ISSN: 0098-4590

Florida Scientist

Volume 42 Winter, 1979 No. 1

CONTENTS

QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

FLORIDA SCIENTIST

QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

The FLORIDA SCIENTIST is published quarterly by the Florida Academy of Sciences, Inc., a non-profit scientific and educational association. Membership is open to individuals or institutions interested in supporting science in its broadest sense. Applications may be obtained from the Executive Secretary. Both individual and institutional members receive a subscription to the FLORIDA SCIENTIST. Direct subscription is available at $13.00 per calendar year.

Original articles containing new knowledge, or new interpretation of knowledge, are welcomed in any field of Science as represented by the sections of the Academy, viz., Biological Sciences, Conservation, Earth and Planetary Sciences, Medical Sciences, Physical Sciences, Science Teaching, and Social Sciences. Also, contributions will be considered which present new applications of scientific knowledge to practical problems within fields of interest to the Academy. Articles must not duplicate in any substantial way material that is published elsewhere. Contributions are accepted only from members of the Academy and so papers submitted by non-members will be accepted only after the authors join the Academy. Instructions for preparation of manuscripts are inside the back cover.

Published by the Florida Academy of Sciences, Inc.
810 East Rollins Street
Orlando, Florida 32803

Printed by the Storter Printing Company
Gainesville, Florida

Florida Scientist

QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

Walter K. Taylor, *Editor* Henry O. Whittier, *Editor*

Volume 42 Winter, 1979 No. 1

Biological Sciences

SALINITY PREFERENCE IN FRESH WATER AND ESTUARINE SNAKES (*NERODIA SIPEDON* AND *N. FASCIATA*)

David A. Zug and William A. Dunson

Department of Biology, The Pennsylvania State University, University Park, Pennsylvania 16802

Abstract: *Salinity preference in aquatic snakes was measured in a divided aquarium over a 6 hr period. Comparative studies were made on 5 species of snakes from marine, estuarine, and fresh-water habitats:* Nerodia fasciata pictiventris, *fresh-water Florida banded water snake;* N. f. compressicauda, *estuarine mangrove snake;* N. s. sipedon, *fresh-water northern water snake;* Laticauda colubrina, *marine banded sea snake; and* Cerberus rhynchops, *marine homalopsid snake. All 3* Nerodia *and* L. colubrina *preferred fresh water to sea water (35‰);* C. rhynchops *showed a random distribution. Severe dehydration of one* C. rhynchops *by submersion in sea water for 109 da without feeding led to a strong preference for fresh water. The* Nerodia *races showed random distributions in two types of control tests, in which both sides of the aquarium contained fresh water, or both sides contained sea water. Both* N. f. pictiventris *and* N. f. compressicauda *preferred fresh water to 50% sea water (17.5‰). At 15% sea water (5.5‰),* N. f. compressicauda *still preferred fresh water, while* N. f. pictiventris *showed a slight preference for the 15% sea water. At 10% sea water (3.5‰),* N. f. compressicauda *again preferred fresh water, whereas* N. f. pictiventris *showed no significant preference for either salinity.* N. f. compressicauda *also preferred fresh water to 2 of 3 solutions osmotically similar to 35‰ sea water, 0.5 Molal NaCl and 0.5 Molal KCl. There was a random distribution between fresh water and 1.0 Molal sucrose. Some preliminary experiments were performed on* N. s. sipedon *to determine the sense organs involved in the preference for fresh water over 35‰ sea water. Blockage of olfaction and the vomeronasal system had no apparent effect on the snakes' preference for fresh water. It is possible that oral sensory papillae and/or general oral gustation are involved in salinity perception.**

Only a limited number of reptiles, such as the sea turtles and sea snakes, have successfully colonized the open sea. However, many other independent and divergent invasions of the coastal areas have occurred. Dunson (submitted), cites such examples as the diamondback terrapin *Malaclemys terrapin* (Emy-

*The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U. S. C. § 1734, this article must therefore be hereby marked "*advertisement*" solely to indicate this fact.

didae), the marine iguana *Amblyrhynchus* (Iguanidae), the several subspecies of estuarine snakes of the genus *Nerodia (N. fasciata clarki, N. f. compressicauda, N. f. taeniata, N. sipedon williamengelsi,* Colubridae, previously *Natrix,* Rossman and Eberle, 1977), and several species of rear-fanged snakes of the family Homalopsidae or subfamily Homalopsinae, Colubridae (*Cerberus rhynchops* is one example). All marine reptiles studied to date have been shown to possess 1 of 4 types of salt gland (lachrymal, nasal, posterior sublingual, and premaxillary) and a skin impermeable to sodium (Dunson, 1976, in press a; Dunson and Dunson, in press). *Nerodia f. compressicauda,* which appears to be in the early stages of marine evolution, probably lacks a salt gland, yet possesses other physiological mechanisms permitting long term survival in sea water. Its skin is less permeable to water and sodium and it has a lower body water influx and efflux and body sodium influx than that of the fresh water race *N. f. pictiventris,* with which it interbreeds (Dunson, 1978, in press b, submitted; Krakauer, 1970). Dunson (submitted) postulated that the high rate of sodium influx of fresh water snakes placed in sea water was the primary factor leading to drinking and subsequent death. Thus, it seems likely that the tolerance of sea water by estuarine races of *N. fasciata* may not be simply due to a reluctance to drink sea water as originally proposed by Pettus (1956, 1958, and 1963), but to underlying physiological and anatomical differences.

This study was designed to examine the salinity preference of a variety of marine, estuarine, and fresh water species and subspecies. Pettus (1956, 1958, and 1963) tested the responses of Texas *N. f. clarki* and *N. f. confluens* in a divided tank with fresh water on one side and full strength sea water on the other. We duplicated these conditions and extended the tests to determine the effects of using intermediate salinities, of substituting other solutions for sea water, and of blocking olfaction and the vomeronasal organ. An objective procedure was developed for classifying the responses of snakes that were only partly in one compartment. Pettus's data are seriously weakened by his failure to account for this source of variation.

TANK SETUP—Preliminary tests were conducted to determine the type of aquarium to be used in the behavioral assay of salinity preference in snakes. All designs consisted of a 23 liter, all glass aquarium, divided in half by a 0.3 cm thick, clear plexiglass barrier. A 10 cm high barrier, similar to that used by Pettus (1958), proved unsuccessful because of the tendency of the snakes to lie on the barrier, often completely avoiding submersion. We are unable to determine how Pettus solved this problem. The use of the barrier as a resting place was partially avoided by extending the barrier to the top of the aquarium, and drilling three 3.75 cm diameter holes, with their centers 5.0 cm from the bottom of the aquarium.

One liter of water was placed on each side of the barrier. Up to 6 tanks were used simultaneously, and each of them was isolated within a wood frame lined by opaque curtains. This arrangement helped to eliminate unequal illumination and other visual cues. *Laticauda colubrina* was tested in a similarly designed 46 liter aquarium. Air temperatures ranged 23-26°C during testing; water temperatures ranged 22-24°C. Dechlorinated tap water was used for fresh water, and also in preparation of "Instant Ocean" sea water. Salinity was measured with an American Optical Refractometer; the calibration was checked with a hydrometer and by sodium determinations (Varian Techtron Atomic Absorption Spectrometer, model 1280, air propane flame).

ANIMALS—Two species of lab-reared juvenile snakes were tested. A brood of *N. s. sipedon* born to a Centre County, Pennsylvania female weighed 22-27 g each and was 18 mo old. A brood of *N. f. pictiventris* born to an Alachua County, Florida female weighed 10-14 g each when 6 mo old. These 2 broods were maintained in dry aquaria with continuous access to fresh water in a small bowl. Fresh water minnows (*Pimephales*) were offered every several days. Older wild-caught snakes were kept in dry aquaria; their tanks were flooded with fresh water approximately once a week at the same time minnows were offered as food. These snakes included *N. f. compressicauda* (52-59 g) collected from Collier County, Florida, *N. s. sipedon* (45-52 g) captured in Centre County, Pennsylvania, and dog-faced water snakes *Cerberus rhynchops* (58-74 g) and banded sea snakes *Laticauda colubrina* (65-75 g) obtained from the Palau Islands.

TEST PROCEDURES—Preliminary tests were conducted in which several snakes were run simultaneously in the same aquarium. These group tests were discontinued because the snakes showed a tendency to aggregate. For each series of tests, individual snakes were initially placed into either the left or right side (half in each) of each aquarium. After introduction of the snake, a 1 hr adjustment period was allowed, followed by observation of the snake's position every 0.5 hr over a 5 hr period. A total of 10 positions was thus observed and recorded for each snake. Most experiments involved the use of 10 individual snakes of each species, resulting in a total of 100 observed positions.

Positions observed were classified according to the following possibilities: (a) The snake was entirely on one side of the barrier and was so recorded; (b) Either more or less than two thirds of the anterior portion of the snake was on one side. The observation was recorded for the side on which the head was located, with an identifying notation added to allow later discrimination between these 2 categories.

This classification of the data allows many possible methods of analysis, including discard of all "equivocal" positions involving the barrier, or simply utilizing head position alone as the deciding factor. We decided to give equal weight to complete presence on one side and the observation that more than two thirds of the anterior body was present there; these data have been pooled. Positions involving less than two thirds of the anterior body are reported separately, were not used in the statistical analysis, and are considered to represent no preference for either side of the aquarium. Statistical analyses were performed with the chi-square test ($P < 0.05$ significance level). It was assumed that the snakes would show a random distribution if no preference occurred.

A series of tests were run in which the salinity preference of individual snakes of various species was tested against fresh water. Sea water (SW) salinities of 35‰ (100% SW), 17.5‰ (50% SW), 5.5‰ (16% SW), and 3.5‰ (10% SW) were used. Control tests had either fresh water or 100% SW on both sides of the barrier. The response to various solutions (0.5 Molal NaCl, 0.5 Molal KCl, 1.0 Molal sucrose) similar to 100% SW in osmotic pressure but not in specific ions was tested. A preliminary analysis of the sense organ(s) used for discrimination between fresh water and 100% SW was made by testing snakes after sectioning of the olfactory tract, blockage of the nares, removal of the tongue, and cauterization of the oral openings of the vomeronasal organs (Noble, 1937; Wilde, 1938; and Kahmann, 1932).

SALINITY PREFERENCE BETWEEN 0 AND 35‰—The results of the first series of salinity preference tests on 3 *Nerodia*, *Cerberus rhynchops*, and *Laticauda colubrina* are in Table 1. *Nerodia* and *L. colubrina* preferred fresh water to sea water. All fresh water and sea water control tests with *Nerodia* revealed random distributions. *Cerberus rhynchops* showed a random distribution in the 0/35‰ tests. Only 2 *L. colubrina* were available, and both were kept in fresh water. Neither of them had fed for a considerable time.

TABLE 1. Snake salinity preference tests between fresh water and sea water (35‰) at 22-24°C.

Habitat/Species	N	Number Trials / Snake	Weight Range, g	Salinities, ‰	Snake Distribution[a]
Fresh water					
N. s. sipedon	10	1	8-14	0/35	75/22[b] (3)
	10	1		0/0 control	46/53 (1)
	10	1		35/35 control	55/41 (4)
N. f. pictiventris	10	1	10-14	0/35	74/8[b] (18)
	10	1		0/0 control	45/53 (2)
	10	1		35/35 control	44/56 (0)
Estuarine-marine					
N. f. compressicauda	10	1	52-59	0/35	76/14[b] (10)
	10	1		0/0 control	45/51 (4)
	10	1		35/35 control	46/52 (2)
Cerberus rhynchops	10	1	58-74	0/35	46/48 (6)
Laticauda colubrina	2	5	65-79	0/35	90/10[b] (0)

[a]Number of positions shown in parentheses in which less than two thirds of the anterior body was on one side.
[b]Significant non-random distribution ($P < 0.05$).

It is possible that the state of body fluid hydration affects salinity preference. This effect was demonstrated with *C. rhynchops*, which under normal laboratory maintenance conditions (slightly dehydrating) shows a random distribution. One specimen was severely dehydrated (about 15% total body weight loss) by submersion in 35‰ sea water for 109 da and then tested. This snake showed a marked preference for fresh water (10 observation periods in fresh water and none in sea water). It also drank 10.6 g of the fresh water within the initial 1.5 hr of testing, nearly regaining its original body weight. *Nerodia s. sipedon* subjected to moderate dehydration (about 5% body weight loss) showed essentially no deviation in 0/35‰ salinity preference tests from the results previously obtained with hydrated snakes (80/18 and 80/19 in 2 animals).

These data suggest that *C. rhynchops*, which is a highly specialized marine species with a salt gland (Dunson and Minton, 1978, Dunson and Dunson, in press), does not exhibit a preference for fresh water unless dehydrated. In contrast, both fresh water *N. fasciata* and *N. sipedon* and a less specialized estuarine form (*N. f. compressicauda)* do exhibit fresh water preference when "normally" hydrated. Pettus (1956, 1958, and 1963) found that 2 Texas races of *N. fasciata* also preferred fresh water over sea water without regard to their respective habitat salinities. Such a preference may also govern the movements of estuarine *N. fasciata* in the field. A large aggregation of mangrove snakes (*N. f. compressicauda)* was found by Dunson (in press, b) in a tiny brackish pool (14‰) on Chokoloskee Island where the surrounding estuary (22‰) apparently lacked snakes. Because *L. colubrina* is a sea snake with a salt gland, its preference for fresh water seems anomalous. It is more terrestrial than any other sea snakes (Dunson, 1975) and the conditions of captivity (long term fasting in fresh water) may have biased the results. Further studies of other aquatic snakes are needed before an association can be made between salinity preference and habitat type.

Preference Tests in Brackish Salinities—*Nerodia f. compressicauda* showed a significant preference for fresh water even in comparison with salinities as low as 3.5‰ (Table 2). *Nerodia f. pictiventris* showed a random distribu-

Table 2. Salinity preference tests between fresh and brackish water for the 2 races of the banded water snake *Nerodia fasciata* at 22-24°C. In all cases 10 snakes were used for one trial each.

Habitat/Species	Weight Range, g	Salinities, ‰	Snake Distribution[a]
Fresh water			
N. f. pictiventris	10-14		
		0/17.5	77/18[b] (5)
		0/5.5	37/58[b] (5)
		0/3.5	44/54 (2)
Estuarine			
N. f. compressicauda	52-59	0/17.5	78/18[b] (4)
		0/5.5	78/18[b] (4)
		0/3.5	71/29[b] (0)

[a]Number of positions shown in parentheses in which less than two thirds of the anterior body was on one side.
[b]Significant non-random distribution ($P < 0.05$).

tion in the 0/3.5‰ comparison, but did show a slight but significant preference for 5.5‰ compared to fresh water (Table 2). The sodium concentration of 35‰ sea water is about 3 times that of reptilian plasma. Thus, it is rather unexpected to find a continued preference for fresh water by *N. f. compressicauda* in comparison with a salinity as low as 3.5‰. The observed difference in the apparent lower level of preference of fresh and brackish water between the 2 races is small and may be due to an artifact. The *N. f. pictiventris* used were smaller and probably slightly better hydrated. It would be useful to repeat these experiments with snakes matched in size and states of hydration. It seems clear there would be a tendency for the salinity preferences of these races to cause them to select similar habitats, rather than the observed distribution of *N. f. compressicauda* mainly in coastal brackish waters and of *N. f. pictiventris* in inland fresh water lakes.

PREFERENCE TESTS IN SOLUTIONS OSMOTICALLY SIMILAR TO SEA WATER—The use of 0.5 Molal NaCl and KCl resulted in the customary strong preference for fresh water (Table 3). However, the chi-square value computed for the sucrose test distribution was very close to the critical value; the distribution was considered to be random at the 0.95 confidence level. These results suggest the presence of a "salt" receptor which is sensitive to both sodium and potassium and/or chloride. The receptor involved may not be sensitive to osmotic pressure. However, these preliminary results are not conclusive.

TABLE 3. Salinity preference tests with estuarine *N. f. compressicauda* using osmotically similar solutions of NaCl, KCl and sucrose at 22-24°C. Four snakes (52-59 g) were used for one trial each.

Solutions	Snake Distribution[a]	
0/0.5 Molal NaCl	37/1[b]	(2)
0/0.5 Molal KCL	30/4[b]	(6)
0/1.0 Molal Sucrose	26/14	(0)

[a]Number of positions shown in parentheses in which less than two thirds of the anterior body was on one side.
[b]Significant non-random distribution ($P < 0.05$).

SENSORY PERCEPTION OF SALINE WATER—Physical blockage of the external nares with silicone grease, removal of the tongue, or cauterization of the roof of the mouth at the openings to the vomeronasal organs had no effect on the "normal" salinity preference of *N. sipedon* (Table 4). An independent method of

TABLE 4. Effect of blockage of the olfactory and vomeronasal sensory systems on salinity preference of *N. s. sipedon* (fresh-water northern water snake). Water 22-24°C.

Operation Performed	N	Number Trials / Snake	Weight Range, g	Salinities ‰	Preoperative Distribution[a]		Postoperative Distribution[a]	
External nares blocked	2	1	22-27	0/35	17/2[b]	(1)	17/2[b]	(1)
Tongue removed	2	2	22-27	0/35	37/0[b]	(3)	29/7[b]	(4)
Sham-tongue extended	2	2	22-27	0/35	25/10[b]	(5)	35/4[b]	(1)
Cauterization of vomeronasal opening	2	2	22-27	0/35	32/7[b]	(1)	33/6[b]	(1)
Sham-cauterization of lateral palatal lining	2	2	22-27	0/35	36/4[b]	(0)	37/3[b]	(0)
Transected olfactory tract	2	2	45-52	0/35	33/4[b]	(3)	34/3[b]	(3)

[a]Number of positions shown in parentheses in which less than two thirds of the anterior body was on one side.
[b]Significant non-random distribution ($P < 0.05$).

ablating olfaction and vomeronasal function by sectioning the olfactory tract between the eyes of 2 snakes (Willard, 1915; Auen and Langebartel, 1977; and Wilde, 1938) likewise had no effect. It is worth noting that one of these snakes, which was wild caught, subsequently was unable to feed normally, despite showing intense interest in live minnows. The other individual, which was lab reared, did continue normal feeding. Burghardt and Pruitt (1975) reported that an experienced snake can successfully feed despite removal of the tongue. Thus, it is likely that in at least one and perhaps in both of these 2 snakes the sectioning of the olfactory tract was complete.

