrow. A compass reading was taken to determine the direction of the burrow entrance. Notes were recorded on the type, location, and abundance of vegetation near the burrow entrance.

RESULTS

Burrow Length. A wide range of burrow-length measurements for *Gopherus polyphemus* are found in the literature; 10-35 feet (Carr, 1952), 10.5-20 feet (Hallinan, 1923), 12-18 feet (Hubbard, 1893), 10-20 feet (Oliver, 1955), with a maximal length of 35-40 feet (Young and Goff, 1939). Measurements of 51 burrows in the present study varied from a minimum length of 6.3 feet to a maximum of 47.5 feet, with a mean length of 15.3 feet. Hallinan (1923) reported an average of 14.5 feet for 19 burrows.

After a number of burrows had been measured, it seemed apparent that burrows having larger diameter dimensions also had greater lengths. A coefficient of correlation calculated for 51 measurements of burrow width against burrow length resulted in a strong positive correlation ($r = .72$, $P < 0.01$). A comparison between 51 measurements of burrow height to burrow length also gave a significant correlation ($r = 64$, $P < 0.01$).

Hallinan (1923) postulated that the length of a burrow is determined by the moisture content of the soil. If this hypothesis were valid, it would seem that burrows might be longer in the better drained Lakewood and St. Lucie soils than those in the less well-drained Lakeland soil. Since it had been found that burrow diameter was correlated to burrow length, it was necessary to determine whether the three populations were of an equivalent size range. A t test between burrow-width measurements from the Lakewood soil (19 burrows) and the Lakeland soil (23 burrows) resulted in a significant difference ($t = 3.42$, $P. < 0.01$). A comparison between the Lakewood and St. Lucie soil (9 burrows) was also significant ($t = 3.85$, $P < 0.01$). The difference between burrow widths for the Lakeland and St. Lucie lacked significance ($t = 1.4$, $P > 0.05$). Thus, with disproportionate populations it became necessary to use a statistic which would hold the burrow diameter constant. A two matched-group design *t* test was used for this particular case. Eight pairs of comparable-sized burrows from the Lakeland and St. Lucie soils failed to show a significant difference in burrow length ($t = 1.73$, $P > 0.05$). Similarly, comparisons between 8 pairs of burrows in the Lakeland and Lakewood soils, and 7 pairs from the Lakewood and St. Lucie, lacked significance ($t = 1.34$, $P > 0.05$; $t = 1.30$, $P > 0.05$, respectively.

As a second check on these data, the analysis of variance was used to test for possible significant variations between burrow width/length ratios for the three habitats. This statistic resulted in a lack of significance at the 5 per cent level of confidence ($F = 1.38$, $P > 0.05$), implying no variation in the width/length ratios.

Although individual variations differ widely in the burrows of the three habitats, the above comparisons (two matched-group *t* test and analysis of variance) would indicate that no significant difference exists in burrow lengths for the three soil types.

Size of the gopher tortoise was correlated with burrow length. Measurements from 13 specimens (greatest width and greatest depth) correlated strongly with the burrow length ($r = .84$, $P < 0.01$; $r = .79$, $P < 0.01$, respectively).

Vertical Depth of Burrows. Young and Goff (1939) state that "the vertical distance from the surface to the end of the burrow appears to be determined by the resistance of the underlying material or by the water table". These writers report vertical depths ranging from 3-8 feet depending upon the underlying parent materials. In the present study, vertical depth measurements for 14 excavated burrows varied from 4.6 to 9.2 feet, with a mean of 6.5 feet. Although the burrows of the Lakewood soil had a greater average depth (91 inches) than those of the St. Lucie (76 inches) or Lakeland (70 inches), a *t* test analysis failed to show that the three populations differed significantly.

Measurements for the 14 excavated burrows failed to show a significant correlation between burrow length and vertical depth ($r = .43$, $P > 0.05$). This lack of correlation is probably explained by the wide variation in declination angles from this sample. Although burrow width and height were correlated with burrow length, neither of these diameter measurements were significantly correlated with vertical depth ($r = .34$, $P > 0.05$; $r = .40$, $P > 0.05$, respectively). Based upon burrow length, or from burrow diameter measurements, it was hoped that a predictive value could be given to estimate the vertical depth. However, from the low correlation between these measures and vertical depth, it was impossible to give a reliable value for such a prediction.

Declination Angle of Burrows. The mean angle of declination for 14 burrows was in remarkable agreement with that of Hallinan (1923). Twelve declination angles from Hallinan averaged 27° with the extremes between 15-45°. In this work the mean angle of declination was 29° with a range of 17-39°.

Horizontal Direction of Burrows. In considering the horizontal pattern of the 14 burrows, it was found that 9 burrows turned to the right, one to the left, one first to the right and then to the left, and 3 first left and then right. Of 12 burrows shown by Hallinan (1923), 6 turned to the right, 3 to the left, 2 right and then left, one left and then right. Both studies showed a predominance of burrows which were dug to the right.

Burrow Proportions. Hallinan (1923) reported the width of the burrow about twice that of the height. From 54 measurements in this study, the height/width ratio of the burrow entrance was 0.51. Two feet down the burrow, the same ratio was 0.54. The burrow entrance had a somewhat larger diameter resulting from rain erosion and lateral movements of the tortoise. The width of these 54 burrow entrances was 1.14 times larger than the burrow width at two feet. The height of the entrance was 1.08 times larger than that at two feet.

Fourteen measurements of occupied burrows, two feet from the entrance, averaged 7 inches for width and 3.5 inches for height. The tortoises taken from these burrows averaged 5.5 inches (greatest width) and 3.0 inches (greatest depth). Thus, the lateral excess space between the tortoise and its burrow (1.5 inches) is three times that of the height (0.5 inches).

Burrow Direction. Hallinan (1923) mentioned that the burrows enter the ground from all points of the compass. Present data agree, as 12 burrows faced predominately northward, 6 eastward, 7 southward, and 14 westward. A chi-square analysis of these data did not reach significance at the 5 per cent level of confidence and thereby suggests no directional preference by gopher tortoises.

Exposed Burrow Soil. A two dimensional surface measurement (greatest length parallel to burrow axis; greatest width at right angles to burrow axis) was recorded for the exposed subsoil fronting 24 burrows. In 1923 Hallinan reported that proportionately more sand was found at the entrance of burrows of smaller tortoises than at the entrance of larger ones. Contrary to Hallinan's findings, the present study showed the exposed soil to be strongly correlated with burrow size. Exposed soil measurements of width and length were significantly correlated with burrow width ($r = .84$, $P < 0.01$; $r = .77$, $P < 0.01$, respectively). A significant correlation was found between the exposed soil width and the length of burrows ($r = .60$, $P < 0.01$).

Vegetation. In general, the gopher tortoise seems to dig the burrow entrance in an area relatively clear from large vegetation. In the three habitats studied, no burrow entrance was found which had been dug closely adjacent to a heavy shrub or tree. Of 24 burrows examined in the Lakeland soil habitat, only 8 had trees within a 10 foot radius of the burrow entrance. These trees were small turkey oaks or longleaf pines with a diameter of 1-3 inches. Various herbs, primarily wire grass (*Aristida stricta*), grow from the exposed subsoil and are more heavily concentrated at the periphery. Many burrows have from 1 to 3 well-used trails, leading from the mouth of the burrow, which are free of vegetation.

DISCUSSION

The lateral curvature of burrows is stated by a number of writers (Hubbard, 1893; Hallinan, 1923; Pope, 1939, Young and Goff, 1939) to be due to obstructions such as roots, rocks, hard materials, or other impeding objects. Each of the 14 burrows excavated in this study exhibited curvature. Yet, no roots nor hard materials which might have stimulated an animal to alter its course were encountered. Since the major portion of the burrow curvature continues at a depth beneath that where roots are normally found, the obstruction hypothesis is further questionable. A further evidence for burrow curvature as a function of digging behavior is that the curves are gradual and smoothly contoured rather than being markedly acute turns. From these observations one might surmise right or left footedness in the majority of individuals.

In all excavated burrows, the floor at the lower terminus was found covered with a fecal deposition of herbage that varied in quantity up to several inches in thickness. Since no fecal deposits were found along the floor of the burrow, the terminal accumulation would indicate that the animal spends the majority of its time at this point while in the burrow. This is in agreement with the conclusions of both Hubbard (1893) and Hallinan (1923), who suggest that the tortoise remains at the bottom of the burrow. In 13 cases where tortoises were retrieved, they were found at the bottom of the burrow, head downward. Prior to the excavation of 5 burrows, hose measurements were made of the burrow length. In each case it was found that the tortoise was at the bottom of the burrow.

One interesting find in this study, the first published record of its kind, was a double burrow occupied by a female gopher tortoise (Table 1, No. 7). The burrow entrance was single and quite typical in proportion. At a depth of 18 inches, some 25 inches from the entrance, the single burrow bifurcated into two well-formed burrows. The left-hand burrow curved off rather sharply to the left and then gradually back to the right. It measured 126 inches in length and 65 inches in depth at the terminus. The right-hand burrow was considered a newer addition since the animal was found occupying it, and it measured ¼ inch larger in diameter proportions. Although somewhat shorter (106 inches in burrow length) the angle of declination was greater and the burrow terminus depth was 68 inches. A few feet past the point of divergence, the two burrows generally paralleled one another at a distance of approximately 5 feet apart. Both burrows curved gradually to the right and terminated at almost identical vertical depths.

SUMMARY

A comparative study was made of the burrow system of *Gopherus polyphemus* from the Lakeland, Lakewood, and St. Lucie soil types common to Florida. Measurement of burrow length in 51 cases varied from 6.3 to 47.5 feet and averaged 15.3 feet. Two statistical analyses indicated no significant differences for burrow length in the three soil types. Tortoise size, burrow width, and burrow height were found to be significantly correlated with burrow length. The angle of declination for 14 excavated burrows

averaged 29° and ranged between 17 and 39°. In 14 excavated burrows, vertical depth from the surface to the burrow terminus varied from 4.6 to 9.2 feet and averaged 6.5 feet. Vertical depth failed to show a significant correlation with burrow length, burrow width, or burrow height. All excavated burrows exhibited horizontal curvatures with a predominance of patterns turning toward the right. In 54 measurements, the height/width ratio of the burrow entrance was 0.51. Two feet down the burrow this ratio was 0.54. A chi-square analysis suggested no directional preference as to burrow entrance. Measurements of exposed soil fronting 24 burrows showed a significant correlation with burrow length, burrow width, and burrow height. Burrow curvature appears to be a function of digging behavior and not soil obstructions. A description of a double burrow was given.

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FOOD HABITS OF THE GROUND SKINK

Garnett R. Brooks, Jr.

As part of a study on the population ecology of the ground skink *Lygosoma laterale,* monthly collections of this lizard were made from August, 1960, to April, 1962, at Gainesville, Florida. This collection was made in order to study the reproductive cycle, parasites, and food habits. The present paper is a report on the food habits of 329 individuals.

Previous studies concerning the food habits of this skink have shown it to be primarily insectivorous. Hamilton and Pollack (1961) examined 154 specimens collected from February to November in Georgia; insects occurred in 83 per cent and spiders in 23 per cent of all food items. Lewis (1951) examined 25 adults and 25 juveniles and also found mostly insect material. Slater (1949) examined 84 adults collected in Louisiana and found insects and spiders to be the most abundant food items. For a summary of the literature prior to 1949 concerning the food habits of *L. laterale,* see Slater's paper.

Procedure

Field trips to collect skinks were made at various times of the month and at various times of the day. Any individual sighted was collected, if possible, and was preserved in 10 per cent formalin within at least three hours of capture. All specimens, regardless of size, were injected with formalin to insure complete preservation of the internal organs. The entire digestive tract, from esophagus to cloaca, was examined under a dissecting microscope. Food items were identified in most cases to the ordinal rank.

The results are tabulated in two ways: 1) the number of individuals with a certain item and the corresponding percentage, and 2) the total number of a certain item and the corresponding percentage. In each table those insects which were unidentifiable to order were included within the group 'Insecta'. The group labeled 'Unidentified' contains items that were digested so that even the class could not be determined.

Adults are considered as those skinks with a snout-vent length of 35 mm or more; juveniles as those with a snout-vent length of 34 mm or below.

GENERAL FOOD HABITS

Only two of the 329 individuals examined were completely empty of food material. A list of the food items is given in Table 1. The major prey of the ground skink consisted of the common orders of insects, spiders, and isopods. The average number of items per lizard was 5.7. Comments concerning certain groups of food items are given below.

TABLE 1

Gut Contents of 327 *Lygosoma laterale*. The total number of items was 1825.

Item	Per Cent with Item	Per Cent of all Items	Item	Per Cent with Item	Per Cent of all Items
Insecta	91	71	Araneae	48	14
Coleoptera	23	6	Isopoda	19	8
Diptera	20	21	Pulmonata	10	2
Orthoptera	10	2	Diplopoda	3	1
Hemiptera	22	6	Opisthopora	2	*
Collembola	17	6	Chilopoda	1	*
Lepidoptera	19	4	Acarina	1	*
Hymenoptera	13	8			
Isoptera	2	2	Vegetation	1	*
Neuroptera	1	*	Unidentified	24	4
Dermaptera	*	*	Shed skin	1	*

* Less than 0.05 per cent.

Coleoptera: Larvae comprised 28 per cent of the coleopterous material. Very few lizards contained more than one beetle, although the maximum number in any one skink was eight.

Diptera: One large, adult female contained 223 adult fruit flies, plus several other food items.