Most reptilian chemosensory work to date has dealt with the relative importance of the olfactory and vomeronasal systems in controlling feeding and courtship behavior in snakes (see Burghardt, 1970 for a comprehensive review of the literature). The dominance of the vomeronasal system over the olfactory system in determining the feeding behavior of snakes is generally agreed upon today (Wilde, 1938; and Burghardt, 1970). It now appears that neither olfaction nor the vomeronasal system is crucial for perception of water salinity by the freshwater snake *N. sipedon*. The clear implication is there are taste receptors in the mouth sensitive to salinity. Very little is known about such organs, except that Burns (1969) has described the presence of numerous "oral sensory papillae" in sea snakes. These structures are "prominent villiform elevations of the epidermis" which lie in bilaterally symmetric rows parallel to the teeth rows. Oral papillae are quite prominent in *N. sipedon* (Fig. 1) and in several other aquatic and terrestrial species we examined (*C. rhynchops*, *Malpolon monspessulanus*, and *Thamnophis sirtalis*). There is certainly no firm evidence these structures are chemosensory, but the possibility is intriguing.

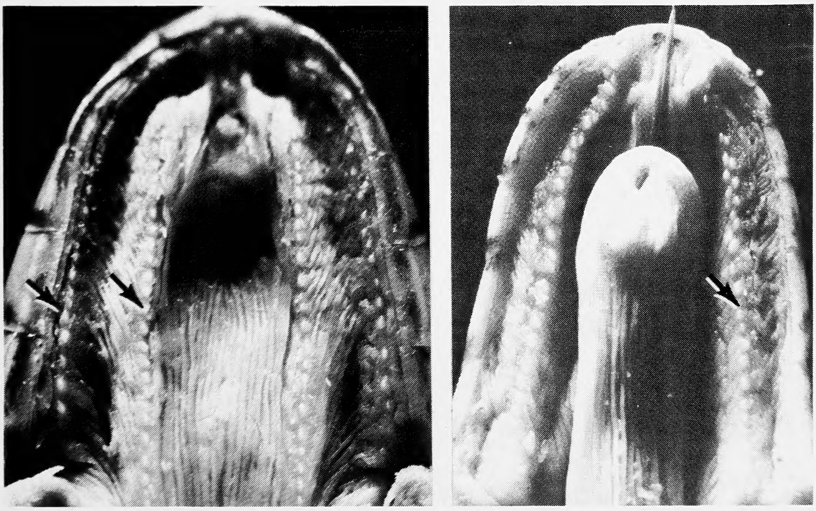

FIG. 1. Oral sensory (?) papillae of the fresh water snake *Nerodia s. sipedon*. Views of the roof (left) and the floor (right) of the mouth are shown approximately twice natural size. There are 4 upper and 2 lower rows of papillae (arrows).

Acknowledgments—Supported by NSF grant BMS 75-18548 to W.A.D. We appreciate the assistance of Peter Saber and Glenn Stokes with some of the experiments. We also thank Dr. Emerson Hibbard for the use of his photographic facilities.

LITERATURE CITED

Auen, E. L., and D. A. Langebartel. 1977. The cranial nerves of the colubrid snakes *Elaphe* and *Thamnophis*. J. Morph. 154:205-222.

Burghardt, G. M. 1970. Chemical perception in reptiles. Pp. 241-308. *In* Johnston, J. W., Jr., Moulton, D. G., and Turk, A. (eds.). Advances in Chemoreception: Communication by Chemical Signals. Vol. 1. Appleton–Century–Crofts, New York.

Burghardt, G. M., and C. H. Pruitt. 1975. Role of the tongue and senses in feeding of naive and experienced garter snakes. Physiol. Behav. 14:185-194.

Burns, B. 1969. Oral sensory papillae in sea snakes. Copeia. 1969:617-619.

Dunson, W. A. 1975. The Biology of Sea Snakes. Univ. Park Press, Baltimore.

__________. 1978. Role of the skin in sodium and water exchange of aquatic snakes placed in sea water. Am. J. Physiol. 235(3):R151-9.

__________. Water and electrolyte balance in reptiles. *In* Gilles, R. (ed.). Mechanisms of Osmoregulation in Animals. John Wiley, New York. (in press a).

__________. Occurrence of partially striped forms of the mangrove snake *Nerodia fasciata compressicauda* Kennicott and comments on the status of *N. f. taeniata* Cope. Florida Sci. in press b.

__________. The relation of sodium and water balance to survival in sea water of estuarine and fresh-water races of the snake *Nerodia fasciata*. Copeia. (submitted).

Dunson, W. A., and M. K. Dunson. A new salt gland in a marine homalopsid snake. Copeia (in press).

Dunson, W. A., and S. A. Minton. 1978. Diversity, distribution, and ecology of Philippine marine snakes. J. Herp. 12(3):281-286.

Kahmann, H. 1932. Sinnesphysiologische Studien an Reptilien–I. Experimentalle Untersuchungen über das Jacobsonische Organ der Eidechsen und Schlangen Zool. Jb. Abt. Allg. Zool. Physiol. 51:173-238.

Krakauer, T. 1970. The ecological and physiological control of water loss. Ph.D. dissert. Univ. of Florida, Gainesville.

Noble, G. K. 1937. The sense organs involved in the courtship of *Storeria, Thamnophis,* and other snakes. Bull. Am. Mus. Nat. Hist. 73:673-725.

Pettus, D. 1956. Ecological barriers to gene exchange in the common water snake (*Natrix sipedon).* Ph.D. dissert. Univ. of Texas, Austin.

__________. 1958. Water relationships in *Natrix sipedon (fasciata).* Copeia. 1958:207-211.

__________. 1963. Salinity and subspeciation in *Natrix sipedon (fasciata).* Copeia. 1963:499-504.

Rossman, D. A., and W. G. Eberle. 1977. Partition of the genus *Natrix,* with preliminary observations on evolutionary trends in Natricine snakes. Herpetologica. 33:34-43.

Wilde, W. S. 1938. The role of Jacobson's organ in the feeding reaction of the common garter snake, *Thamnophis sirtalis sirtalis* (Linn.). J. Exp. Zool. 77:445-465.

Willard, W. A. 1915. The cranial nerves of *Anolis carolinensis*. Bull. Mus. Comp. Zool. 59:17-116.

Florida Sci. 42(1):1-8. 1979.

Biological Sciences

BIOLOGICAL CHARACTERISTICS OF *LUIDIA CLATHRATA* (ECHINODERMATA:ASTEROIDEA) FROM TAMPA BAY AND THE SHALLOW WATERS OF THE GULF OF MEXICO

JOHN M. LAWRENCE AND PAULA F. DEHN

Department of Biology, University of South Florida, Tampa, Florida 33620

ABSTRACT: *The population of the primitive platyasteroid starfish,* Luidia clathrata *(Say) in Tampa Bay differs from those found in the shallow waters of the Gulf of Mexico in lacking regenerating arms, having a better nutritional condition as indicated by higher caecal indices, and having a greater reproductive capacity as indicated by higher gonadal indices. The lack of regenerating arms probably is a result of lower energy water in the bay; the better nutritional condition and reproductive capacity undoubtedly reflects the better food supplies in the bay. For open waters to have localities of equal suitability would require a water depth sufficient to reduce surface water energy and to increase the amount of appropriate infaunal food.*°

FELL AND PAWSON (1966) indicated that "the Platyasterida doubtless represent a basal stock from which all other Asteroidea have evolved . . . [and that] a study of the physiology and ecology of asteroids such as *Luidia* . . . can be expected to throw much light on the manner of life of the earliest Paleozoic asterozoans." In such a study, one should evaluate the characteristics of populations found in different localities to determine the suitability of different environments for the species. Fell (1966), Pawson (1966), and Moore (1966) gave criteria for evaluating the characteristics of various echinoderm classes: rate of growth, maximum size, age at maturity, population density, and gonadal production. In addition to these, we believe that the nutritional condition of the individual is a valid criterion. In species of *Luidia*, the number of regenerating arms is also of interest. The lack of whole arms may indicate a requirement for nutrients for arm regeneration, a decreased capacity for storage of nutrient reserves in the pyloric caecae and for production of gametes in the gonads, and an adverse effect on the ability of the individual to move and burrow.

In an earlier study (Lawrence, 1973), it became apparent that *Luidia clathrata* was more abundant in Tampa Bay than in the nearby Gulf of Mexico. Collections in the two localities showed obvious differences in the number of individuals with regenerating arms and in the size of the pyloric caeca and gonads. We have quantified these characteristics of individuals from different populations to evaluate the suitability of the different environments.

MATERIALS AND METHODS—*Luidia clathrata* (Say) were collected at Courtney Campbell Causeway in Tampa Bay, at nearby Mullet Key in the Gulf of Mexico at the mouth of the bay, and at Seahorse Reef 100-200 km N of the bay and approximately 2 km offshore. We collected in November 1971 and 1972, in January 1974, and in September 1975. Collections were made by hand at depths of less than 5 m; all animals seen were collected. The percentage of individuals

°The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U. S. C. §1734, this article must therefore be hereby marked "*advertisement*" solely to indicate this fact.

collected with regenerating arms was calculated for each population. The nutritional well-being of individuals was estimated by calculating the caecal index (wet weight of the caeca X 100/wet body weight), and the reproductive capacity was estimated by calculating the gonadal index (wet weight of the gonads × 100/wet body weight) as done by Lawrence (1973). These indices were tested using the t-test (α.05). The difference between treatment means was determined by Duncan's New Multiple Range (DNMR) test (α.05) (Steele and Torrie, 1960).

RESULTS—Fig. 1 shows individuals typical of Tampa Bay and the nearby shallow waters of the Gulf. The percentage of individuals having regenerating arms was highest in the population at Seahorse Reef; none collected from Tampa Bay had regenerating arms (Table 1). Table 2 gives the caecal and gonadal indices. Individuals collected from Tampa Bay had significantly higher pyloric

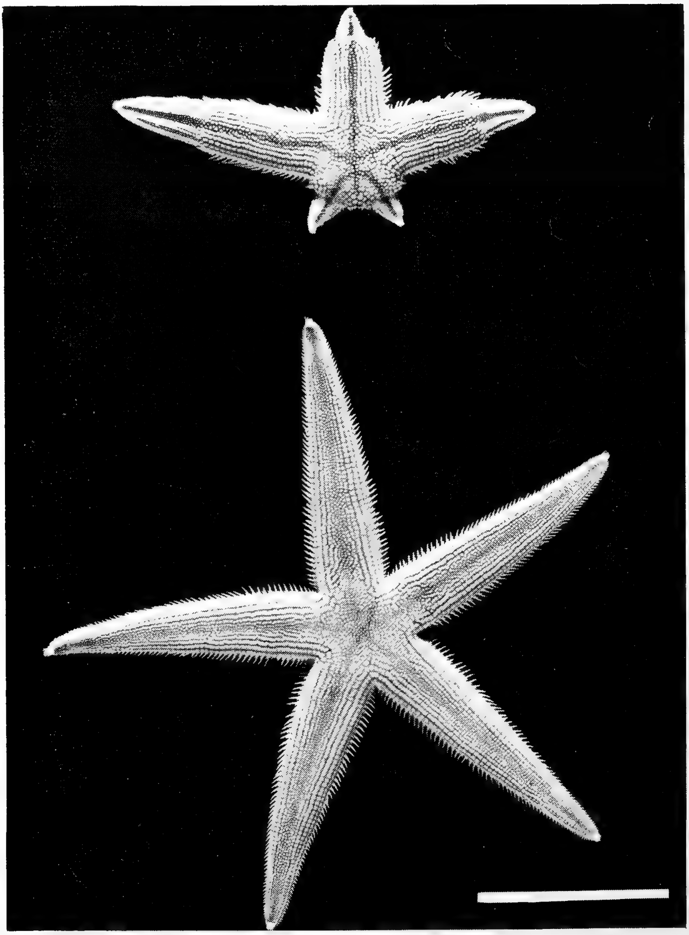

FIG. 1. Typical specimens of *Luidia clathrata* (Say) collected from Seahorse Reef in shallow water, offshore Gulf of Mexico (top) and in Tampa Bay (bottom). Bar is 5 cm.

TABLE 1. Ratio of the number of individuals of *Luidia clathrata* (arm length > 50 nm) with regenerating arms from different localities.

Locality	Ratio	Percentage
Tampa Bay	0:45	0
Mullet Key	3:52	6
Seahorse Reef	24:28	86

caecal indices than those collected at the same time from Mullet Key in 1971 (t=2.5), in 1972 (t=5.57), and in 1975 (t=7.60). In 1974, when collections were made from all 3 localities at the same time, the DNMR test showed a statistically significant difference between the pyloric caecal and gonadal indices of individuals from Tampa Bay and the other two localities, but not between individuals from Mullet Key and Seahorse Reef (Table 3).

TABLE 2. Pyloric caecal and gonadal indices of *Luidia clathrata* collected from different localities.

Date	Organ	Tampa Bay	Mullet Key	Seahorse Reef
Nov., 1971	Pyloric caeca	12.7 ± 2.1 (8)[1] (t=2.482*)	8.5 ± 4.3 (8)	
Nov., 1972	Pyloric caeca	12.6 ± 2.9 (8) (t=4.939*)	7.2 ± 1.2 (10)	
Jan., 1974	Pylorica caeca	11.9 ± 2.3 (9)	4.7 ± 2.1 (9)	3.4 ± 1.1 (9)
	Gonads	4.5 ± 4.0 (10)	1.5 ± 1.8 (10)	0 (10)
Sept., 1975	Pylorica caeca	7.4 ± 1.3 (10) (t=7.70*)	3.2 ± 1.2 (11)	

Means ± 1 S. D. and n (in parentheses) are given.

DISCUSSION—The level of the pyloric caecal and gonadal indices undoubtedly reflects food availability. Feder and Christensen (1966) have discussed the significance of abundance and suitability of food on asteroid nutrition and reproduction. Population differences in caecal and gonadal development have been attributed to differences in food for *Asterias rubens* (Vevers, 1949), *Odontaster validus* (Pearse, 1965), *Pisaster ochraceus* (Mauzey, 1967), and *Patiriella regularis* (Crump, 1971). The caecal index of starving *L. clatrata* decreases in size (Lawrence, 1973) and inadequate diets result in reduced gonadal development (Dehn and Lawrence, 1975). *Luidia clathrata* is a non-selective feeder on infauna (Hulins and Hemlay, 1963; Edwards, 1973; Lawrence, Erwin and Turner, 1974). Quiet waters with high nutritional content typically have a large infaunal population; Tampa Bay is no exception (Bloom, Simon and Hunter, 1972).

TABLE 3. Statistical analysis by Duncan's New Multiple Range test (α.05) of pyloric caecal and gonadal indices of *Luidia clathrata clathrata* collected from different localities in January 1974.

Organ	Tampa Bay	Mullet Key	Seahorse Reef
Pyloric caeca	10.7	4.3	3.1
Gonads	5.7	1.0	0

The higher proportion of regenerating arms in the gulf populations could be due to predation or to breakage as a result of living in an area with high energy water. Recorded observations of predators on *Luidia clathrata* are lacking, although crabs and fish may eat arm tips. Hunt (1925) stated there were no known predators on *Luidia ciliaris*. On the other hand, species of *Luidia* are notorious for fragmentation of their arms (Forbes, 1841); arm loss might be caused by strong waves or currents. Brun (1972) suggested that the absence of *L. ciliaris* in some areas of the Calf of Man might be due to strong currents which affect the substratum and food sources.

Based on the criteria of lacking regenerating arms, having a better nutritional condition as indicated by higher caecal indices, and a greater reproductive capacity as indicated by higher gonadal indices, Tampa Bay is a more suitable environment for *Luidia clathrata* than the shallow waters of the gulf. *Luidia clathrata* has the capacity to cope with the reduced and variable salinities found in the bay (Ellington and Lawrence, 1974). One would anticipate that other characteristics of *Luidia* (i.e., population density, growth rate and age at maturity) would also indicate greater suitability of the bay. For the open gulf to have localities of equal suitability would require a water depth sufficient to reduce surface water energy and to have adequate levels of the appropriate infaunal food. *Luidia clathrata* is known to occur in deeper waters (to 45 fathoms) where these conditions probably prevail (Bernasconi, 1943; Downey, 1973; Gray, Downey and Cerame-Vivas, 1968).

ACKNOWLEDGMENTS—We thank Dr. Steve Stancyk for making possible the collections at Seahorse Reef.

LITERATURE CITED

BERNASCONI, I. 1943. Los asteroideos Sudamericanos de la familia Luidiidae. An. Mus. Argent. Cienc. Nat. 41. Invertebrados Marinos. No. 7.

BLOOM, S. A., J. L. SIMON, AND V. D. HUNTER. 1972. Animal-sediment relations and community analysis of a Florida estuary. Mar. Biol. 13:43-56.

BRUN, E. 1972. Food and feeding habits of *Luidia ciliaris*. Echinodermata: Asteroidea. J. Mar. Biol. Assn. U. K. 52:225-236.

CRUMP, R. G. 1971. Annual reproductive cycles in three geographically separated populations of *Patiriella regularis* (Verrill), a common New Zealand asteroid. J. Exp. Mar. Biol. Ecol. 7:137-162.