Isoptera: Two lizards, an adult female and an adult male, each contained 33 winged termites.

Lepidoptera: Only four per cent of all lepidopterans eaten were adults. One juvenile lizard, 24 mm in snout-vent length, contained a 16 mm long larva, and another juvenile also 24 mm in snout-vent length contained a larva 13 mm long.

Neuroptera: Both occurrences of neuropterans were larvae.

Araneae: All of the spiders taken were what are commonly called ground spiders. A juvenile female skink contained nine species of spiders, plus two isopods, two species of coleopterans, and five hemipterans of four different species.

Isopoda: A juvenile male contained 33 isopods, plus four other items.

Diplopoda: All of the millipedes eaten belonged to the family Polydesmidae.

Acarina: Both occurrences of acarinids were hard ticks.

In feeding, a ground skink is first attracted by motion of the food item. Motion is probably a prerequisite for initiating the feeding response since no pupal cases of any insect were eaten, and all the non-insect food is capable of movement. Some doubt might exist concerning the snails but the movement of the head portion has been observed to be sufficient to elicit attention from a hungry skink. Once the item is seized, the lizard violently shakes it against objects on the ground and then swallows it. The lizard's tail slowly twitches from side to side during the entire sequence.

SIZE VARIATION

The food habits of adults as compared with those of juveniles are given in Table 2. There appear at first to be only slight differences between the two size groups as regards major food items. The mean number of items per skink is similar; 5.5 for adults, and 5.8 ($\text{S.E.}_{\text{m}} = 0.51$) for juveniles. However, when the 223 fruit flies in an adult female are subtracted from the total number of items and a new mean computed for adults the difference is greater (4.5 for adults, $\text{S.E.}_{\text{m}} = 0.29$). The results of a t test comparing these means, 5.8 and 4.5, indicates a significant difference ($t = 2.27$, $\text{P.} > .05$). Also, in 11 of the 14 highest groups, ranked by percentage of guts with item, juveniles had a higher percentage than adults. These results indicate that juveniles eat more items than do adults. Since no measurements were made concerning weight or volume of the food items no conclusions can be made as to which group consumes the most biomass. Since young animals tend to have a higher metabolic rate than older and larger animals, it is possible that juveniles also eat more per size unit than do adults.

TABLE 2

Gut contents of *Lygosoma laterale* listed by age and sex

	Adults (234)		Juveniles (93)		Adult Male (128)		Adult Female (106)	
Item	Per Cent with Item	Per Cent of Item	Per Cent with Item	Per Cent of Item	Per Cent with Item	Per Cent of Item	Per Cent with Item	Per Cent of Item
Insecta	89	75	94	61	91	71	87	78
Coleoptera	21	6	30	8	20	7	22	5
Diptera	17	25	27	5	14	6	20	40
Orthoptera	11	2	7	1	12	4	10	2
Hemiptera	19	6	29	8	20	7	17	5
Collembola	10	4	33	12	9	4	10	4
Lepidoptera	19	4	17	3	19	6	20	3
Hymenoptera	14	10	12	5	16	16	10	5
Isoptera	3	6	1	**	2	6	4	6
Neuroptera	**	**	1	**	0	0	1	**
Dermaptera	**	**	0	0	0	0	1	**
Araneae	46	12	54	18	45	15	47	9
Isopoda	19	7	19	11	16	7	23	6
Pulmonata	9	2	12	2	6	2	12	2
Diplopoda	2	**	5	1	3	1	0	0
Opisthopora	1	**	3	1	1	**	2	**
Chilopoda	1	**	0	0	0	0	2	**
Acarina	**	**	1	**	1	**	0	0
Vegetation	1	**	1	**	1	**	1	**
Unidentified	20	4	32	6	17	4	24	3
Shed skin	1	**	0	0	0	0	2	**
Number of items	1282		543		549		733	
Mean no. items	5.5		5.8		4.3		6.9	

** Less than 0.05 per cent.

SEXUAL VARIATION

The food habits of male and female adults are given in Table 2. There appears to be very little difference between sexes as regards per cent with item. The mean number of items per skink for males is 4.3 ($S.E._m = 0.35$), that for females is 6.9. But here again the one female containing 223 fruit flies should receive special attention. The mean number of items per female, excluding this particular one, is 4.8 ($S.E._m = 0.47$). A t test comparing these means, 4.3 and 4.8, gives a non-significant value ($t = 1.20$, $P. < .05$).

SEASONAL VARIATION

The food habits by season and the mean number of items per skink per season are given in Table 3. The mean number of items per skink for September through November, excluding the female with 223 dipterans, is 4.4. The insects as a whole are very constant in both percentages for all four seasons, whereas the per cent of skinks with spiders and isopods changes with the seasons. These results are probably due to population changes within these particular food groups or changes in environmental factors which affect the activity cycle of the food item.

DISCUSSION

The type of food eaten by the ground skink is of course restricted by the habitat and size of the skink. Yet with these restrictions the results do not indicate a preference for any one type of food. Food items within a certain size range are probably taken according to their availability.

Food habit studies are of considerable interest, not only for answering the question as to what the animal eats, but also for supplying data for studies on population energetics. To get an estimate of the gross amount of energy taken in by a population it is necessary to know the type and amount of food eaten, and the caloric values of these food items. The results of a recent study by Slobodkin and Richman (1961) indicate that for several animal species the caloric values per gm lie within a relatively narrow range. Thus in order to obtain a crude estimate of the gross energy taken in by a population it would be necessary to know only the total amount of food eaten per unit time.

TABLE 3

Gut contents of *Lygosoma laterale* listed by season

Item	Dec-Jan-Feb (95)		Mar-Apr-May (68)		Jun-Jul-Aug (93)		Sep-Oct-Nov (71)	
	Per Cent with Item	Per Cent all Items	Per Cent with Item	Per Cent all Items	Per Cent with Item	Per Cent all Items	Per Cent with Item	Per Cent all Items
Insecta	89	68	90	74	92	66	89	78
Coleoptera	21	8	16	6	30	9	20	4
Diptera	17	4	21	14	17	14	25	48
Orthoptera	5	1	10	2	14	4	11	1
Hemiptera	24	9	21	6	16	5	27	5
Collembola	14	5	9	3	22	8	21	7
Lepidoptera	19	4	12	3	18	5	24	3
Hymenoptera	21	22	18	6	10	2	3	*
Isoptera	1	*	6	21	2	1	0	0
Neuroptera	1	*	0	0	1	*	0	0
Dermaptera	0	0	0	0	0	0	1	*
Araneae	47	17	63	16	51	16	31	6
Isopoda	26	8	9	2	5	9	37	10
Pulmonata	7	1	10	2	14	3	8	1
Diplopoda	2	*	0	0	5	1	3	*
Opisthopora	0	0	0	0	3	1	4	1
Chilopoda	1	*	0	0	0	0	1	*
Acarina	0	0	1	*	0	0	1	*
Vegetation	1	*	0	0	0	0	3	*
Unidentified	28	5	25	5	23	4	23	3
Shed skin	1	*	0	0	0	0	1	*
Number of items	500		330		459		536	
Mean no. items	5.3		4.9		4.9		7.5	

* Less than 0.05 per cent.