DEHN, P. F., AND J. M. LAWRENCE. 1975. Laboratory maintenance of *Luidia clathrata* on a controlled diet. Florida Sci. 38:6.

DOWNEY, M. E. 1973. Starfishes from the Caribbean and the Gulf of Mexico. Smithsonian Contrib. Zool. No. 126.

EDWARDS, R. R. C. 1973. Production ecology of two Caribbean marine ecosystems. I. Physical environment and fauna. Estuarine Coastal Mar. Res. 1:303-318.

ELLINGTON, W. R., AND J. M. LAWRENCE. 1974. Coelomic fluid volume regulation and isosmotic intracellular regulation by *Luidia clathrata* (Echinodermata: Asteroidea) in response to hyposmotic stress. Biol. Bull. Mar. Biol. Lab., Woods Hole. 146:20-31.

FEDER, H. M., AND A. M. CHRISTENSEN. 1966. Aspects of Asteroid Biology. Pp. 73-85. *In* Boolootian, R. (ed.). Physiology of Echinodermata. John Wiley and Sons, New York.

FELL, H. B. 1966. The Ecology of Ophiuroids. Pp. 129-143. *In* Boolootian, R. (ed.). Physiology of Echinodermata. John Wiley and Sons, New York.

FELL, H. B., AND D. L. PAWSON. 1966. General Biology of Echinoderms. Pp. 1-48. *In* Boolootian, R. (ed.). Physiology of Echinodermata. John Wiley and Sons, New York.

FORBES, E. 1841. A History of British Starfishes and Other Animals of the Class Echinodermata. John van Voorst, London.

Gray, I. E., M. E. Downey, and M. J. Cerame-vivas. 1968. Sea stars of North Carolina. Fish. Bull. Fish Wildl. Serv. U.S. 67:127-163.

Hulings, N. C., and D. W. Hemling. 1963. An investigation of the feeding habits of two species of sea stars. Bull. Mar. Sci. Gulf Carib. 13:354-359.

Hunt, O. D. 1925. The food of the bottom fauna of the Plymouth fishing grounds. J. Mar. Biol. Ass. U. K. 13:560-599.

Lawrence, J. M. 1973. Level, content, and caloric equivalents of the lipid, carbohydrate and protein in the body components of *Luidia clathrata* (Echinodermata: Asteroidea: Platyasteroida) in Tampa Bay. J. Ecp. Mar. Biol. Ecol. 11:263-274.

Lawrence, J. M., K. Erwin, and R. L. Turner. 1974. Stomach contents of *Luidia clathrata*. (Asteroidea). Florida Sci. 37:8.

Mauzey, K. P. 1967. The interrelationship of feeding, reproduction and habitat variability in *Pisaster ochraceus*. Ph.D. dissert. Univ. of Washington, Seattle.

Moore, H. B. 1966. Ecology of Echinoids. Pp. 73-85. *In* Boolootian, R. (ed.). Physiology of Echinodermata. John Wiley and Sons, New York.

Pawson, D. 1966. Ecology of Holothurians. Pp. 63-71. *In* Boolootian, R. (ed.). Physiology of Echinodermata. John Wiley and Sons, New York.

Pearse, J. S. 1965. Reproductive periodicity in several contrasting populations of *Odonaster validus* Koehler, a common Antarctic asteroid. Biol. Antarctic Seas II. Antarctic Res. Ser. 5:39-85.

Steele, R., and J. H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill, New York.

Vevers, H. G. 1949. The biology of *Asterias rubens* L: growth and reproduction. J. Mar. Biol. Assn. U.K. 28:165-187.

Florida Sci. 42(1):9-13. 1979.

Biological Sciences

DISTRIBUTION, HABITAT PREFERENCE AND STATUS OF POPULATIONS OF THE BLACK CREEK CRAYFISH, *PROCAMBARUS (ORTMANNICUS) PICTUS* (DECAPODA: CAMBARIDAE)

Richard Franz and Lea M. Franz

Florida State Museum, University of Florida, Gainesville, Florida 32611

Abstract: *The Black Creek Crayfish (*Procambarus pictus *(Hobbs)), is endemic to cool, steep-gradient, tannic-stained creeks in the Black Creek drainage in northeast Florida. It appears to be extremely susceptible to human interference, particularly alteration of headwater areas and pollution. Currently, this crayfish is doing well but with additional pressure from urbanization, particularly with its proximity to the Jacksonville metropolitan area, the species might quickly be brought to the brink of extinction. Because of this, we are recommending* Procambarus pictus *for the Special Concern category, as outlined in the Florida Audubon Society's Inventory of Rare and Endangered Biota of Florida.*[*]

Procambarus (Ortmannicus) pictus was described by Hobbs as *Cambarus pictus* in 1940, based on specimens collected from two small creeks in Clay County in northeast Florida. Later, Hobbs (1958, 1974) stated that this cray-

*The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U.S.C. § 1734, this article must therefore be hereby marked "*advertisement*" solely to indicate this fact.

fish was only known from tributaries of Black Creek, and he recently indicated to us that he believed the species to be endemic to this drainage. Our interest in *Procambarus pictus* stems from our recent investigation of Florida troglobitic species of *Procambarus*. Studies by Hobbs (1958) indicated that *Procambarus pictus* is closely allied to the troglobitic species and in fact may actually be close to the ancestral form that gave rise to several of these cave obligates. If this assertion is correct, we have an exceptional opportunity to study the ecological and behavioral adjustments that a surface crayfish must undergo to become a troglobite.

Our stream surveys in Duval, Clay, Putnam, and Marion counties reveal *Procambarus pictus* only in the Black Creek drainage and not in adjacent streams (with the possible exception of Governor's Creek). Hobbs (1942) listed only two localities for the species (small creeks approximately 2 [type locality] and 4 mi SW Green Cove Springs, along Fla. Hwy. 48 [now Fla. Hwy. 16], Clay County, Florida). According to the Clay County highway map (1971), the type locality is a tributary of Governor's Creek, an independent drainage flowing into the St. Johns River at Green Cove Springs. The second locality, Peters Creek, is a tributary of the lower portion of Black Creek. Hobbs (pers. comm.) was never certain of the exact place where the original series was taken and suggested that it may have been Peters Creek. Subsequent collecting by Hobbs and by us in Governor's Creek and several tributaries failed to produce any specimens. However, we found *Procambarus pictus* at 24 sites in Clay County and one in Duval County including both the North and South Forks of the Black Creek drainage and their tributaries, and tributaries entering the lower, sluggish portions of Black Creek itself (Little Black, Grog, and Peters creeks) (Fig. 1). Essentially populations of this crayfish frequent all cool, tannic-stained, flowing streams in the Black Creek basin; however, it is apparently absent in the sluggish lower parts and from the adjacent St. John's River.

In general, the densest populations were observed in headwater streams. Populations declined downstream, though with certain human modifications large populations can occur in larger tributaries (see below).

Three types of streams contain populations—headwater streams, small tributaries, and large tributaries (e.g., North and South Forks). Headwater streams flow through bayheads supporting dense growths of *Pinus palustris, Magnolia virginiana, Persea borbonia, Myrica cerifera, Vaccinium corymbosum, Cornus formina,* and *Itea virginica* in the overstory and *Lyonia lucida, Leucothoe axillaris,* and *Hypericum galioides* bordering the streams. These headwater creeks are usually less than a meter wide and deeply stained from the run-off of surrounding flatwoods. These small creeks flow over frequent debris jams and tree roots. *Procambarus pictus* occurs in detritus accumulations on the bottoms of pools interspersed between the turbulence areas. *Gambusia affinis, Siren intermedia, Amphiuma means, Rana clamitans, Acris gryllus,* and an occasional *Agkistrodon piscivorus,* as well as the more typical pond invertebrates, are associated with the crayfish in this habitat. In small tributaries downstream the water is usually more swift and less colored; bottoms consist of sand (occasionally

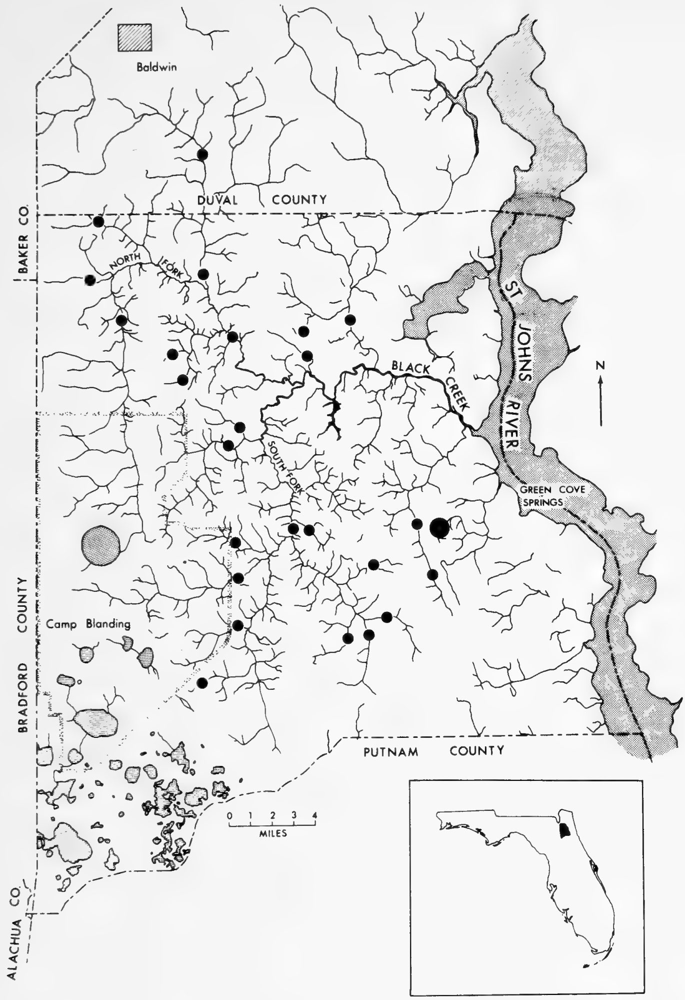

FIG. 1. Map showing the collection sites for *Procambarus pictus*. The large solid dot represents the type locality, based on the mileage from Green Cove Springs as presented in Hobbs, 1942.

as shifting sand), submerged and partially buried logs are common, and pooled areas are essentially absent. Here the crayfish occurs most commonly in detritus accumulations behind submerged logs and in dense mats of fibrous tree roots. Farther downstream, large tributaries have in places cut through the sandy terrace deposits, exposing the underlying yellow clays, partly indurated marls, and thinbedded limestones (Choctawhatchee Fm. of Clark, et al. 1964). These streams contain small rapids and clay riffles, with bottoms frequently scoured by the swift current; submerged logs and detritus are quickly covered with sand or washed away. The water appears yellow rather than red. In these large streams, the crayfish inhabits organic accumulations in eddies and the root systems of aquatic and emergent plants, particularly *Vallisneria americana*, *Spar-*

ganium sp., *Potamogeton tenuifolius, Orontium aquaticum, Batrachospermum vagum,* and *Juncus scirpoides.* The associated fauna of the smaller and larger tributaries include *Etheostoma edwini, Percina nigrofasciata, Noturus insignis, Notropis petersoni,* and mayfly, stonefly, and dragonfly nymphs, typical of swift, cool streams. Both stream types are usually entrenched 0.5 to 2.0 m below the surrounding flood plain. The flood plain vegetation, consisting of *Acer negundo, Liquidamber styraciflua, Betula* sp., *Carpinus carolinianum, Clethra alnifolia, Itea virginica, Sambacus simpsoni, Ilex decidua, Ilex opaca,* and *Ilex cassine,* shade these creeks and keep the water cool.

Data gathered in March (1976) provide the following physical and chemical profiles of streams inhabited by *Procambarus pictus*: headwater stream—0.006 cu m/sec, temperature 16°C pH 6.0, oxygen conc 5 ppm; small tributary (Peters Creek)—0.107 cu m/sec, temperature 17°C, pH 7.0, oxygen conc 8 ppm; large tributary (South Fork)—1.101 cu m/sec, temperature 16°C, pH 7.0, oxygen conc 8.0 ppm.

The following data gathered during this study shows that *Procambarus pictus* is extremely susceptible to human alteration of headwater areas and pollution. Because of Black Creek's promixity to the Jacksonville metropolitan area, the basin is receiving pressure from urbanization. Land developers have cleared large tracts of land for houses and have applied for permits to alter the creeks by damming. Destruction of forests surrounding these unique streams will certainly have an adverse effect on the interesting fauna. A good illustration of this is seen at Mill Creek, a rather large tributary of the lower South Fork approximately 25 km W Green Cove Springs. Thousands of acres of flatwoods have been drained through extensive canal systems and the area laid out in city blocks delimited by raised sand roads. Erosion along road shoulders and canals has caused extensive siltation in headwater streams. Siltation and flooding in these bayheads have killed trees, opening the canopy and producing high light penetration and warm, sluggish creeks, or areas of extensive sheet wash. Superficially Mill Creek appears "healthy" downstream, but close inspection shows that the high sand load has obliterated the typical log jams, root mats, and aquatic vegetation. Extensive collecting at various points along Mill Creek produced only 2 crayfish.

Runoff from dairy farms and possibly human sewage have created essentially "open sewers" of several South Fork tributaries originating near the town of Penny Farms. *Procambarus pictus* does not exist in these polluted streams.

Thus, most habitat alteration leads to reduction or extirpation of *Procambarus pictus.* However, one situation promotes large populations. Tree removal in small sections where creeks cross the roads exposes streams to direct sunlight, producing luxuriant aquatic plant growth, particularly *Orontium aquaticum, Vallesneria americana,* and *Batrachospermum vagum. Procambarus pictus* finds abundant hiding places among these plants. It is under these conditions that some of the largest populations occur. However, it is apparently essential that only a small part of the creek receive this direct light, otherwise the water will become too warm and the populations will decline markedly or be lost.

Currently, most populations within the basin are in "good condition" but the effects of urbanization have already destroyed a number of populations in headwater tributaries. That portion of the basin either in public hands or under the control of paper companies is safe for now, and current management policies assure continuance of these unique streams and their interesting fauna. However, the portions not under such control are "in trouble". It is important that changes (or alterations) in the Black Creek basin be monitored. For this reason, we recommend that *Procambarus pictus* be included on the list of species of Special Concern, as outlined in the Florida Audubon Society's Inventory of Rare and Endangered Biota of Florida.

ACKNOWLEDGMENTS—We wish to thank Ray Ashton, Pat Ashton, and Sylvia Scudder for help in the field, Walter Auffenberg, Horton H. Hobbs, Jr., and Rhoda Rybak for their helpful criticisms of this manuscript, and M. Glen Rogers and Nancy Halliday for preparation of the map.

LITERATURE CITED

CLARK, WILLIAM E., RUFUS H. MUSGROVE, CLARENCE G. MENKE, AND JOSEPH W. CAGLE, JR. 1964. Water resources of Alachua, Bradford, Clay and Union counties, Florida. Florida. Geol. Survey, Rept. No. 35.

CLAY COUNTY, GENERAL HIGHWAY MAP. 1971. State of Florida, Dept. of Transportation.

HOBBS, HORTON H., JR. 1940. Seven new crayfishes of the genus *Cambarus* from Florida, with notes on other species. Proc. U.S. Nat. Mus. 89:387-423.

__________. 1942. The crayfishes of Florida. Univ. of Florida Publ., Biological Science Series. 3.

__________. 1958. The evolutionary history of the Pictus Group of the crayfish genus *Procambarus* (Decapoda, Astacidae). Quart. Florida Acad. of Sci. 21:71-91.

__________. 1974. A checklist of the North and Middle American crayfishes (Decapoda: Astacidae and Cambaridae). Smithsonian Cont. to Zool. 166.

Florida Sci. 42(1):13-17. 1979.

THE LARGEST DIRE WOLF: LATE PLEISTOCENE OF NORTHERN FLORIDA—

David D. Gillette, Museum of Natural History, College of Idaho, Caldwell, Idaho 83605

ABSTRACT: *A large skull and associated teeth of the extinct dire wolf* (Canis dirus) *from the Aucilla River, Jefferson County, Florida, more closely resemble dire wolves from Texas, Missouri, and Kentucky.* Canis dirus *may have been highly variable ontogenetically; or there may be a chronocline in dire wolf evolution, grading from small to large.**

THE EXTINCT dire wolf *(Canis dirus)* ranged throughout southern and central United States from coast to coast during the late Pleistocene Rancholabrean Land Mammal Age (Martin, 1974; Guilday, Hamilton and McCrady, 1971; Lundelius, 1972; Galbreath, 1964; Merriam, 1912; Young and Goldman, 1944). Apparently contemporaneous in the Late Pleistocene with the living timber

*The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U. S. C. § 1734, this article must therefore be hereby marked *"advertisement"* solely to indicate this fact.

wolf *(C. lupus)* (Martin, 1974), the dire wolf was larger and the jaw and dentition were hypertrophied (Guilday, Hamilton and McCrady, 1971).

Dire wolf remains from the Aucilla River, Jefferson County, Florida (Florida State Museum, Vertebrate Paleontology Specimen Nos. 19329-19344) possess some highly unusual traits potentially important in elucidating this species' evolutionary history. Geographically, the Rancholabrean Aucilla River local fauna is in an intermediate position along with Gulf Coast dispersal corridor (Guilday, Hamilton and McCrady, 1971; and Webb, 1974). Unexpectedly, the Aucilla River dire wolf exhibits greater affinity to representatives from the Texas Gulf Coast (Lundelius, 1972) and farther inland, in Kentucky (Guilday, Hamilton and McCrady, 1971) and Missouri (Galbreath, 1964), than with those recorded from peninsular Florida (Martin, 1974).