SUMMARY

A total of 329 specimens of *Lygosoma laterale* were examined for food habits. Only two lacked food material.

The major food items in rank of importance were insects, spiders, and isopods.

The mean number of food items per individual for juveniles was significantly higher than that for adults.

No major difference in food habits was found between male and female adults.

Insects, but not spiders and isopods, occurred as food items in approximately the same frequency throughout the year.

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COMPARATIVE GROWTH AND REPRODUCTION OF HEREFORD AND BRAHMAN CATTLE IN FLORIDA

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The growth and reproductive pattern of beef cattle breeds which originated in Great Britain (*Bos taurus*) is well established for temperate climatic zones. Such information on Zebu (*Bos indicus*) cattle breeds is limited and mostly based on research in tropical climatic zones. These aspects of cattle production were reviewed by Rhoad (1955) and Cunha *et al.* (1963). This study was designed to provide data concerning the influence of controlled diets upon the growth and reproductive performance of Hereford (*Bos taurus* origin) and Brahman (*Bos indicus* origin) cattle in the Florida environment, which is intermediate to that in which both breeds originated. Two levels of protein intake were studied, one recommended and one prevalent on the average Florida ranch.

Methods

Three groups of registered purebred animals as representative as possible of the two breeds were employed in this study. Group I consisted of 24 yearling heifers, 12 of each breed; Group II included 24, 8-month-old weaned calves, 12 of each breed; and Group III was composed of 20 pregnant cows, 10 of each breed. Groups I and II were selected on the basis of age and weight. The cows in Group III were selected on the basis of production record and date of conception.

Half of the animals of each group were allocated at random by breed into two dietary treatments as follows: (1) a nutrient allowance recommended by the National Research Council (1950) for their respective ages and hereafter designated NRC and (2) the same nutrient allowances less 50 per cent of the crude protein intake, hereafter designated 50% NRC. All animals were grazed on grass pasture between May 15 and Oct. 15 for the summers of 1957, 1958, and 1959. The two dietary regimens were maintained during the summer by rotation of fertilized and unfertilized pastures in conjunction with monthly proximate analyses of forage from each pasture. As indicated in Table 1, the winter diets consisted of Pangolagrass hay with high or low protein supplements consist-

TABLE 1

Diets received by animals

Ingredient*	Crude Protein Approx. %	Summer May 15–Oct. 15 N.R.C.	Summer May 15–Oct. 15 50% N.R.C.	Winter Oct. 16–May 14 N.R.C.	Winter Oct. 16–May 14 50% N.R.C.
Fertilized pasture	12–14	X	—	—	—
Non-fertilized pasture	7–9	—	X	—	—
Pangolagrass hay	3–4	—	—	X	X
H.P.S.**	40	—	—	X	—
L.P.S.**	10	—	—	—	X

* These ingredients were fed in different ratios during the respective periods to meet the N.R.C. recommended nutrient allowances as suggested for cattle of various weights and conditions.

** H.P.S. and L.P.S. designate high and low protein supplements, respectively. These were composed of 41% cottonseed meal, ground yellow corn, steamed bonemeal, trace mineralized salt and a vitamin mix. The vitamin mixture was calculated to provide 15,000 I.U. vitamin A, 2,000 I.U. vitamin D, 22 I.U. vitamin E per day for each animal.

N.R.C. indicates diet recommended by National Research Council (1950) for the respective age and classification of animal.

TABLE 2

Reproduction data, groups I & II

Group	Breed	Diet	No.	Foll.[a]	C.L.[b]	Estrus[c]
I	Hereford	NRC	6	4.8 ± 0.70	8.8 ± 3.86	1.3 ± 0.07
	Hereford	50%	6	5.2 ± 0.84	10.0 ± 1.00	1.5 ± 0.35
	Brahman	NRC	6	6.7 ± 1.76	8.8 ± 1.73	0.2 — [d]
	Brahman	50%	6	6.5 ± 1.38	10.2 ± 1.70	0.5 ± 0.22
II	Hereford	NRC	6	12.0 ± 3.83	20.0 ± 3.20	0.8 ± 0.17
	Hereford	50%	6	10.0 ± 1.51	16.0 ± 2.59	1.0 — [d]
	Brahman	NRC	6	25.0 ± 3.86	9.0 ± 1.76	1.2 ± 0.60
	Brahman	50%	6	29.0 ± 4.48	5.0 ± 1.03	1.3 ± 0.42

[a] Mean number large ovarian follicles for each animal in treatment over experimental period.

[b] Similar data for corpora lutea.

[c] Similar data for observed estrus.

[d] Too few data to calculate Standard Error.

ing basically of 41 per cent cottonseed meal and ground yellow corn.

In the spring of 1958, the two year-old heifers of Group I were exposed to bulls of their own breed during a 90-day period. The two bulls of each breed were exchanged every 14 days between the two dietary treatments to avoid confounding fertility of the bulls with the dietary treatments. Group II were similarly bred during the spring of 1959. The pregnant cows selected for Group III had been bred to bulls of their own breed in the previous spring of 1958.

During the breeding season and for the interval thereafter until pregnancy had been confirmed, all animals were rectally palpated at 14 day intervals. Rectal palpation was also carried out at various intervals subsequent to calving to determine the presence of corpora lutea and ovarian follicles.

At 28-day intervals, all adult animals were individually weighed. The calves were individually weighed at biweekly intervals until they were weaned at 8 months of age. By means of rectal palpation in conjunction with a record of observed signs of estrus and copulations, it was possible to obtain an accurate estimate of the age of puberty, the length of interval between first breeding and calving, the length of gestation period, the number of ovarian follicles and corpora lutea on each of the ovaries over a given period of time, and other data relating to reproductive efficiency.

Results

Growth data for the Herefords and Brahmans are presented in Figures 1a and 1b, respectively. All of the Hereford heifers calved when they were approximately 36 months of age. Brahmans on the low protein diet calved at approximately 34 months of age, and those receiving the NRC diet calved at an average age of 36 months. Only four out of each group of six Brahmans calved. Data for both lactating and non-lactating heifers are presented in Figure 1b. The growth of calves in the four breed-treatment lots of Group I is illustrated in Figure 2. The growth curves for Group II heifers are presented in Figures 3a and 3b respectively, and Figure 4a illustrates the body weights of the suckled dams for all four lots in Group III together with the growth of their calves (Figure 4b).