Dimensions (in mm) of the Aucilla River cranial fragment are: Length from a line across posterior ends of glenoid gossae to posterior extremity occipital condyle:61.8. Oblique diameter, glenoid fossa to posterior extremity occipital condyle:67.3. Maximum width occipital condyle:57.8. Transverse diameter squamosal constriction:ca. 100.0. Minimum vertical diameter, basioccipital to superior extremity of sagittal crest:100.0. Vertical diameter, superior border foramen magnum to posterior extremity inion (junction of sagittal and lambdoidal crests):60.8. Minimum transverse diameter between glenoid foramina: 55.4. Transverse diameter between lambdoidal-zygomatic protuberances:101.4.

Crown length-width dimensions of the Aucilla River isolated teeth are: I^3: 13.6-9.5; 11.6-9.2; 10.1-8.3; ca. 10.5-8.2 P^2: 13.5-6.3; 16.3-6.6 P^3: 24.1-7.4. P^4: 19.0-13.4; 35.0-16.7. M^1: 22.0-28.8. dP_4: 24.3-10.2. P_2: 16.9-7.7. M_1: trigonid width 13.2. These measurements compare favorably with those from large individuals from the Ingleside, Texas fauna (Lundelius, 1972) and the Welsh Cave, Kentucky fauna (Guilday, Hamilton and McCrady, 1971). The dimensions for the Aucilla, Ingleside, and Welsh Cave individuals are clearly much greater than similar measurements for the representatives from peninsular Florida (Martin, 1974; Martin and Webb, 1974) and Rancho La Brea, California (Guilday, Hamilton and McCrady, 1971; and Merriam, 1912). The dentition also possesses a set of characters and proportions hitherto unrecognized in the species.

The two anterior upper premolars (P^2) from the Aucilla River are exceptionally narrow in proportion to length. The length of the larger premolar is considerably greater than that of the two large individuals from Ingleside (14.8-7.1) and Welsh Cave (14.9-7.7), while the width for the Aucilla River premolars is considerably less. Similarly, P^3 is extremely long and narrow, proportionally distinct from all other known dire wolves (Fig. 1).

Although less pronounced, the upper fourth premolars (P^4) from the Aucilla River also exhibit narrow proportions (Fig. 2). The smaller premolar represents a small individual, while the larger one is longer than any P^4 hitherto reported. Identification as *C. dirus* is based on the vestigial antero-internal cusp, which is always present and well-developed in wolves (Merriam, 1912; Young and Goldman, 1944) and is always reduced in dire wolves (Martin, 1974; Lundelius, 1972; Merriam, 1912; Young and Goldman, 1944). The anterior width of the

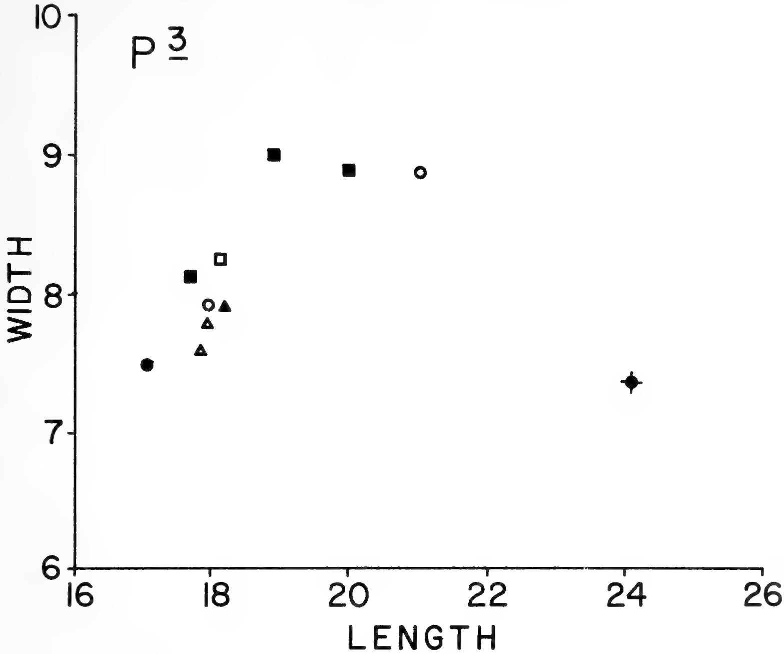

FIG. 1. Dimensions, in mm, of the P³ of *Canis dirus*, various localities; data and legend as for Fig. 3.

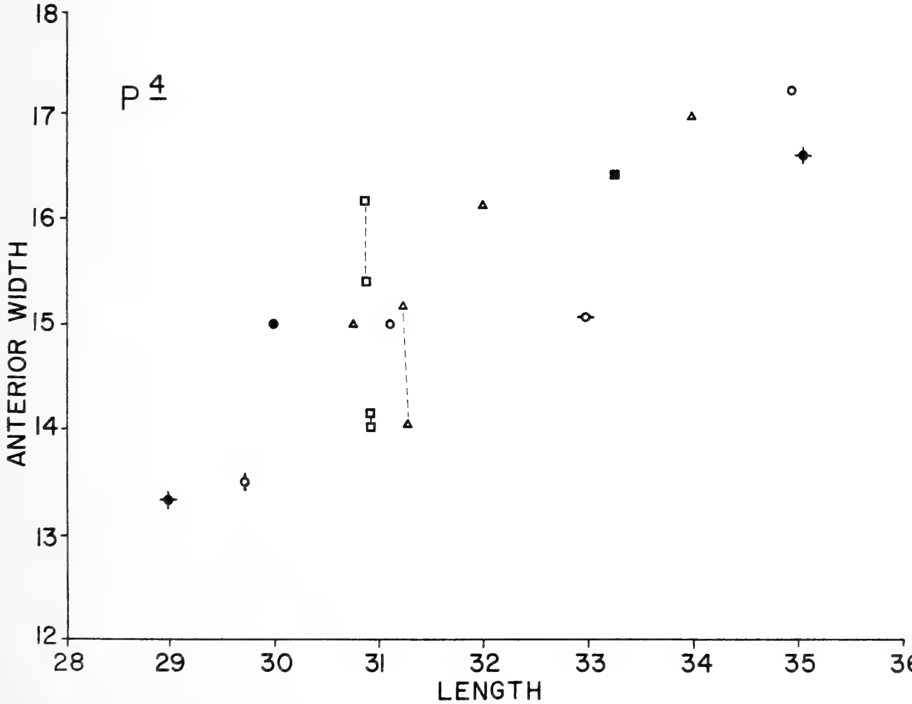

FIG. 2. Dimensions, in mm, of the P⁴ of *Canis dirus*, various localities, data and legend as for Fig. 3.

largest P^4 is narrower than in the Ingleside specimen; this condition is attributed to the weak cusp.

Dimensions for the Aucilla River first upper molar (M^1) are the largest reported for *C. dirus* in North America (Fig. 3). These measurements are sub-

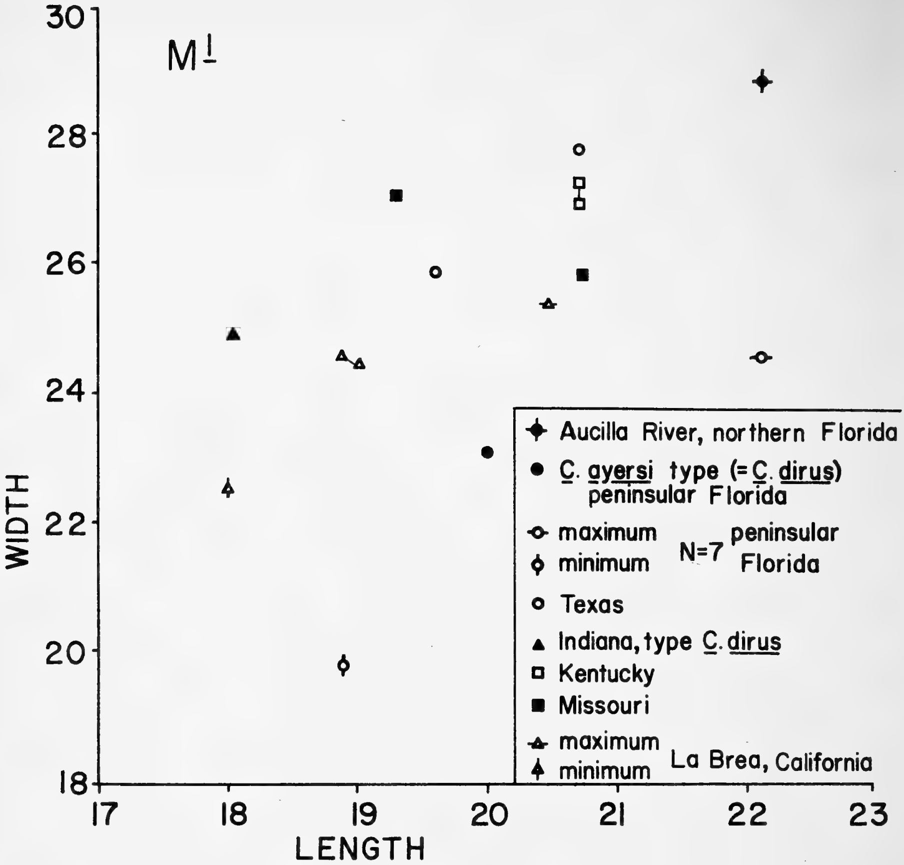

FIG. 3. Dimensions, in mm, of the M^1 of *Canis dirus*, various localities; John E. Guilday (pers. comm.) kindly provided corrected measurements for the type specimen (ANSP 11614); Merriam's (1912) published measurements apparently were in error.

stantially greater than those provided by Martin (1974) from peninsular Florida; they are close to the dimensions of large individuals at Ingleside, Texas (Lundelius, 1972) and Welsh Cave, Kentucky (Guilday, Hamilton and McCrady, 1971). Similar comparisons can be made for the second and third upper premolars (P^2 and P^3) and the lower deciduous carnassial tooth (dP_4) from the Aucilla River.

A dire wolf skull with partial upper dentition from an unpublished cave fauna near the Aucilla River locality (80 kilo. W. near Marianna, Florida) compares favorably with the small specimens to the east in peninsular Florida, and far to the west with the Rancho La Brea specimens. The cave fauna (so-called Peccary-tooth Cave fauna) includes the extinct bog lemming (*Synaptomys aus-*

tralis), extinct quail, opossum, several species of bats, turtle, and salamander. The age is indeterminate at present, but may be reasonably assigned to the Late Pleistocene.

Thus, the Aucilla River dire wolf is anomalous for its large size. The dire wolf population along the Gulf Coast may have been much more ontogenetically variable than hitherto supposed. Alternatively, there may have been a chronocline in dire wolf evolution with trend from small to large, but occurring over only a short timespan rather than for the full history of the species.

ACKNOWLEDGMENTS—A Gerald L. Beadle Scholarship from Tall Timbers Research Station, and a research grant from the Theodore Roosevelt Memorial Fund, American Museum of Natural History provided necessary field and laboratory expenses for completion of this study as a part of a larger project on the Aucilla River fossil vertebrates. I am grateful to D. Bruce Means and Richard Ohmes for collecting the new specimens and generously donating them to the Florida State Museum. I am also grateful to John E. Guilday for reviewing the manuscript, and for graciously providing corrected measurements for the M^1 of the type specimen *Canis dirus*. Sheilah R. Starkey and Lenis A. Hazlett assisted in research culminating in this report.

LITERATURE CITED

GALBREATH, E. C. 1964. A dire wolf skeleton and Powder Mill Creek Cave, Missouri. Trans. Illinois State Acad. of Sci. 47:224-242.

GUILDAY, J. E., H. W. HAMILTON, AND A. D. McCRADY. 1971. The Welsh Cave peccaries *(Platygonus)* and associated fauna, Kentucky Pleistocene. Annals of the Carnegie Mus. 43:249-320.

LUNDELIUS, E. L. 1972. Fossil vertebrates from the late Pleistocene Ingleside fauna, San Patricio County, Texas. Bureau of Economic Geol., Rept. of Investigations. 77:1-74.

MARTIN, R. A. 1974. Fossil Mammals from the Coleman IIA Fauna, Sumter County. Pp. 114-145. *In*: Webb, S. D. (ed.). Pleistocene Mammals of Florida. Univ. Presses of Florida, Gainesville.

MARTIN, R. A., AND S. D. WEBB. 1974. Late Pleistocene Mammals from the Devil's Den Fauna, Levy County. Pp. 5-31. *In*: Webb, S. D. (ed.). Pleistocene Mammals of Florida. Univ. Presses of Florida, Gainesville.

MERRIAM, J. C. 1912. The Fauna of Rancho La Brea. Vol. I and II. Univ. of California, Berkeley.

WEBB, S. D. 1974. Chronology of Florida Pleistocene Mammals. Pp. 5-31. *In*: Webb, S. D. (ed.). Pleistocene Mammals of Florida. Univ. Presses of Florida, Gainesville.

YOUNG, S. P., AND E. A. GOLDMAN. 1944. The Wolves of North America. Reprint (1964), Dover Publ., Inc., New York.

Florida Sci. 42(1):17-21. 1979.

Education

THE WISC-R COMPARED WITH THE WISC AND IMPLICATIONS AS A DIAGNOSTIC TOOL FOR SCHOOL PLACEMENT[1]

Anita N. Griffiths

1520 Commercial Park Drive, Lakeland, Florida 33801

Abstract: *Twenty-one children from a second grade class were given the WISC in the spring of 1976. In December of that year they were again given a WISC, a WISC-R and a Stanford-Binet. The children scored significantly lower on the WISC-R than on either of the two WISC examinations or the Stanford-Binet. This has implications for the placement of children in academically handicapped or gifted programs. It appears that use of the WISC-R will result in more academically handicapped and fewer gifted children in a given sample than would be the case if the WISC had been used.*[*]

The wisc-r (Wechsler, 1974) test is being substituted for the WISC as the primary diagnostic tool for determining academic potential. The Full Scale score is commonly used as a cutoff point for the placement of children in special classes for the handicapped or special classes for the academically gifted.

Swerdlik (1977) has reviewed 12 studies, both published and unpublished, which compared the results obtained on the WISC with those obtained on the WISC-R. Of these 12, only 2 were not primarily associated with EMR, SES, or some other potentially handicapped group of children. Larrabee and Holroyd (1976) compared 38 high ability children in California and Schwarting (1976) compared 58 randomly selected children ages 6-15 in Omaha, Nebraska. In addition to the studies reviewed by Swerdlik (1977), Gironda (1977), and Kaufman and Van Hagen (1977) have reported similar results on EMR children. All such studies appear to indicate a reduction in the IQ score on the WISC-R as compared with the WISC regardless of the nature of the population sampled.

Subjects—In the spring of 1976, the WISC had been administered to 26 children in a second grade class in a public school in Polk County, Florida. In December, 1976, 21 of these children were still enrolled in the same school and were retested. None of the children came from Black or Spanish-American families, but the class did include a wide range of socio-economic backgrounds. The group was composed of 11 boys and 10 girls. The ages varied from 6 yr, 3 mo to 8 yr, 11 mo at the time of the second testing in December, 1976.

Procedure—Although some new items have been added in the WISC-R and some of the original WISC items have been deleted, a high percentage of the items are essentially identical in the WISC to those found in the WISC-R.

---

[1]Presented at the 1977 Annual Meeting of the Florida Psychological Association.

[*]The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U. S. C. § 1734, this article must therefore be hereby marked "*advertisement*" solely to indicate this fact.

This offers an opportunity to administer both tests simultaneously. By such administration any bias caused by counter-balancing the order of testing, or any bias as the result of growth effects due to the time interval between the two testings was eliminated.

To do the simultaneous testing, where WISC items had been dropped in the WISC-R or where a new item had been added, both sets of items were included. The sequence of test items followed that prescribed for the WISC-R. Thus, it was possible to complete the testing of a child within 75 min, and if for any reason the child exhibited distress or fatigue, an opportunity to walk about the room or to pause for a few minutes was created. At the conclusion of the testing, the items were separated and were scored according to the procedure described for the WISC and then separately according to the procedure prescribed for the WISC-R. Thus, two separate results were obtained without raising the problem of a practice effect by the necessity for repeating the entire test.

I administered all of the tests. Each test was given at one sitting and all were given in the morning, before lunch. Each child was given the Stanford-Binet, Form LM, at some time after the WISC and the WISC-R testing.

Data Analysis—Differences between the scores for the three testings for Verbal IQ (VIQ), Performance IQ (PIQ), and Full Scale IQ (FIQ) as well as the scores of the 10 subtests were determined by analysis of variance. The differences between the individual testings were further analyzed by the Duncan (1955) Multiple Range Test. The latter test was applied even though a significant difference was not found on a given subtest by analysis of variance. To compare these data with those of Schwarting (1976), a t-test analysis was made for the WISC and WISC-R tests given in the fall of 1976.

Results—Table 1 shows the mean scaled score, VIQ, PIQ and FIQ for each of the three tests. In addition, the mean FIQ for the Stanford-Binet is included.

Table 1. Comparison of WISC, Stanford-Binet and WISC-R in a second grade class.

Subtest or IQ	WISC Spring 1976	WISC Fall 1976	WISC-R	Stanford Binet
Information	9.6a	9.4a	8.8a	
Comprehension**	12.4a	12.6a	11.0 b	
Arithmetic*	10.7a	10.5a	9.4 b	
Similarities**	12.4a	12.7a	10.9 b	
Vocabulary**	13.8a	12.4 b	11.1 c	
Picture Completion	9.9ab	10.6a	9.4 b	
Picture Arrangement**	11.3ab	13.1a	10.8 b	
Block Design	10.3ab	11.1a	9.9 b	
Object Assembly	12.1a	12.2a	11.9a	
Coding**	12.4a	12.5a	10.6 b	
Verbal IQ**	111.9a	109.6a	100.5 b	
Performance IQ**	108.4a	113.8 b	103.5 c	
Full Scale IQ**	111.3a	112.7a	101.8 b	111.0a

* Significant at 5% level.
** Significant at 1% level.