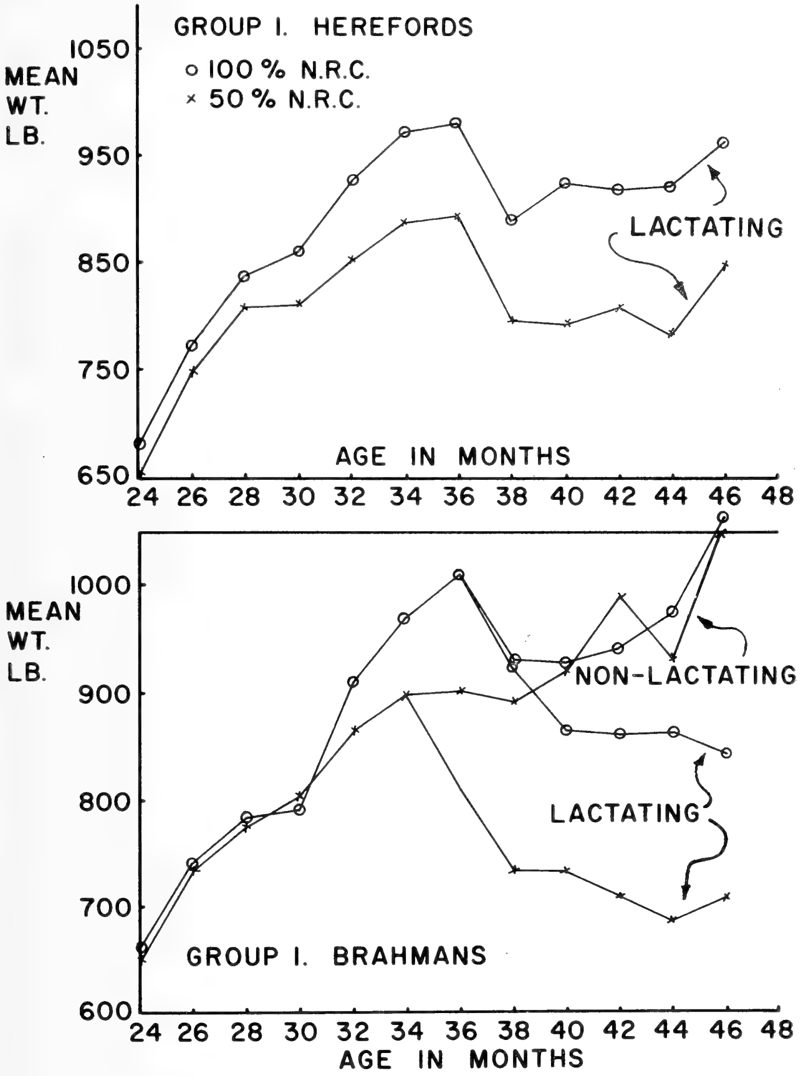

Fig. 1. Live weights of Herefords and Brahmans in Group I. Calving occurred at 34-36 months of age.

There were no significant differences between the growth patterns of the two breeds as demonstrated by analysis of variance of Group I and co-variance analysis of the combined data for Groups I and II. Analysis of the Group II data, however, did indicate that the Brahmans, which weighed less at the beginning of the experiment, were significantly heavier ($P < 0.01$) at 34 months of age. Analysis of covariance showed that the 50% NRC diet significantly depressed growth ($P < 0.01$) in both groups. Analysis of variance of the calf data in Figure 2 showed a significant difference in growth rate between both breeds and diets ($P < 0.01$). There were no significant differences between the data for breeds or diets in Figures 4a and b. A close inspection of these two graphs reveals the small amount of variability in the results for all four treatments.

Data relating to reproductive efficiency are presented for the three groups in Tables 2-6. Limited information with respect to duration of estrus for the two breeds is presented in Table 7. Because of limited digital data, none of the data presented in Table 2 were statistically analyzed. Only the first year interval between breeding and calving and the number of days for the first corpora lutea to appear after calving were subjected to analysis of variance in Table 3. No significant difference between

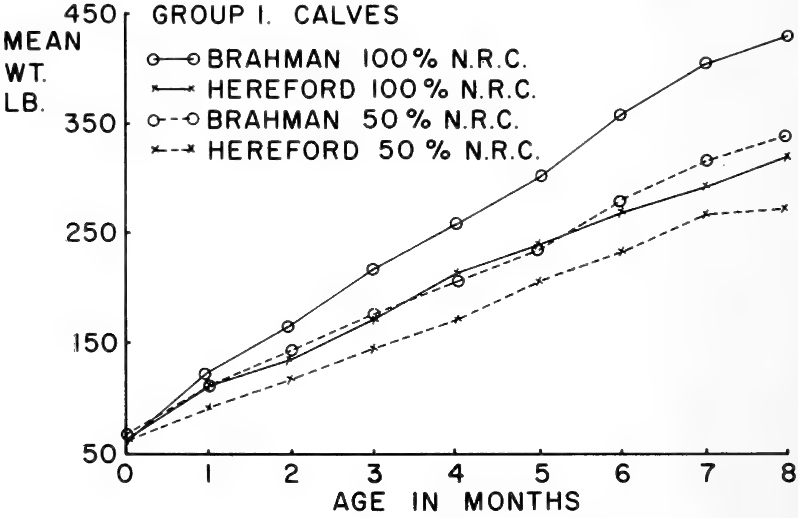

Fig. 2. Growth curves for calves of group I.