Asterisks are used to indicate significant differences between testings as determined by analysis of variance.

Letter designations (a, b, and c) indicate whether or not the two WISC tests and the WISC-R differed from each other for each of the subtests and for the IQs. The Stanford-Binet was included in this analysis on FIQ. Items with the same letter designation are not significantly different from each other.

At the 5% level of confidence, as measured by the Duncan Multiple Range Test, the subtests for Information and Object Assembly showed no difference between the WISC-R and the two WISC tests. Picture Completion, Picture Arrangement, and Block Design were significantly lower on the WISC-R than only the latter of the two WISC tests. On the WISC-R, Comprehension, Arithmetic, Vocabulary, and Coding were significantly lower than either of the two WISC administrations.

On all 10 subtests, the WISC-R average score was lower than the average score on either of the two WISC administrations. When the IQ averages were compared, the WISC-R scores were significantly lower, at the 1% level of confidence than the scores on either of the two WISC administrations or on the Stanford-Binet. Although FIQs between the two WISC administrations did not differ, there was a difference on PIQ for the two different application dates for the WISC.

When all the individual subtest scores were compared for each child at each of the three testings, only 29% of the scores on the first WISC administration and 10% of the scores on the second WISC administration were lower than the scores on the comparable subtest for the WISC-R.

In this study, 5 children on the two WISC tests and the Stanford-Binet had FIQs above 120; none scored below 90. On the WISC-R, no children scored above 120 and two scored below 90. Thus, the bell curve peak plotted from the WISC or Stanford-Binet results is skewed above 100 to about 111, while the curve for the WISC-R peaks at about 101.

Discussion—If one deemed it desirable to place a child in a program or a school for the intellectually gifted, the chances of such placement would be enhanced by giving the WISC or the Stanford-Binet rather than the WISC-R. Conversely, if it were considered desirable to increase the size of a program for the academically handicapped, administration of the WISC-R would probably increase the numbers.

Schwarting (1976) was the only author found in a review of literature who apparently worked with a randomly selected normal population of children. The differences for subtests between the WISC-R and the last WISC administration in this study are compared with his differences and t-values in Table 2. Schwarting's data differ in that on the WISC-R he reported a higher average scaled score on Comprehension than was received on the WISC, and he had no significant difference on the Vocabulary subtest. In this study Object Assembly and Picture Completion were lower, but not significantly so.

On the basis of his data, Schwarting formulated a procedure for predicting the WISC score from the WISC-R score. Swerdlik (1977) also reviewed some

TABLE 2. Comparison of the results from Schwarting's sample of 58 children and Griffiths' sample of 21 children.

	Difference in average score on WISC-R		t-value for paired differences	
	Schwarting	Griffiths	Schwarting	Griffiths
Information	-0.74**	- 0.62*	2.80	2.13
Comprehension	+1.02**	- 1.67**	- 3.06	3.31
Arithmetic	-0.77*	- 1.09**	2.22	3.06
Similarities	-2.71**	- 1.77**	10.04	3.49
Vocabulary	-0.27	- 1.28**	1.07	3.30
VIQ	-4.84**	- 9.10**	5.01	4.09
Picture Completion	-0.91**	- 1.15	2.88	1.81
Picture Arrangement	-0.75*	- 2.24**	1.94	3.04
Block Design	-1.38**	- 1.19*	4.58	2.78
Object Assembly	-0.89*	- 0.38	2.36	1.31
Coding	-2.23**	- 1.95**	5.19	3.86
PIQ	-8.74**	-10.30**	6.47	3.79
FIQ	-7.49**	-10.90**	7.10	4.14

* 5% Confidence level.
** 1% Confidence level.

efforts to draw specific conclusions on relationships between the WISC and the WISC-R. However, these reports differ in both detail and magnitude from the study reported here as well as from each other, but a lower IQ with the WISC-R is a constant result. The differences between these studies suggest that manipulations to predict WISC-R from WISC results are premature and unjustified at this time.

While the present results indicate an opportunity for manipulation of test scores if someone is so inclined, there is also an opportunity for honest confusion. Teachers and parents have put their trust in the WISC as being the most reliable measurement for prediction of academic achievement. It is important that everyone be knowledgeable about the fact that the WISC-R cannot be used interchangeably with the WISC.

These results suggest possible complications in comparing results from the WPPSI and the WAIS. Wechsler (1974) suggested a good relationship between the WPPSI and the WISC-R, but differences between the WAIS and the WISC-R. The WISC was developed in 1949, the WAIS in 1955, and the WPPSI between 1963-1976. Thus, the WISC and the WAIS were standardized in a different time period from the WISC-R and the WPPSI. This time differential is probably the major factor in the differences. Children today are exposed to much more manipulative material and mass media than in 1955, and the WISC-R has attempted to compensate for the bias due to ethnic and cultural backgrounds.

CONCLUSIONS—In general, the present findings, coupled with other reported studies, appear to indicate that children will score significantly lower for FIQ on the WISC-R than on the WISC or Stanford-Binet. All subtests will tend to be scored lower on the WISC than on the WISC-R for any individual child.

If school administrators are to use the IQ as a criterion for pupil placement, it seems necessary to specify the test from which the IQ determination is to be made, and probably to use different cutoff numbers for each test. Thus, the cutoff levels for scores on the WISC-R should be lowered from those currently in use for either the WISC or the Stanford-Binet, but additional research is needed to properly determine how much lower.

LITERATURE CITED

DUNCAN, D. B. 1955. Multiple range and multiple F tests. Biometrics. 11:1-42.

GIRONDA, R. J. 1977. A comparison of WISC and WISC-R results of urban educable mentally retarded students. Psychology in the Schools. 14:271-275.

KAUFMAN, A. S., AND J. VAN HAGEN. 1977. Investigation of the WISC-R for use with retarded children: Correlation with the 1972 Stanford-Binet and comparison of WISC and WISC-R profiles. Psychology in the Schools. 14:10-18.

LARRABEE, G. J., AND R. G. HOLROYD. 1976. Comparison of WISC and WISC-R using a sample of highly intelligent children. Psychological Reports. 38:1077-1080.

SCHWARTING, F. G. 1976. A Comparison of the WISC and WISC-R. Psychology in the Schools. 13:139-141.

SWERDLIK, M. E. 1977. The question of comparability of the WISC and WISC-R: Review of the research and implications for school psychologists. Psychology in the Schools. 14:260-270.

WECHSLER, D. 1974. Wechsler Intelligence Scale for Children (Revised). Psychological Corporation, New York.

Florida Sci. 42(1):22-26. 1979.

Physical Sciences

LOW FREQUENCY NEARSHORE CURRENT FLUCTUATIONS ON FLORIDA'S CENTRAL EAST COAST

ORTWIN VON ZWECK AND DAVID A. HALE

Department of Oceanography, Florida Institute of Technology, Melbourne, Florida 32901[1]

ABSTRACT: *Nearshore current measurements in 10 m of water off Hutchinson Island on Florida's central east coast were obtained over 40 da. Data analyses reveal independent alongshore and cros-shelf systems of subinertial waves superimposed on a weak southward, essentially alongshore mean current. The crosshelf current fluctuations appear to be wind driven, while only the 2-2.8 da along-shore current fluctuations are coherent with windstress.*[*]

NEARSHORE currents encountered on the continental shelf are characterized by a high degree of variability which spans several orders of magnitude in time and spatial scales. The low frequency fluctuations of these currents and their relation to windstress and atmospheric pressure over the inner shelf are of interest here.

Lee and Mayer (1977) observed the currents over the inner shelf (< 6 m water depth) off Miami, Florida to consist of essentially alongshore fluctuations,

[1]Present Address: U.S. Naval Oceanographic Office, Bay St. Louis, Mississippi 39522.

[*]The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U.S.C. § 1734, this article must therefore be hereby marked "*advertisement*" solely to indicate this fact.

with low frequency oscillations (periods 40 > hr) accounting for 50-60% of the total observed variance. Alongshore fluctuations with periods greater than 3.5 da were highly coherent with the N-S component of the local wind, suggesting an essentially wind driven nearshore circulation.

The currents near the shelfbreak off Miami are largely influenced by "spin-off" eddies and wave-like meanders of the Florida Current. These eddies reappear weekly, have dia between 10 and 30 km and a lifetime of 2-3 wk. Observations by Lee (1975) indicate that the nearshore currents off Miami are, however, somewhat isolated from the current fluctuations at the shelfbreak.

Because the shelf increases in width along the central Florida east coast northward from Miami, a reduction of the influence of the "spin-off" eddies and wave-like meanders on the circulation over the wider inner shelf may be expected, thus resulting in a predominantly wind driven circulation on the inner shelf on Florida's central east coast.

Measurement and Data Analaysis—A 40 da record of half-hourly average current speed and direction measurements was acquired between 25 July and 3 September 1975 using an impeller driven current meter (Endeco Model 105). The meter was set at a depth of 8 m on a taut subsurface mooring located in 10 m of water 1 km offshore. The bathymetry of the area and the location of the current meter site are shown in Fig. 1.

Hourly meteorological data for Miami, Vero Beach, Daytona Beach, and Jacksonville were obtained from the National Climatic Center. The meteorological data obtained from the Vero Beach Airport, about 30 km NW of the current meter site and 4 km inland, were used to represent local atmospheric conditions.

Prior to time series analysis, the wind and current vectors were resolved into alongshore (340 T) and crosshelf components. Auto and cross spectrum estimates of 6 degrees of freedom were obtained by averaging over 3 adjoining raw frequency estimates.

Results—Statistical analyses of the current meter data indicate periodic flow reversals from essentially alongshore northward to alongshore southward, superimposed on a weak, mostly southward but onshore mean current. The mean velocity is 1.5 cm/sec at 195T; the nearby coastline is oriented 160 to 340T. The diagram of 2 hourly current vectors (Fig. 2) and rotary spectral analysis of the current (not shown) reveal little rotary motion. The coefficients of variation for the u (offshore) and v (alongshore northward) current components are 9.5 and 11.4%, respectively; the alongshore current component being about 17 times more energetic than the offshore component (Hale, 1976). Tidally driven currents account for 30% of the variance of the v-component, the K_1, M_2, O_1, P_1, and N_2 tidal constituents, in decreasing order of magnitude, being the most important components.

The low frequency portion of the v–spectrum of the current (Fig. 3) exhibits 3 broad band subinertial spectrum peaks centered at 0.14, 0.45, and 0.77 cpd (periods of 7.1, 2.2, and 1.3 da, respectively). Less energetic broad band peaks in the u-spectrum occur at periods of 3.5, 1.8, and 1.2 da. Alongshore

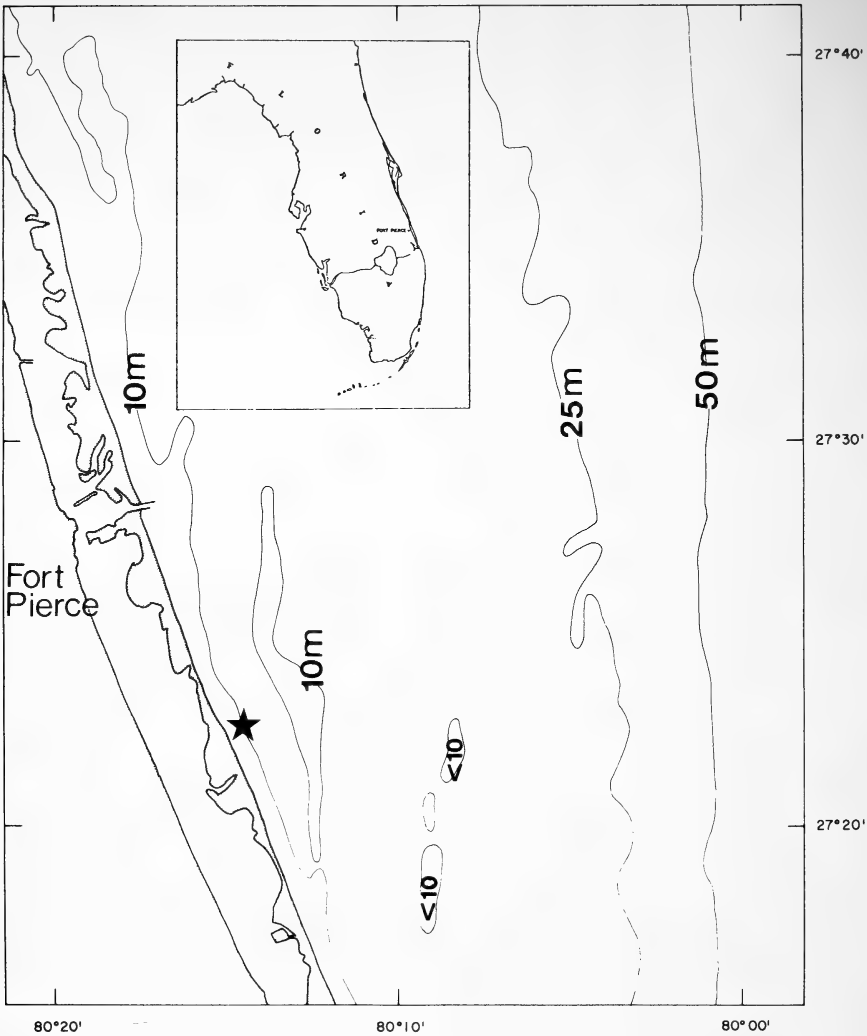

Fig. 1. Site map of current meter.

and crosshelf current oscillations are mutually coherent (at the 95% significance level) in 3 bands with periods of 1.3-1.6, 2.4-2.8, and 4.7-14 da.

Estimates of squared coherence between the alongshore and cross shore components of windstress (π_y and π_x, respectively), alongshore components of atmospheric pressure gradients, and both components of the current were obtained. Fig. 4 shows the coherence estimates between the u and v current components and τ_x and τ_y together with the 90 and 95% significance levels.

The only subinertial, alongshore current fluctuations significantly coherent ($>$ 95% significance) with both components of the windstress have a period of 2.8 da. At this period small peaks are found in the τ_x and τ_y spectra. Oscillations in the 2-2.8 da band, which include the peak in the v–spectrum, are also significantly coherent with τ_x.

The spectrum of the local sea level pressure shows no distinct peaks. Spectrum peaks were found in the alongshore component of the atmospheric pressure gradient at 1.1 cpd for the Miami–Jacksonville gradient and a 0.8 cpd for the Miami–Vero Beach gradient. Significant squared coherence between the alongshore currents and the longshore component of both the Miami–Jacksonville

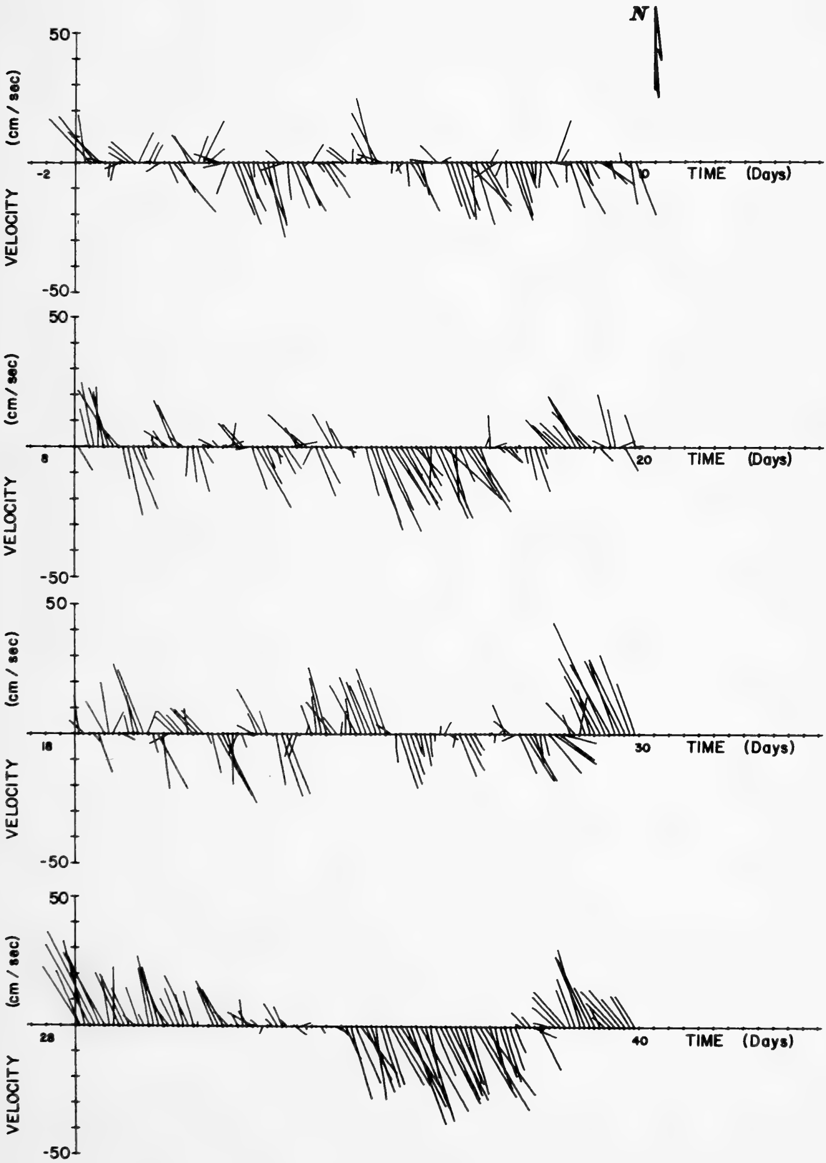

FIG. 2. Stick diagram of 2 hourly current vectors 25 July-3 September 1975.

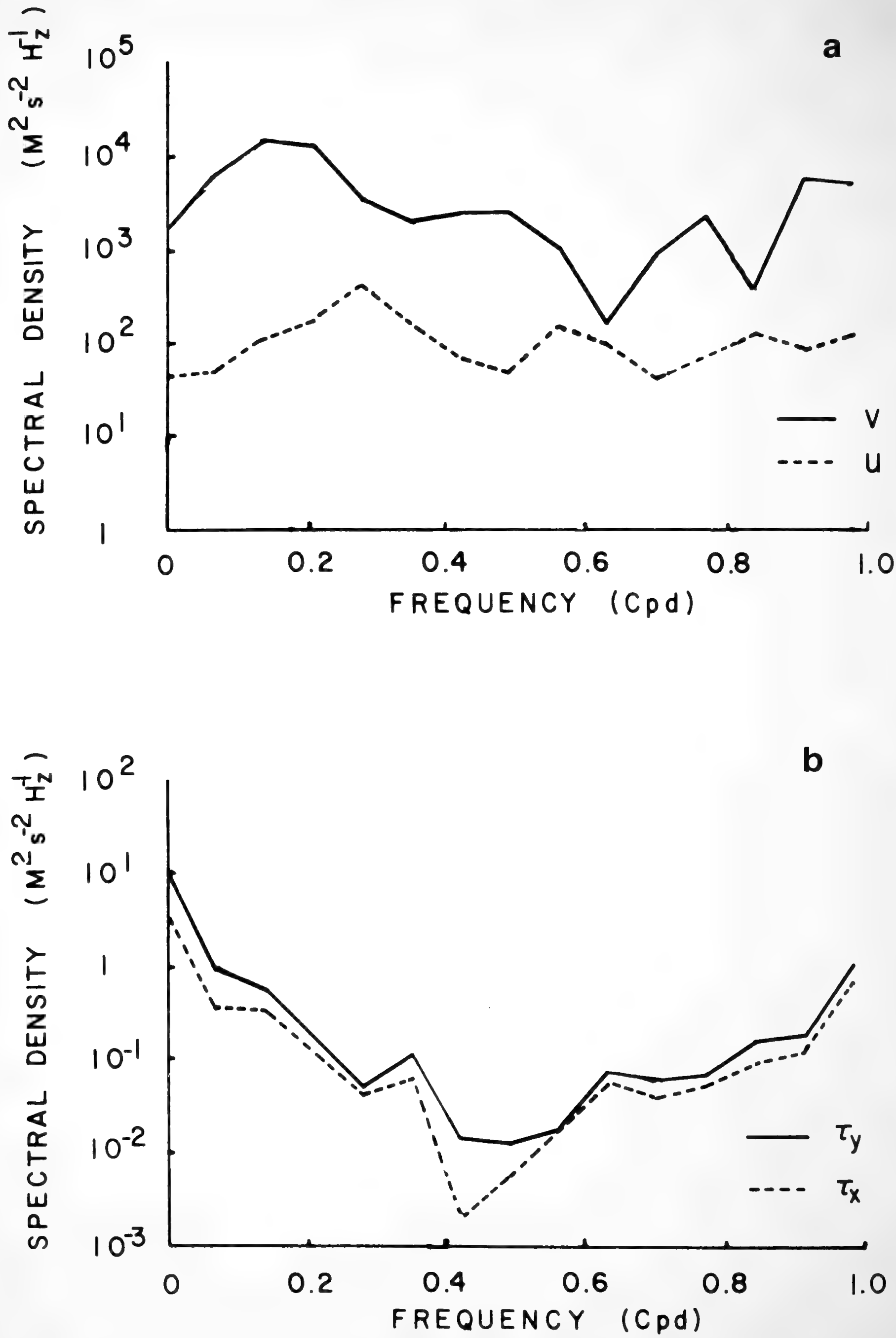

FIG. 3. a. Autospectra of u (offshore) and v (alongshore) components of the current. b. Crosshore (τ_x) and longshore (τ_y) autospectra of the windstress.

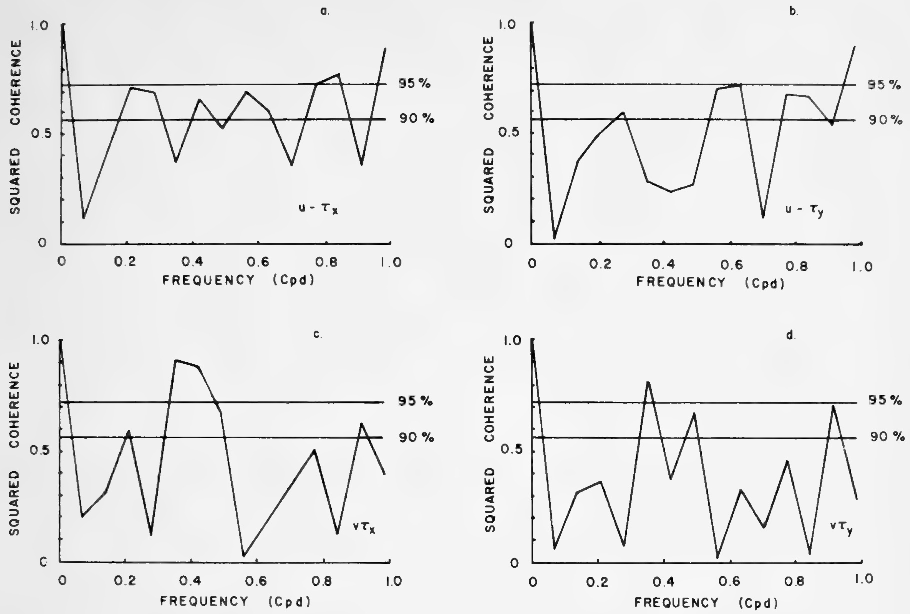

FIG. 4. Squared coherence estimates between components of the windstress and current.

and the Miami–Vero Beach atmospheric pressure gradient were found only at 0.77 cpd. At that frequency the coherence between Miami–Vero Beach pressure gradient and the v-component is approximately twice the coherence between the same component and the Miami–Jacksonville pressure gradient.

The only significant (> 95%) coherence between the crosshelf current and the wind is found with τ_x for motions with a period of 1.2 da. If the 90% significance limit were acceptable, all oscillations corresponding to peaks in the u-spectrum would be coherent with both components of the windstress.

DISCUSSION—None of the peaks of the u and v current spectra are found to occur at the same frequency, suggesting an alongshore system of subinertial waves which is independent of a system of crosshelf subinertial current fluctuations. The significant coherences which are observed between the u and v components probably result from the deflection into the crosshelf direction, of the more energetic, basically alongshore but onshore subinertial oscillations, by the nearby coast.

The coherence (if a 90% significance level is accepted) of the crosshelf currents with both components of the windstress suggest wind forced crosshelf low frequency current oscillations. The peaks of the u–spectrums do not align with any energetic components of the windstress. The generating mechanism of the crosshelf system of current fluctuations appears to be frequency selective.

The high observed coherence between v and τ_x and to a lesser, but still significant, degree with τ_y in the 2-2.8 da period band suggests wind forced alongshore subinertial waves, such as continental shelf waves. The available data are, however, insufficient to determine the nature of these waves. Brooks (1975), found no evidence for the presence of shelf waves from tidal height measurements along the Florida east coast north of Boynton Beach. The nature and forcing of the 1.3-1.6 and 4.7-14 da period alongshore current fluctuations is also not clear. Coherent oscillations between the alongshore current and alongshore components of the atmospheric pressure gradient similar to the ones described here for the 1.3-1.6 da motions have been reported by Kielman and Düing (1974) in deeper water in the straits of Florida. A longer data record will be required to determine whether the observed 4.7-14 da current oscillations are wind induced or a result of the forcing of the inner shelf waters by meanders or spin-off eddies of the Florida Current.

ACKNOWLEDGMENT—The support of this work by the Harbor Branch Foundation, Inc., Fort Pierce, Florida is gratefully acknowledged.

LITERATURE CITED

BROOKS, D. A. 1975. Wind-forced continental shelf waves in the Florida current. Ph.D. dissert. Univ. Miami. Coral Gables.

HALE, D. A. 1976. Observations of the nearshore current off Hutchinson Island, East Central Florida. M.S. Thesis. Florida Inst. Tech. Melbourne, Florida.

KIELMAN, J., AND W. DÜING. 1974. Tidal and sub-inertial fluctuations in the Florida current. J. Phys. Ocean. 4:227-236.

LEE, T. N. 1975. Florida current spin-off eddies. Deep-Sea Res. 22:753-765.

———, AND D. A. MAYER. 1977. Low-frequency current variability and spin-off eddies along the shelf of south east Florida. J. Mar. Res. 35:193-219.

Florida Sci. 42(1):26-32. 1979.

Environmental Sciences

A PRELIMINARY INVESTIGATION OF THE EFFECTS OF ENRICHMENT ON THE MACROBENTHOS IN AN EAST-CENTRAL FLORIDA LAGOON

R. E. Grizzle

Brevard County Health Department, Environmental Engineering and Pollution Control Section, 2575 N. Courtenay Parkway, Merritt Island, Florida 32952

Abstract: *A preliminary investigation was made of the macrobenthos in an enriched (by secondary sewage effluents and urban runoff) east-central Florida lagoon, Sykes Creek, and in other less-enriched parts of the same system. Peterson grab samples were taken at 6 stations in Sykes Creek and at 2 control stations in the Indian and Banana Rivers, once during the summer and once during winter. Sykes Creek stations showed greater temporal variability than did the controls in almost all macrobenthic parameters measured (i.e., species diversity, density, biomass, and species ratio differences). Sykes Creek stations also had decreased species numbers and diversity values and a predominance of opportunistic species.**

Macrobenthic investigations in the Indian River region have been ongoing for several years by the Harbor Branch Foundation, Ft. Pierce, Florida. Published macrobenthic investigations of this area include Young et al. (1976), and Young and Young (1977). However, there have been no such studies in Sykes Creek. Sykes Creek is relatively enriched as a result of discharges of secondarily-treated sewage effluents and urban runoff. Consequently, it exhibits heavy phytoplankton concentrations, with sporadic blooms resulting in widely fluctuating dissolved oxygen (D.O.) levels (unpublished data, Brevard County Health Dept).

This study was initiated as a preliminary investigation of the macrobenthos of the enriched Creek in conjunction with other macrobenthic monitoring programs related to lagoonal water quality in Brevard County. I compare preliminary macrobenthic and physical-chemical data collected from the enriched Creek with 2 less-enriched control areas, and discuss the relationship between opportunistic species in the macrobenthos of Sykes Creek and environmental predictability and disturbance.

Study Areas—The primary study area is in the southern part of Sykes Creek, Brevard County, in east-central Florida adjacent to the Atlantic Ocean (Fig. 1). The climate of Brevard is humid and subtropical, with an annual air temperature range of −2 – 36°C, and a yearly rainfall of approximately 132 cm, occurring mainly between May and October (Brown et al., 1962).

Sykes Creek is part of a lagoon complex consisting of the Indian River, Banana River, and Newfound Harbor. The nearest direct connection to the Atlantic Ocean is Sebastian Inlet, about 60 km S of Sykes Creek. Historically, the southern

*The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U. S. C. § 1734, this article must therefore be hereby marked "*advertisement*" solely to indicate this fact.

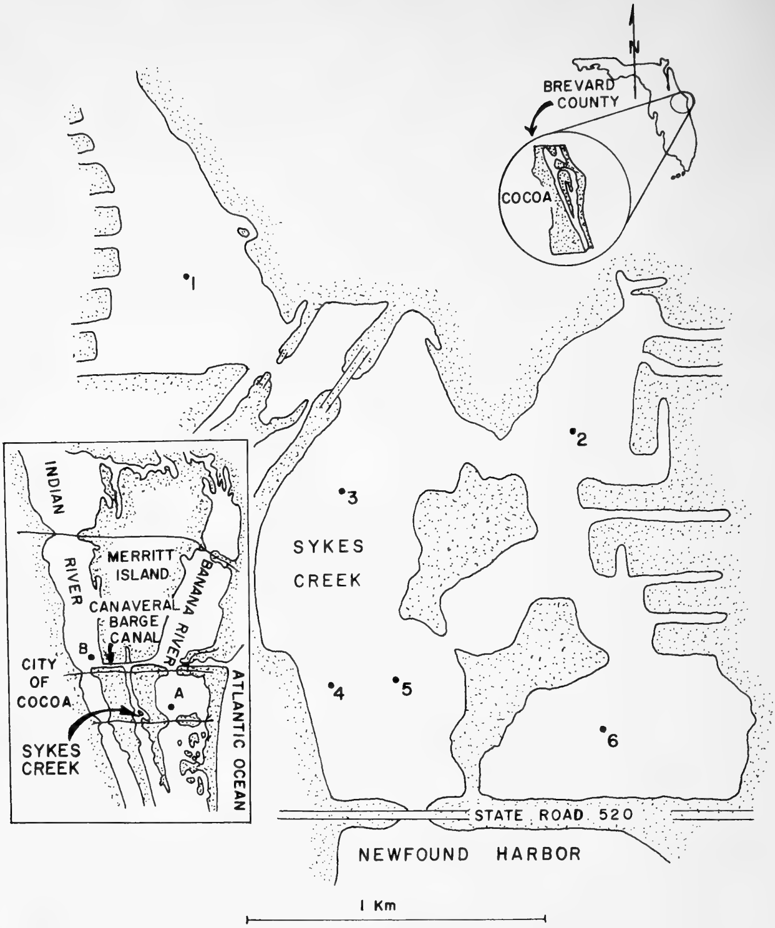

FIG. 1. Study Area. Sykes Creek sampling stations numbered 1–6. Banana and Indian River control stations listed A and B.

part of the Creek in most areas was shallow with water depths not exceeding 1 m. Presently, water depths range from approximately 1 m in the undredged areas to greater than 7 m in the dredged portions. Most of the Creek and its marshes have been altered by either dikes and canals for mosquito control, or dredge and fill projects in the form of finger–fill canals for housing developments.

Residential communities along Sykes Creek are now mainly served by sanitary sewers, but the final effluent from the sewage treatment plants, as well as urban runoff, goes into the Creek. Approximately 1.4 million gallons per day of secondary sewage effluents from 3 treatment plants enter Sykes Creek. No pollutants with serious toxic effects on the invertebrates are known to enter Sykes Creek.

Monthly samples taken from laboratory records of Brevard County Health Dept for 1972 through 1975 show a mean nitrate (NO_3) level for the Creek of 0.146 mg/1 and a mean total phosphate (PO_4) level of 0.983 mg/1. Adjacent control areas in the Indian and Banana River lagoons have similar NO_3 concentrations, but PO_4 levels are about half as those of the Creek. Heavy phytoplankton concentrations occur in Sykes Creek during the summer. Chlorophyll *a* levels in the Creek generally average about 2-3 times the levels in the control areas (C. Down, pers. comm.). Occasional blooms, mostly during the summer and generally of dinoflagellate species, result in widely fluctuating D.O. levels in the Creek. The Environmental Engineering Section of the Brevard County Health Dept has investigated numerous fish kills in Sykes Creek and its upland canals. In most cases the kills have resulted from low D.O. concentrations, occasionally below 1 mg/1. No such fish kills or low D.O. levels have been observed in the control areas.

There have been no hydrological studies in Sykes Creek. Astronomical tides are not evident and observed currents are probably wind driven; currents in the adjacent Indian and Banana River lagoons are wind-dependent (Carter and Okubo, 1965; Schneider et al., 1974).

MATERIALS AND METHODS—Macroinvertebrate collections were made at 6 stations in lower Sykes Creek and 1 station each in the Indian and Banana River lagoons, (Fig. 1) using a 0.1 m^2 Peterson grab. Three to 5 grabs were taken at each station per sampling occasion and pooled for a composite sample. Each sample was sieved through a 0.42 mm mesh (U.S. Standard No. 40) and the residue fixed in a 5% formalin solution with rose bengal added. Animals were sorted in the laboratory and preserved in 80% EtOh. All specimens were identified, generally to species, and enumerated. Wet weights were made of all specimens by group from each sorted sample by blotting the specimens dry on paper then weighing on a Mettler balance. Molluscs were not removed from their shells before weighing. In those cases where a taxon was extremely abundant (i.e., greater than approximately 5,000 per m^2) a 1/10 to 1/2 aliquot of the sorted sample was taken of that particular taxon to facilitate counting.

Sykes Creek was sampled in July 1975 and in February 1976. Samples were taken in January and July 1975 from Station A, and in September 1975 and March 1976 from Station B. The winter Station A sample was taken 1 yr. previous to the other winter samples; all stations were sampled at an approximate 6–mo interval and during the winter and summer seasons.

Sediment samples were taken from the contents of one of the replicate samples on one sampling occasion and analyzed for grain–size distribution and organic content (% volatile). Grain-size analysis procedures were carried out, with silt-clay (particles < 62 microns), sand (particles > 62m) and shell (all caught on a 1.00 or 2.00 mm mesh) fractions determined (Holme and McIntyre, 1971). An estimate of the sediment organic content was made by the technique of Weber (1973). Water samples were also taken at the time of benthic sampling, and analyzed in the laboratory for D.O., biochemical oxygen demand (B.O.D., 5-da), and salinity. D. O. content was determined with a Beckman D.O. analyzer, and salinity was measured with a hydrometer. Water temperatures, at surface and approximately 0.3m above the sediment-water interface, were measured with a mercury thermometer.

Data Analyses—Shannon-Weaver diversity index (Pielou, 1975) was measured where $H' = -\Sigma\, p_i \log_2 p_i$. Equitability (Weber, 1973) was determined where $e = \frac{s'}{s}$.

A faunal affinity index (Sanders, 1960) was obtained by determining the percent of the total abundance that each species represents within each sample, and then summing the lower percentage values for all species common to the 2 samples being compared. The summer and winter data from each station were compared to determine the seasonal changes in species composition. The lower the value, the greater the amount of change at the species level. The index value range is 0–100%.