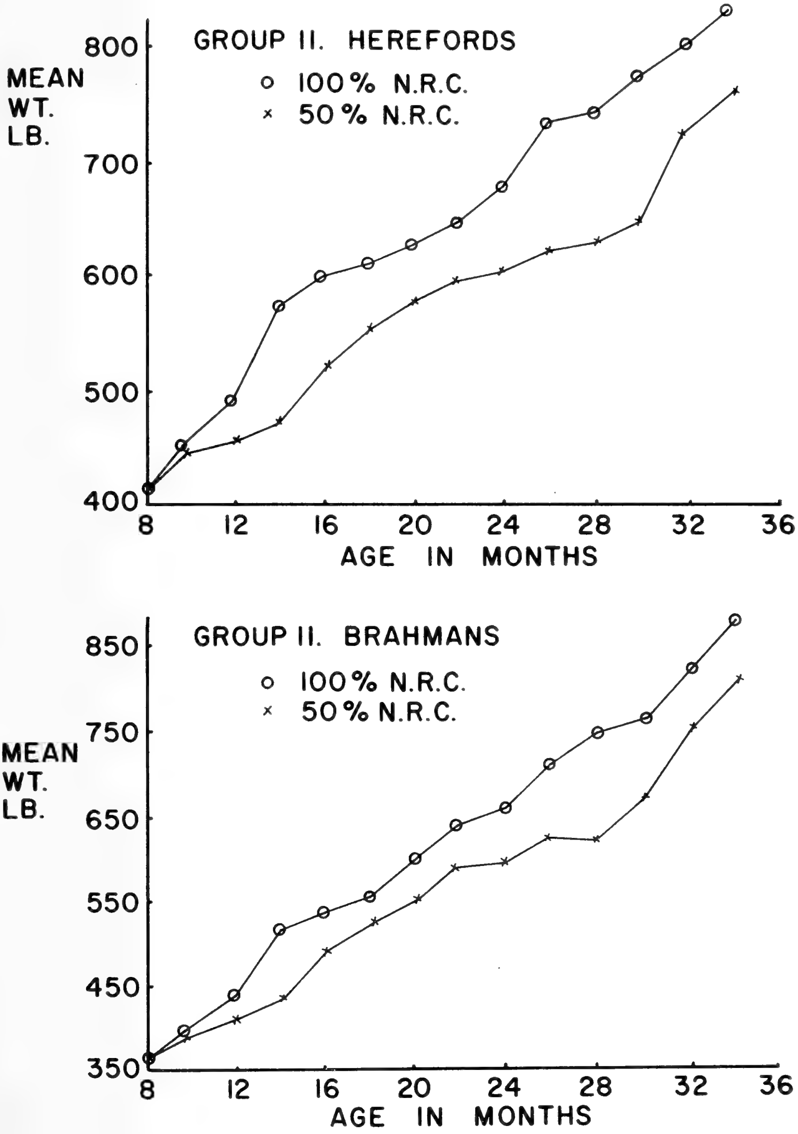

Fig. 3. Growth curves for Herefords and Brahmans in group II.

breeds or diets was evident. An analysis of variance of the gestation length of heifers in Group 3 (Table 4) showed a significantly shorter gestation period ($P < 0.05$) in Herefords. When puberty is estimated by first corpus luteum, Brahmans required an average of 50 days longer to reach puberty on the NRC diet and 63 days longer on the 50% NRC diet (Table 4). Puberty as judged by age at first estrus is to be viewed with apprehension because of the error inherent in visual detection of the first estrus. Although the difference in ages at which the first corpora lutea were detected was non-significant ($P < 0.075$) between diets, the protein restriction delayed puberty in both breeds. Analysis of variance of the breeding to calving interval for Group II (Table 4) showed a significant difference between species and also a species-diet interaction ($P < 0.05$).

DISCUSSION

The accent of this report is upon the growth and reproductive efficiency of Hereford and Brahman cattle maintained in an environment intermediate to those in which these breeds originated. It is therefore appropriate to review the climographs for Gainesville, Florida, Herefordshire, England and the Ongole district of Madras State, India. The Nellore environment was used since the Nellore was one of the predominate breeds in the formation of the American Brahman (Jacobs, 1955). The climograph shown in Figure 5 was constructed by joining in a linear fashion the twelve monthly mean points for temperature as ordinates plotted against the relative humidity as abscissa. Thirty years of data were used.

There were no significant differences in growth rate for the two breeds after weaning and up to 1000 lb. weight. Brahman heifers continued to gain weight up to 1200 lb. whereas Hereford heifers did not attain this weight. As calves, the Brahmans were heaviest in both dietary groups when weaned at 8 months of age. This may be the result of more milk being available to the Brahman calf as reported by Howes *et al.* (1958). The protein restriction slowed growth in Group I and II cows, and in both groups of calves.

Figures 1a and 1b and 4a show the effects of calving and lactation upon the body weight of both species. Herefords in Group I lost weight on both diets and gradually began to gain weight towards the end of lactation. Lactating Brahmans in Group I be-

TABLE 3

Reproduction data, group I

		1st Year	Post Calving Int. Days			2nd Year	
Breed	Diet	Br./Cal. Days[a]	C.I.[b]	Fol.[c]	C.L.[d]	Est.[e]	Br./Cal Days
Hereford	NRC	303 ± 6.78	36.7 ± 3.35	29.8 ± 5.96	56.6 ± 6.17	1.8 ± 0.40	323 ± 4.80
Hereford	50%	313 ± 10.8	33.0 ± 6.89	30.0 ± 7.00	51.2 ± 10.3	0.8 ± 0.30	304 —[f]
Brahman	NRC	319 ± 4.22	35.8 ± 4.22	14.0 —[f]	55.3 ± 7.39	1.0 ± 0.36	346 ± 10.8
Brahman	50%	306 ± 3.39	26.5 ± 1.94	49.0 ± 3.54	65.0 ± 6.69	1.2 ± 0.31	342 —[f]

[a] Interval in days from first observed breeding to calving.
[b] Days after calving to cervical involution.
[c] Days after calving to first large follicle.
[d] Days after calving to first corpora lutea.
[e] Days after calving to first observed estrus.
[f] Too few data to calculate Standard Error.

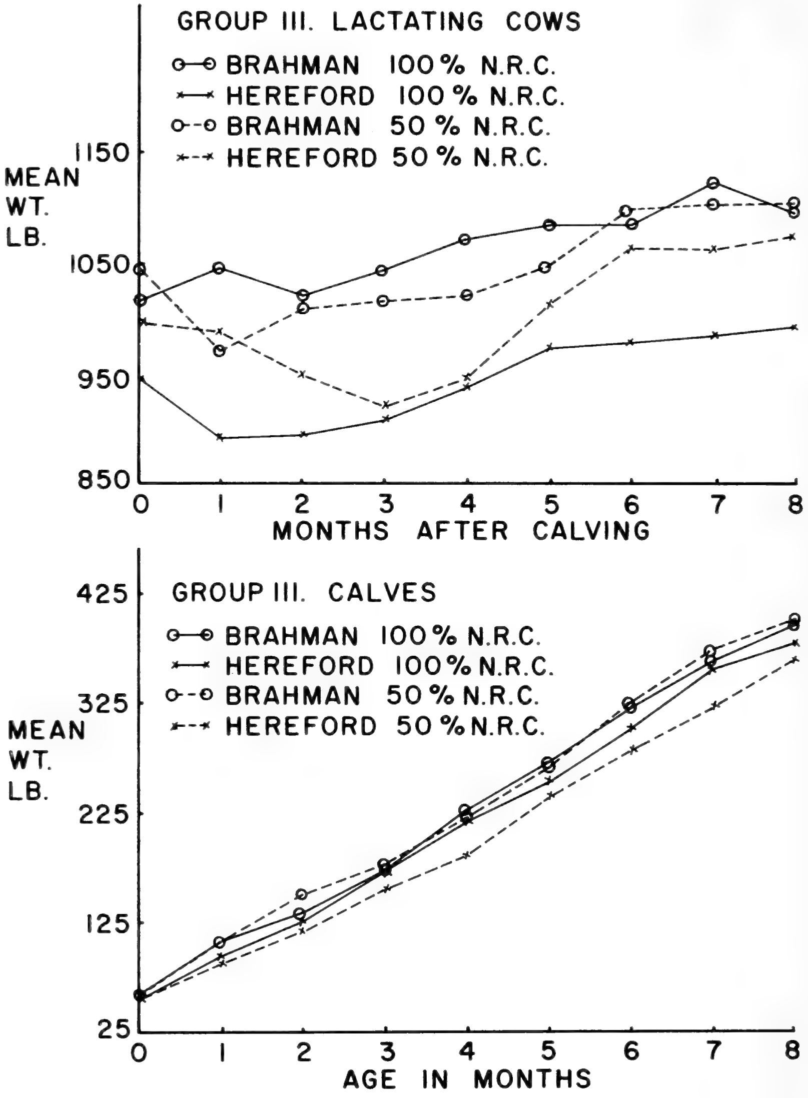

Fig. 4. Live weights of lactating cows in group III and growth curves of their calves.