Results—Stations A and B are included as controls only for Sykes Creek stations 1, 2, 5 and 6. All these stations are considered similar enough to compare the macrobenthos from each based on the following. The sediment of all is greater than 85% sand, with some shell and less than 3% organic (Table 3). Salinity at these stations ranged 20.3–29.1 ppt. Monthly samples for January 1975 through September 1976 from areas near the sampling stations for this study in Sykes Creek, Indian River, and Banana River were 20.3–31.1, 23.9–31.4, and 22.7–34.7, respectively (unpublished Brevard County Health Dept records). Qualitative personal observations of the vegetation made at the time of each benthic sampling effort resulted in none present at stations 1 and 6 during either season, and only sparse algal cover at 2 and 5 during both seasons. Controls A and B had sparse algal cover during the winter and no vegetation during the summer. All these stations seem to be influenced primarily by drift algae, and none were covered with dense vegetation.

Stations 3 and 4 are excluded from comparisons with the control stations for the following reasons. Station 3 was densely covered during both seasons with the red alga *Gracilaria foliifera.* This cover provided additional substrate support for the bivalve *Mytilopsis leucophaeata.* Additionally, there is apparently a positive correlation between densities of some macroinvertebrates and macroalgae biomass present in a given area (George Kulczycki, pers. comm.; pers. obs.). Station 4 was in a deep dredged area, and no other stations were sampled that even nearly approached its depth (~ 7m), sediment characteristics (97% silt-clay, 16% organic), or D.O. values (1 mg/1 or less). Also, temperature stratification was evident (Table 3). No macroinvertebrates were present at this station in either sample. These data indicate that the deep dredged areas act as traps for organic matter and probably have little water exchange near the bottom. The same general observations have been reported in dredged saline canal systems in other parts of Florida (Sykes and Hall, 1970; Barada and Partington, 1972; Lindall, et al., 1973).

Due to the extreme dissimilarity of stations 3 and 4 any further mention of "the Sykes Creek stations" is a reference to stations 1, 2, 5, and 6.

Comparisons with Control Stations—The 7 samples from stations 1, 2, 5 and 6 yielded 65 species. The 4 control samples yielded at least 83 species.

For the present study a species was considered numerically dominant in a sample if it represented 35% or more of the total number of specimens present in the sample, and occurred at a density of greater than $2,000/m^2$. One main difference between the control stations and Sykes Creek stations was the frequent dominance of one or more species in most samples from the Creek. The 7 Sykes Creek samples had 6 instances of dominance. In the 4 samples from the control stations there was only one instance of dominance. As Table 1 shows, only 4 species represent 74.51% of all specimens collected from the Creek, as opposed to 10 species representing 74.52% of the specimens collected from the control stations.

Station 2 was numerically dominated by the amphipod *Grandidierella bonnieroides* (50.1%) and the tanaid *Leptochelia rapax* (41.3%) during the summer; the bivalve *Parastarte triquetra* (51.6%) was dominant in the winter. Station 5 was dominated by the amphipod *Ampelisca abdita* (39.0%) during the summer, and by *L. rapax* (55.4%) during the winter. Station 6 was sampled only during the summer; the amphipod *Corophium ellisi* (39.0%) was dominant. These numerical dominants include 5 species; only one, *L. rapax*, was dominant at 2 stations. In most cases the Sykes Creek dominants were present at high densities (8,000 to 30,000 per m^2) in the sample where they were dominant. The control sample containing a numerical dominant was from station B during winter, where a small ($<$ 7 mm total length) unidentified capitellid polychaete made up 40% of the sample, occurring at a density of $2,245/m^2$.

In addition to the relatively frequent occurrences of numerical dominants in the Creek, a striking difference between the Sykes Creek macrobenthos and the control areas was the greater temporal variability of the Sykes Creek macrobenthos. Station 1 showed the greatest changes in time for every biological parameter measured (Table 2). Stations 2 and 5 had less temporal changes, but still indicated relatively high variability as compared to the control station data (Table 2). The degree of temporal change in the species composition of the macrobenthos at each station from summer to winter was also greater at the Sykes Creek stations than at the controls, with mean faunal affinity values of 22% and 45%, respectively.

Discussion—Some of the concepts put forth in MacArthur and Wilson (1967), Margalef (1968), Sanders (1968, 1969), and Slobodkin and Sanders (1969) are part of a developing theory relating environmental variability to various population and community properties. Some literature is available directly testing and supporting some of the generalizations in these reports (Randolph, 1973). An "unpredictable" environment is defined by Slobodkin and Sanders (1969) as one where the variations of environmental properties around their mean values are relatively high and unpredictable. The unpredictability refers to the occurrence of harsh conditions, such as low D.O. I suggest that Sykes Creek is such an environment primarily because of the previously discussed sporadic and extreme fluctuations in D.O. concentrations. Salinity and temperature also fluctuate somewhat and contribute to the unpredictability of the environment, but they probably do not have nearly the impact on the macrobenthos that the D.O. fluctuations have, as their ranges in the Creek are very similar to ranges in the control areas. The enriched condition and resulting unpredictable environment in

TABLE 1. List of the most numerically-important species collected from Sykes Creek and the control stations in the Indian and Banana River lagoons.

Species		Sykes Creek Number of Specimens	% of Total	Station-Season Occurrence Summer 1	Summer 2	Summer 5	Summer 6	Winter 1	Winter 2	Winter 5
Leptochelia rapax (?)	(T)[1]	19503	25.14	X	X	X	X	X	X	X
Grandidierella bonnieroides	(A)	15413	19.86	-	X	X	X	X	X	X
Corophium ellisi	(A)	12450	16.05	-	X	-	X	-	X	X
Apseudes (?) sp.	(T)	10444	13.46	-	X	X	X	X	-	-
Anomalocardia auberiana	(B)	7034	9.06	X	X	X	X	X	X	X
Parastarte triquetra	(B)	3329	4.29	-	X	-	X	X	X	X
Ampelisca abdita	(A)	2169	2.79	X	X	X	X	X	X	X
Gammarus mucronatus	(A)	2053	2.64	-	X	-	X	-	X	X
Acteocina canaliculata	(G)	1175	1.51	-	X	X	X	X	X	X
Eteone heteropoda	(Po)	676	0.87	-	X	X	X	X	X	X
Pectinaria gouldii	(Po)	600	0.77	-	X	X	X	X	-	X
Haploscoloplos foliosus	(Po)	562	0.72	-	X	X	-	X	X	X
unidentified actinarian		430	0.55	-	X	X	-	-	X	-
unidentified rhynchocoel(s)		350	0.45	-	X	X	X	X	X	X
Amygdalum papyrium	(B)	229	0.29	-	X	X	X	X	X	X
Cymadusa compta	(A)	160	0.20	-	-	-	-	-	-	X
Ophiophragmus filograneus	(O)	107	0.13	-	X	X	X	X	X	X
Tagelus plebeius	(B)	104	0.13	-	X	X	X	X	X	X

CONTROL AREAS

Species		Number of Specimens	% of Total	Summer A	Summer B	Winter A	Winter B
Pectinaria gouldii	(Po)	926	16.62	X	X	X	X
unidentified polychaete		650	11.67	-	-	-	X
Ophiophragmus filograneus	(O)	525	9.42	X	X	X	X
unidentified ascidian		478	8.58	X	X	X	X
Diopatra cuprea	(Po)	376	6.75	X	X	X	X
Glycinde solitaria	(Po)	278	4.99	X	X	X	X
Melinna maculata	(Po)	264	4.74	X	X	X	X
Tharyx sp.	(Po)	240	4.30	X	X	X	X
Amygdalum papyrium	(B)	220	3.95	X	X	X	X
Paraprionospio pinnata	(Po)	195	3.50	X	X	X	X
Gyptis vittata	(Po)	135	2.42	X	X	X	-
Phascolion sp.	(S)	124	2.22	X	X	X	X
Nereis (Neanthes) succinea	(Po)	101	1.81	X	X	X	X
Brachidontes exustus	(B)	76	1.36	X	X	-	X
Armandia maculata	(Po)	74	1.32	-	-	-	X
Branchioasychis americana	(Po)	70	1.25	-	X	X	X
Glycera americana	(Po)	55	0.98	X	X	X	X
Ophiophragmus pulcher	(O)	40	0.77	X	X	X	X
Phoronis sp.	(Ph)	35	0.62	X	-	-	X
Sabella microphthalma	(Po)	33	0.59	-	X	X	X
Marginella apicina	(G)	32	0.57	-	X	X	X

[1]The following abbreviations are used and appear in parenthesis after each species listing. A–amphipod, B–bivalve, G–gastropod, O–ophiuroid, Ph–phoronid, Po–polychaete, S–sipunculid, T–tanaid. An X denotes presence at that station, and an – denotes absence.

TABLE 2. Biological data and analyses by station for summer and winter samples from Sykes Creek and from the control stations in the Indian and Banana Rivers.

Station & Season		Number of Species	Specimens Per m²	Wet Weight (g/m²)	H′	e	Faunal Affinity (%)
1	Summer	5	25	3.8	2.05	1.10	35
	Winter	34	1303	22.4	3.48	0.47	
2	Summer	25	39755	42.9	1.54	0.15	9
	Winter	30	15030	115.1	2.36	0.23	
3	Summer	28	2055	13.9	3.24	0.49	13
	Winter	45	12860	1602.5	2.16	0.13	
4	Summer	0	0		0	0	--
	Winter	0	0		0	0	
5	Summer	32	8427	61.4	2.71	0.28	22
	Winter	35	54065	142.8	1.83	0.13	
6[1]	Summer	31	75050	112.5	1.81	0.14	--
	Winter	--	--	--	--	--	
A	Summer	46	3320	176.8	3.89	0.48	52
	Winter	41	3658	210.8	3.37	0.36	
B	Summer	50	3752	220.3	4.42	0.63	38
	Winter	57	5357	116.5	3.64	0.32	

[1]Station 6 was not sampled in the winter due to low water levels and inaccessibility.

the Creek are the major physical differences, and probably the major influences producing the macrobenthic differences in Sykes Creek and the control areas. It should be noted that Stirn et al. (1975) pointed out the similarities of some organically-polluted systems and Margalef's (1968) "immature ecosystems".

Slobodkin and Sanders (1969) suggest that unpredictable environments will generally have total species numbers and species diversity depressed below levels found in comparable more predictable environments. The results in this present report support this generalization. The mean species per station is 27 from the Creek and 48 from the controls (Table 2). A total of 65 species was collected from the Creek and at least 83 from the controls. H′ values ranged 1.54–3.48 from the Creek and 3.37–4.42 from the controls, with respective means of 2.25 and 3.83 (Table 2).

Slobodkin and Sanders (1969) state there should be more opportunistic species in unpredictable environments than in more predictable environments. Data sufficient to determine the degree of opportunism of many species collected in the present study are not available. McCall (1977) considered opportunistic species as related to disturbances; he defined opportunists based on abundance, and invasion and mortality rates. The definition of opportunist in the present report follows the criteria given in Mozley (1960) for invaders or pest species and includes the following characteristics: the ability to readily invade a newly-avail-

TABLE 3. Physical-chemical data by station for summer and winter sampling efforts.

Station & Season		Water Depth (m)	Water Analyses: Sal.[1] (ppt)	D.O.[1] (mg/1)	B.O.D.[1] (mg/1)	Temp. (°C) Surf.	Temp. (°C) Bott.[1]	Sediment Analyses (%): Sand	Silt-Clay	Shell	Organic
1	Summer	2.5	20.3	3.4	3.0	29.0	28.0	88.3	8.6	3.1	1.1
	Winter	2.0	26.9	8.6	3.7	15.0	14.5	-	-	-	-
2	Summer	1.0	21.4	7.6	7.0	30.0	30.0	94.9	3.5	1.6	0.7
	Winter	0.5	25.6	10.0	1.0	15.5	15.5	-	-	-	-
3	Summer	1.0	21.3	4.8	4.6	29.0	29.0	77.1	17.2	5.7	4.6
	Winter	0.6	27.2	10.0	1.7	15.0	15.0	-	-	-	-
4	Summer	~7	22.7	0.5	48.0	30.0	28.0	3.0	97.0	0.0	16.7
	Winter	~7	30.2	1.0	0.6	18.0	15.0	-	-	-	-
5	Summer	1.3	21.4	2.4	0.2	27.5	27.5	93.6	5.0	1.4	0.9
	Winter	0.6	26.7	10.0	3.3	17.0	17.5	-	-	-	-
6	Summer	0.7	20.9	3.4	2.8	27.0	27.0	89.1	9.2	1.7	1.5
	Winter[2]	-	-	-	-	-	-	-	-	-	-
A	Summer	2.5	24.0	-	-	29.0	28.5	-	-	-	2.5
	Winter	2.3	23.7	-	-	19.5	19.0	86.9	11.6	1.5	1.7
B	Summer	2.0	25.2	-	-	29.0	29.0	-	-	-	-
	Winter	2.0	29.1	6.4	0.7	20.0	20.0	85.2	12.4	2.4	-

[1]Sample taken from approximately 0.3 m above the sediment surface.
[2]No winter sample was taken because of low water levels and inaccessibility.

able habitat, a high reproductive rate leading to predominance in the area, and being temporary or transient dominants in the newly-invaded habitat. To the author's knowledge no species collected during the present study, except the 6 species discussed below, are defined as opportunists by these criteria in other literature.

Grassle and Grassle (1974) and McCall (1977) listed 4 opportunists, *Ampelisca abdita, Capitella capitata* (which consists of at least 6 sibling species, Grassle and Grassle, 1977), *Polydora ligni,* and *Streblospio benedicti,* that were also collected in the present study. These were collected from all study areas, but were present in low numbers, except *A. abdita* which represented 2.79% of the specimens from Sykes Creek and was a numerical dominant at station 5. Also, sampling data from the present study suggest at least 2 additional species, *G. bonnieroides* and *L. rapax,* collected from Sykes Creek are opportunistic. Because the samples were taken at a 6–mo interval, it would not be possible to detect rapid invasion rates. This fact precluded considering the species dominant in only the winter samples (*P. triquetra* and the unidentified capitellid) from being considered to possess any opportunistic characteristics except high reproductive rates associated with their dominance. A high reproductive rate and numerical dominance may be associated with species that are not opportunistic. Station 6 summer dominant, *C. ellisi,* could only be considered to have a high reproductive rate as winter samples were not taken at that station. However, the 3 remaining numerical dominants from Sykes Creek, *A. abdita* (also listed as an opportunist by McCall, 1977), *G. bonnieroides,* and *L. rapax,* possessed at least 2 of the 3 opportunist characteristics given. These species were numerical dominants in their respective samples and were also temporary dominants; none dominated the following winter samples. They are then considered to be opportunists of some degree.

Thus, 6 opportunistic species represented approximately 50% of the total specimens collected from Sykes Creek, as compared to 4 opportunists which represented less than 4% of the specimens from the Indian and Banana River samples.

The dynamic nature of the macrobenthos in many marine and estuarine areas is well-documented (Thorson, 1957; Johnson, 1970; Tenore, 1972; Boesch, 1973; and Boesch et al., 1976), and it is generally recognized that data from short-term studies are often of limited use. Also, many reports list "indicator species" or "indicator communities" for sewage or other polluted areas (Filice, 1959; Reish, 1959; Wass, 1967; Henriksson, 1968, 1969; and Bagge, 1969). Several such indicator species (e.g., *Capitella capitata, Streblospio benedicti,* and *Polydora ligni*) have been shown to be opportunistic by Grassle and Grassle (1974) and McCall (1977). The present report is then additional documentation of a predominance of opportunistic species in an enriched sewage-polluted lagoon, with the suggestion that the polluted system is comparable to other unpredictable, chronically-disturbed environments. Based on these data further investigations concerned with more accurately assessing aspects of environmental predictability, defining opportunistic species, and describing colonization sequences (as per the methods in McCall, 1977) are ongoing in Sykes Creek and the Banana River.

ACKNOWLEDGMENTS—I thank Dr. Robert W. Virnstein, Dr. David K. Young, Mrs. Martha Young, and Mr. James D. Stevenson for their helpful suggestions in review of the manuscript. The following people identified or confirmed the identification of organisms in their respective fields: Mrs. Cherie Down (algae), Mr. Richard S. Fox (amphipods), Mrs. Martha Young (polychaetes), and Dr. David K. Young (molluscs).

LITERATURE CITED

BAGGE, P. 1969. The succession of the bottom fauna communities in polluted estuarine habitats. Limnologica (Berlin). 9:87-94.

BARADA, W., AND W. M. PARTINGTON, JR. 1972. Report on the investigation of the environmental effects of private waterfront canals. Enviro. Info. Cent., Winter Park, Florida.

BOESCH, D. F. 1973. Classification and community structure of macrobenthos in the Hampton Roads area, Virginia. Mar. Biol. 21:226-244.

———, M. L. WASS, AND R. W. VIRNSTEIN. 1976. The dynamics of estuarine benthic communities. Pp. 177-196. *In* Wiley, M. L. (ed.). Estuarine Processes, Vol. I., Academic Press, New York.

BROWN, D. W., W. E. KENNER, J. W. CROOKS, AND J. B. FOSTER. 1962. Water resources of Brevard County, Florida. Florida Geol. Sur., Rept. of Invest. 28.

CARTER, H. H., AND A. OKUBO. 1965. A Study of the physical processes of movement and dispersion in the Cape Kennedy area. Chesapeake Bay Institute, Johns Hopkins Univ. Rept. No. NYO-2973-1.

FILICE, F. P. 1959. The effects of wastes on the distribution of bottom invertebrates in the San Francisco Bay estuary. Wasmann J. Biol. 17:1-17.

GRASSLE, J. F., AND J. P. GRASSLE. 1974. Opportunistic life histories and genetic systems in marine benthic polychaetes. J. Mar. Res. 32:253-284.

__________. 1977. Faunal adaptations in sibling species of *Capitella*. Pp. 177-190. *In* Coull, B. C. (ed.). Ecology of Marine Benthos. Univ. South Carolina Press, Columbia.