haved much the same except their loss of weight during lactation was more substantial. This may be the result of their higher milking performance (Howes *et al.*, 1958). Lactating Group I Brahmans on the 50% NRC diet lost so much weight that their ability to show estrus and breed was apparently hindered while still lactating. Koger *et al.* (1962) suggested that lactational status was one reason for low fertility in Florida range cattle. The failure to

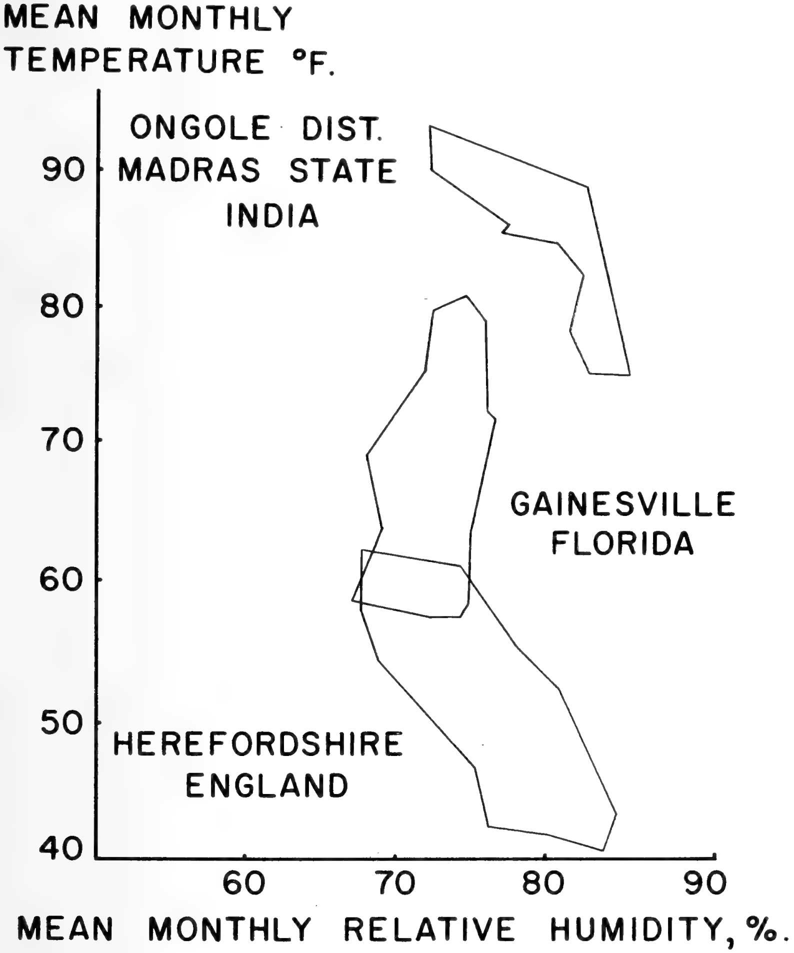

Fig. 5. Climograph for Gainesville, Florida and areas native to Hereford and Nellore cattle.

obtain similar results with the lactating animals in Group III may probably be ascribed to the shorter period that these animals were exposed to the various dietary regimens prior to calving and the lack of an excessive weight loss in these mature cows. They were fed their respective diets only during the latter part of their pregnancy, whereas Group I animals were fed the low protein diet for one year prior to calving.

Breed differences with respect to reproductive performance were the most obvious. Brahmans exhibited very few signs of

TABLE 4

Reproduction data, group II

Breed	Diet	Days for Puberty[a] C.L.	Days for Puberty[a] 1st Estrus	BR/Cal., days[b]	Gestation, days
Hereford	NRC	408 ± 30.9	436 ± 44.9	296 ± 13.5	278 ± 1.66
Hereford	50%	528 ± 69.8	609 ± 76.7	290 ± 4.74	276 ± 4.07
Brahman	NRC	458 ± 71.3	582 ± 96.2	297 ± 7.71	281 ± 2.66
Brahman	50%	591 ± 79.4	402 ± 34.9	332 ± 14.0	285 ± 3.16

[a] Time in days to reach puberty as measured by first corpora lutea (C.L.) and first estrus.

[b] Interval in days from first observed breeding to calving.

TABLE 5

Reproduction data, for group III*

Breed	Diet	Time in days following parturition to: C.I.	1st Foll.	1st C.L.	1st Estrus
Hereford	NRC	41 ± 5.89	33 ± 9.70	48 ± 6.59	54 ± 14.6
Hereford	50%	38 ± 4.39	44 ± 8.19	65 ± 8.48	57 —[a]
Brahman	NRC	37 ± 4.65	59 ± 12.3	56 ± 9.38	83 —[a]
Brahman	50%	48 ± 15.5	46 ± 5.00	67 ± 11.5	86 —[a]

* Five animals per treatment.

[a] Too few data to calculate Standard Error.

estrus (Table 7); the few estrus periods detected were extremely short (Table 7) and most occurred at night. Brahmans raised fewer calves (Table 6), had significantly longer breeding to calving intervals, took significantly longer to reach puberty, and experienced significantly longer gestation periods. Howes *et al.* (1960) and Warnick *et al.* (1960) have also indicated the lower reproductive efficiency of Brahmans under Florida conditions.

The reduction of dietary protein had serious effects upon reproduction efficiency in both breeds. Most notable was the delay in maturity. The lack of dietary protein may well be a significant cause for the delay in reaching puberty frequently observed in

TABLE 6

Calving percentages

Group	Breed	Diet	No.	1st Calving	2nd Calving
I	Hereford	NRC	6	100	67
	Hereford	50%	6	100	17
	Brahman	NRC	6	67	67
	Brahman	50%	6	67	33
II	Hereford	NRC	6	67	—
	Hereford	50%	6	100	—
	Brahman	NRC	6	67	—
	Brahman	50%	6	67	—
III	Hereford	NRC	5	100	80
	Hereford	50%	5	100	80
	Brahman	NRC	5	100	60
	Brahman	50%	5	100	100

TABLE 7

Duration of estrus in Hereford and Brahman cattle

Breed	Total Estrus Periods	Duration of Estrus Period, Hours							
		0–2	2–4	4–6	6–8	8–10	10–12	12–14	Over 14
Hereford	31	9	6	5	2	1	0	2	6
Brahman	9	5	3	0	0	0	0	0	1

Florida cattle. The low protein diet restricted subsequent conception in both the Herefords and Brahmans of Group I (Table 6). This may be associated with the lactational status as reported by Koger *et al.* (1962). The only Brahmans receiving the low protein diet which calved the second year were those which were not suckling calves the first year.

SUMMARY

The comparative growth and reproductive performance is reported for three representative groups of purebred Herefords and Brahmans raised on two dietary levels of protein in the same environment. The environment of central Florida is intermediate between the environments in which the Brahman and Hereford breeds originated.

Brahmans weaned the heaviest calves, but the growth rate of Hereford heifers was equivalent to that of Brahmans up to approximately 1000 pounds live weight. Brahmans continued to grow under satisfactory conditions to a heavier live weight. Reduction of the dietary protein by 50 per cent seriously impaired the growth rate of both breeds at all ages. The nutrient allowances as recommended by the NRC (1950) provided the anticipated weight gains for lactating Herefords but not for lactating Brahmans. During lactation, Brahmans on both dietary treatments lost more weight than Herefords, probably because of their better milking performance. Weight losses were so severe on the low protein diets of first calf heifers of both breeds that subsequent reproductive performance was jeopardized.

Brahmans exhibited few visible signs of estrus, and the periods detected were extremely short and mostly nocturnal. Brahmans raised fewer calves, had longer breeding to calving intervals, took significantly longer to reach puberty, and experienced longer gestation periods. The low protein diet significantly delayed the onset of puberty and jeopardized subsequent reproductive performance in both breeds. The impairment of reproductive efficiency in these animals may be directly associated with lactational status. It is concluded from this study that under the conditions prevailing in central Florida Brahman females may have a lower reproductive efficiency than Herefords, but their calves may grow faster up to the time of weaning, probably because of the better milking ability of the Brahman dam. Part of the lower reproduc-

tive efficiency attributed to lactating Brahman cows may be due to an insufficient supply of feed nutrients to meet their relatively higher requirements for superior milk production.

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FOOD OF THE BARN OWL IN FLORIDA

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Many pellet analyses of the barn owl (*Tyto alba pratincola*) have been made, but none from Florida. The present study treats the vertebrate remains from a nest in McIntosh, Marion County, Florida. This locality is only six miles north of the fossil site at Reddick, whose fauna is listed in the present number of this journal (Gut and Ray, 1964). The barn owl was the fourth most abundant bird in the Pleistocene at Reddick, and its pellets are thought to be the source of the abundant rodents and insectivore remains (Brodkorb, 1957). It is of interest, therefore, to compare the food remains from this recent nest with the fossils from the nearby site, for clarification of the paleoecology and mode of fossil deposition.

The barn owl nest was located in the attic of an old house. It was visited on December 7, 1961, when four young were in the nest and July 21, 1962, when a second brood of three young had just left the nest. According to the property owner, the nest had been occupied since at least 1960. The house is situated in a live oak (*Quercus virginiana*) hammock, less than one mile from Orange Lake, a large shallow body of water with extensive marshy and brushy fields around its shores. Much of the higher ground nearby has been converted into orange groves.

The nest debris, consisting of about ten pounds of matted hair and bone, was collected on July 21, 1962. Very few pellets were intact in the nest, but 26 were picked up under the large live oaks in the yard.

Table 1 gives the contents of both the nest debris and the pellets. Of the 865 animals found, 96.5 per cent were mammals, 3.2 per cent birds, and 0.3 per cent amphibians. The ratio of mammals to birds is very similar to that reported in several studies, and the only species previously unrecorded in barn owl pellets were the round-tailed muskrat (*Neofiber alleni*), flying squirrel (*Glaucomys volans*), and grasshopper sparrow (*Ammodramus savannarum*).

Sigmodon is normally found in rather open, grassy or brushy areas. *Oryzomys* also is found in grassy areas, but closer to water than *Sigmodon*. Both Wallace (1948) and Cunningham (1960) noted that barn owls frequently fly as far as two miles to their

TABLE 1

Analysis of barn owl nest debris and pellets

Species	Number of Individuals	Per cent within Class	Per cent of Total
Sigmodon hispidus	650	78.0	75.2
Oryzomys palustris	93	11.1	10.7
Cryptotis parva	19	2.3	2.2
Peromyscus polionotus	18	2.2	2.1
Scalopus aquaticus	17	2.0	2.0
Blarina brevicauda	9	1.8	1.0
Peromyscus gossypinus	8	1.0	0.9
Neofiber alleni	7	0.8	0.8
Reithrodontomys humulis	3	0.4	0.3
Mus musculus	3	0.4	0.3
Sylvilagus floridanus	2	0.2	0.2
Pitymys pinetorum	2	0.2	0.2
Neotoma floridana	2	0.2	0.2
Glaucomys volans	1	0.1	0.1
Total mammals	834		96.5
Agelaius phoeniceus	11	39.3	1.3
Colinus virginianus	5	17.9	0.6
Porzana carolina	2	7.1	0.2
Capella delicata	1	3.6	0.1
Cassidix mexicanus	1	3.6	0.1
Sturnella magna	1	3.6	0.1
Passer domesticus	1	3.6	0.1
Ammodramus savannarum	1	3.6	0.1
Unidentified passerines	5	17.9	0.6
Total birds	28		3.2
Rana pipiens	3	100.0	0.3
Total amphibians	3		0.3
Grand total	865		

hunting grounds. Since both *Sigmodon* and *Oryzomys* comprise such a high proportion in this study, it is quite probable that the owls usually fed near the shore of Orange Lake. The round-tailed muskrat, red-winged blackbird (*Agelaius phoeniceus*), boat-tailed grackle (*Cassidix mexicanus*), sora rail (*Porzana carolina*), and snipe (*Capella delicata*) would also be indicative of a wet habitat.

The similarities between the prey composition at this nest and the fossil deposits at Reddick are very striking. All of the mammals recorded here also occur at Reddick, except for the introduced house mouse (*Mus musculus*). The fossil *Colinus suilium* is the ancestral form of the recent quail (*Colinus virginianus*). Of the other birds only the boat-tailed grackle, grasshopper sparrow, and the introduced house sparrow (*Passer domesticus*), were not recorded from Reddick. Brodkorb (1957) records the ratio of mammals to birds in the fossil site as 175:1, or 0.6 per cent. Since this includes both barn owl remains and mammals too large to be taken by owls, a corrected percentage without these items would be higher than 0.6 per cent. In the present study, the ratio of mammals to birds is 834:28, or 3.4 per cent. The evidence, therefore, strongly indicates that many of the fossils were, in fact, deposited by owls and the paleoecology of the Reddick site probably was very similar to the present area around Orange Lake.

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