HENRIKSSON, R. 1968. The bottom fauna in polluted areas of the sound. Oikos 19:111-125.

__________. 1969. Influence of pollution on the bottom fauna of the sound (Öresund). Oikos. 20:507-523.

HOLME, N. A., AND A. D. MCINTYRE. 1971. Methods for the study of marine benthos. IBP Handbook No. 16. Blackwell Scientific Publ., Oxford.

JOHNSON, R. G. 1970. Variations in diversity within benthic marine communities. Amer. Nat. 104:285-300.

LINDALL, W. N., JR., J. R. HALL, AND C. H. SALOMAN. 1973. Fishes, macroinvertebrates, and hydrological conditions of upland canals in Tampa Bay, Florida. Fish. Bull. 71:155-163.

MCCALL, P. L. 1977. Community patterns and adaptive strategies of the infaunal benthos of Long Island Sound. J. Mar. Res. 35:221-266.

MACARTHUR, R. H., AND E. O. WILSON. 1967. The Theory of Island Biogeography. Princeton U. Press, Princeton, New Jersey.

MARGALEF, R. 1968. Perspectives in Ecological Theory. Univ. Chicago Press, Chicago.

MOZLEY, A. 1960. Consequences of Disturbance. H. K. Lewis and Co., London.

PIELOU, E. C. 1975. Ecological Diversity. Wiley-Interscience, Somerset, New Jersey.

RANDOLPH, P. A. 1973. Influence of environmental variability on land snail population properties. Ecology. 54:933-955.

REISH, D. J. 1959. An ecological study of pollution in Los Angeles–Long Beach Harbors, California. Allan Hancock Found. Publs., Occas. Paper, No. 22.

SANDERS, H. L. 1960. Benthic studies in Buzzard's Bay. No. III. The structure of the soft-bottom community. Limnol. Oceanogr. 5:138-153.

__________. 1968. Marine benthic diversity: a comparative study. Amer. Nat. 102:243-282.

__________. 1969. Benthic marine diversity and the stability-time hypothesis. Pp. 71-81. *In* Woodwell, G. M., and H. H. Smith (eds.). Diversity and Stability in Ecological Systems. Brookhaven Symposia in Biol., No. 22.

SCHNEIDER, W. K., P. S. DUBBELDAY, AND T. A. NEVIN. 1974. Measurement of wind-driven currents in a lagoon. Florida Sci. 37:72-78.

SLOBODKIN, L. B., AND H. L. SANDERS. 1969. On the contribution of environmental predictability to species diversity. Pp. 82-95. *In* Woodwell, G. M., and H. H. Smith (eds.). Diversity and Stability in Ecological Systems. Brookhaven Symposia in Biol. No. 22.

STIRN, J., A. AVCIN, I. KERZAN, B. M. MARCOTTE, N. MEITH-AVCIN, B. VRISER, AND S. VUKOVIC. 1975. Selected biological methods for assessment of marine pollution. Pp. 307-327. *In* Pearson, E. A. (ed.). Proceedings of the First International Conference on Waste Disposal in the Marine Environment. Pergamon Press, New York.

SYKES, J. E., AND J. R. HALL. 1970. Comparative distribution of mollusks in dredged and undredged portions of an estuary, with a systematic list of species. Fish. Bull. 68:299-306.

TENORE, K. R. 1972. Macrobenthos of the Pamlico River estuary, North Carolina. Ecol. Monogr. 42:51-69.

THORSON, G. 1957. Bottom communities. Pp. 461-535. *In* Hedgepeth, J. W. (ed.). Treatise on Marine Ecology and Paleoecology. Vol. I Ecology. Geol. Soc. Amer. Mem. 67.

WASS, M. L. 1967. Biological and physiological basis of indicator organisms and communities. Pp. 271-283. *In* Burgess, T. A., and F. J. Olson (eds.). Pollution and Marine Ecology. Interscience Publ., New York.

WEBER, C. I. (ED.). 1973. Biological field and laboratory methods for measuring the quality of surface waters and effluents. NERC U.S. EPA, Cincinnati, Ohio.

YOUNG, D. K., M. A. BUZAS, AND M. W. YOUNG. 1976. Species densities of macrobenthos associated with seagrass: a field experimental study of predation. J. Mar. Res. 34:577-592.

__________, AND M. W. YOUNG. 1977. Community structure of the macrobenthos associated with seagrass of the Indian River estuary, Florida. Pp. 359-382. *In* Coull, B. C. (ed.). Ecology of Marine Benthos. Univ. of South Carolina Press, Columbia.

Florida Sci. 42(1):33-42. 1979.

Agricultural Sciences

EFFECT OF SALT ON SEED GERMINATION AND TRANSPLANT SURVIVAL OF VEGETABLE CROPS[1]

ALEXANDER A. CSIZINSZKY

Agricultural Research and Education Center, IFAS,
University of Florida, Bradenton, Florida 33508

ABSTRACT: *Following a fall tomato crop, 9 vegetable crops were grown with or without additional fertilizer. The fall tomato crops received 283 kg/ha N, 112 kg/ha P_2O_5, 393 kg/ha K_2O, and minor elements. The vegetable crops were fertilized at a rate of 220 kg/ha N, 112 kg/ha P_2O_5, and 112 kg/ha K_2O, or were grown on residual nutrients alone. Additional fertilizer restricted or prevented to a greater degree the germination of carrot, green onion, lettuce and radish seeds, whereas residual fertilizer did not. The survival and growth of broccoli, cabbage, cauliflower, and kohlrabi transplants were also affected by additional or residual fertilizers. Zucchini squash was not significantly affected by excess salts.*[*]

THE utilization of residual nutrients of the highly fertilized tomato fields in Florida by planting a second crop without additional fertilizers would be desirable for environmental and economic reasons.

Marlowe and Geraldson (1976) reported a total soluble salt (TSS) content of 29,700 ppm in the fertilizer band, 20,100 ppm in the mid band, and 16,000 ppm in the plant row region of the 0-20 cm soil depth in a Hillsborough County tomato field after harvest. They found similarly high TSS content in harvested tomato fields in other counties in southwest Florida. The usual practice after the tomato harvest is to leach out the residual fertilizers from the soil to reduce or prevent salt buildup. Thus, the excess fertilizer from the cultivated lands ends up in the runoff waters contributing to their salt content (Baker and Chesnin, 1975). Increasing salinity of the irrigated lands in Florida and in the western United States is not a new problem (Spencer, 1945; Westgate, 1950; Geraldson, 1966; Hayward and Wadleigh, 1948; Bernstein, 1964). Researchers recommended balanced nutrition (Tucker et al., 1968) and crop rotation (Kretschmer et al., 1963; Hayslip et al., 1964) to prevent or to reduce the accumulation of salts in soils caused by excessive amounts of fertilizers.

The utilization of residual fertilizers by a second vegetable crop would also help to reduce production costs. Otte (1976) calculated a sum of $1396 as the growing cost per net acre for 1 crop of full bed plastic mulch staked tomatoes, without harvest costs. In his data, $476 per acre (34%) were spent for plastic mulch and fertilizers. This amount could partially be saved if the tomato fields were used after the harvest of the fall crop for vegetable production without re-

[1]Florida Agricultural Experiment Stations Journal Series No. 1172.

[*]The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U. S. C. § 1734, this article must therefore be hereby marked "*advertisement*" solely to indicate this fact.

moving the plastic mulch cover from the beds and without applying additional fertilizers.

I report the results of experiments conducted to utilize the residual fertilizers of a fall tomato crop by growing vegetables in the spring season, and on the effect of the residual and added fertilizers on seed germination and seedling survival of the vegetable crops.

MATERIALS AND METHODS—In the spring of 1976 nine different vegetable crops were planted in a randomized split-plot design after a staked full bed plastic mulch fall tomato crop was harvested. The tomatoes received 283 kg N, 112 kg P_2O_5, 393 kg K_2O per ha, and minor elements. Stakes and plastic mulch were removed from the field and the beds reformed before planting. Each of the 4 replications were divided into nine, 7.60 m long plots. One–half of each plot received fertilizer at a rate of 220 kg N, 112 kg P_2O_5, and 112 kg K_2O per ha, and minor elements. Superphosphate was applied in a broadcast form on the top of the beds; the rest of the fertilizer was worked into the top 5 cm of the soil. Total soluble salt contents were determined by the saturated paste procedure (USDA Handbook No. 60, 1954; Geraldson, 1957) in both treated and nontreated halves of each plot before and after fertilizer placement.

Seeds of radish (*Raphanus sativus* L., cv. Scarlet Globe), lettuce (*Lactuca sativa* L., cv. Bibb), green onions (*Allium cepa* L., cv. Evergreen White Bunching), and carrots (*Daucus carota* L., cv. Danvers Half Long), were sown in rows after cutting a narrow slit in the plastic. Green onions and lettuce were sown in double rows; carrots and radish in triple rows.

Seedlings of broccoli (*Brassica oleracea* var. *italica,* cv. Green Comet Hybrid), cabbage (*B. oleracea* var. *capitata,* cv. Golden Acre), cauliflower (*B. oleracea* var. *botrytis,* cv. Snow King Hybrid), kohlrabi (*B. oleracea* var. *caulorapa,* cv. Early White Vienna), and zucchini squash (*Cucurbita pepo* L., cv. Fordhook) were transplanted in the first week of March. Within row planting distance between plants were 46 cm for broccoli, cabbage and cauliflower, 15 cm for kohlrabi, and 76 cm for zucchini.

TABLE 1. Changes in total soluble salt (TSS) content of soil in nonfertilized split-plots from planting to harvest, ppm, 0-15 cm soil depth.*

Crop:	Broccoli	Cabbage	Carrots	Cauliflower	Green onions	Kohlrabi	Lettuce	Radish	Zucchini
TSS, at planting	15,054	15,775	12,513	14,287	13,576	12,702	13,154	14,893	14,080
TSS, after harvest	7,380	7,120	8,078	7,207	9,253	7,205	M**	M**	10,050

*Average of 4 replications.
**M = missing.

Water was provided by seep irrigation throughout the growing season. Plants were sprayed twice weekly with approved pesticides against plant pests. Data were analyzed by calculating correlation coefficient and t test (Little and Jackson Hills, 1975).

RESULTS—Residual TSS contents were high in nonfertilized treatments even after the second crop had been harvested (Table 1). In the fertilized split-plots the TSS content of the soil after the spring harvest was as high or higher than the soil TSS content after the harvest of the fall tomato crop (Table 2).

Seeds of carrot, green onion, and lettuce failed to germinate in the fertilized split-plots (Table 3). Radish seeds germinated very poorly at the high soil TSS levels. The Ψ_s values in bars for soil moisture content (Salisbury and Ross, 1969) for the fertilizer treated plots were –6.81 for carrot, –7.96 for green onion, –7.26 for lettuce, and –6.23 for radish.

The residual salt in the nontreated plots almost totally prevented the germination of carrot and reduced the germination of lettuce seeds. The Ψ_s values

TABLE 2. Changes in total soluble salt (TSS) content of soil in fertilized split-plots from planting to harvest, ppm, 0-15 cm soil depth.*

Crop:	Broccoli	Cabbage	Carrots	Cauli-flower	Green onions	Kohlrabi	Lettuce	Radish	Zucchini
TSS, at planting	23,880	27,867	26,173	23,667	30,590	26,910	27,912	23,943	22,806
TSS, after harvest	16,666	9,637	16,350	13,466	17,307	13,008	M**	M**	11,828

*Average of 4 replications.
**M = missing.

in these plots were –3.24 bars for carrot and –3.4 bars for lettuce. Germination of seed and yield of green onion and radish were influenced to a smaller degree by the residual soluble salts. Both vegetables gave a satisfactory per hectare yield at –3.53 bars and –3.88 bars compared to average Florida yields (Brooke, 1978).

With the exception of zucchini, seedling survival of the 5 transplanted vegetable crops was poor in the fertilized split-plots (Table 4; Figs. 1-4). Kohlrabi had the least tolerance to the high TSS content; only 21% of the transplants survived at –7.01 bars Ψ_s.

Cabbage had a transplant survival of 65% at –7.25 bars, cauliflower 55% at –6.16 bars, and broccoli 45% at –6.22 bars. Shortly after transplanting, seedlings started to show stress symptoms in the fertilized plots. Many of the plants wilted, leaves turned yellow and developed tip burn. On the stems, at just below the soil level, lesions developed and in windy weather these plants broke easily and died. Surviving plants of the cole crops had stunted growth and had a dark green color of leaves and stems. Plants often wilted during the warmest part of the day. Zucchini squash transplants survived the high soil TSS content of –5.94 bars. However, in the early stages of development the squash were stunted and often wilted during the daytime.

Plants grown on residual fertilizer also showed signs of salt injury. None of the cole crops had a 100% survival of the seedlings (Table 4). Cabbage seedlings had the highest tolerance for soil salt; 92% survival at –4.10 bars. Broccoli had a survival of 85% at –3.92 bars, cauliflower 77% at –3.72 bars, and kohlrabi 79% at –3.30 bars. All the zucchini seedlings survived at –3.66 bars.

TABLE 3. Total soluble salt (TSS) content of soil[1] and yields[1] of direct seeded vegetable crops.

	CROP							
	Carrot Treatment[2]		Green onion Treatment[2]		Lettuce Treatment[2]		Radish Treatment[2]	
	R	F	R	F	R	F	R	F
TSS in 0-15 cm of soil depth at planting	12,475	26,150**	13,575	30,575**	13,150	27,900**	14,900	23,950**
Average number of plants harvested per split-plot	11	0	277	0	2.48[4]	0	489	83
Yield per hectare	1,757[3]	0	44,171[3]	0	2.37[5]	0	77,975	13,234

[1]Average of 4 replications.
[2]Treatment: R = residual fertilizer alone; F = fertilized split-plot.
[3]Bunch, 6 plants per bunch.
[4]Kg.
[5]Tons per ha.
**Significant at the 5% level and ***significant at the 1% probability level for t values.

TABLE 4. Total soluble salt (TSS) content of soil[1] and yields[1] of transplanted vegetable crops.

	CROP									
	Broccoli Treatment[2]		Cabbage Treatment[2]		Cauliflower Treatment[2]		Kohlrabi Treatment[2]		Zucchini Treatment[2]	
	R	F	R	F	R	F	R	F	R	F
Total soluble salts at planting time ppm	15,054	23,880**	15,755	27,867***	14,287	23,667**	12,702	26,910***	14,080	22,806
Number of seedlings transplanted per split-plot	8	8	8	8	8	8	24	24	5	5
% of seedlings survived	85***	45	92.5***	65	77.5	55	79***	21	100	100
Yield per plant kg	0.307*	0.236	1.075	0.959	0.821	0.492	0.289	0.278	7.142	5.668
Yield per hectare tons	4.16**	1.69	15.86**	9.94	10.15**	4.31	10.48**	2.68	68.32	54.22

[1]Average of 4 replications.
[2]Treatment: R = residual fertilizer; F = fertilized split-plots.
*Significant at the 10% level, **significant at the 5% level, and ***significant at the 1% probability level for t values.

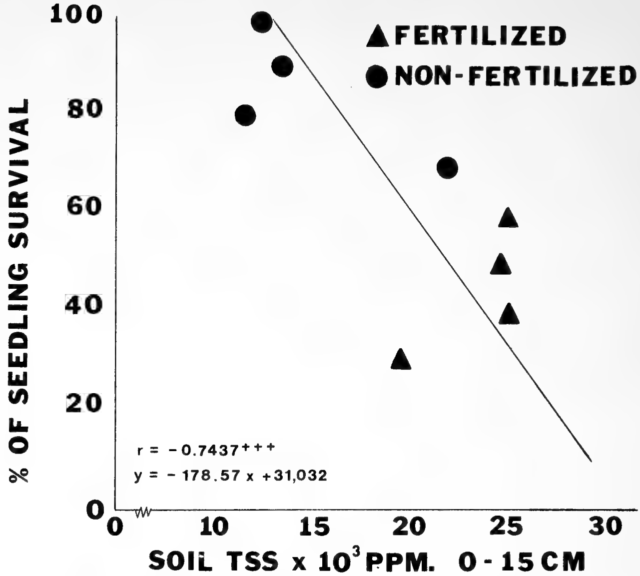

FIG. 1. Seedling survival of broccoli at various soil TSS content. ***significant at the 0.1% probability level.

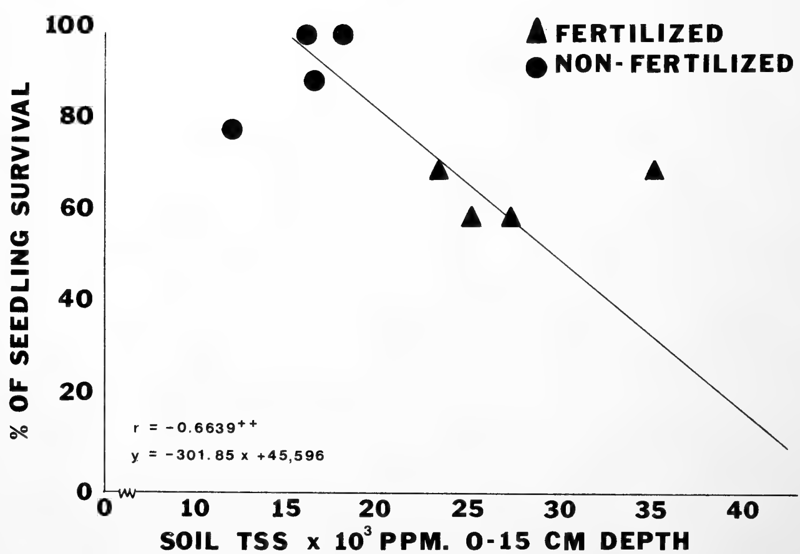

FIG. 2. Seedling survival of cabbage at various soil TSS content. **significant at the 1% probability level.

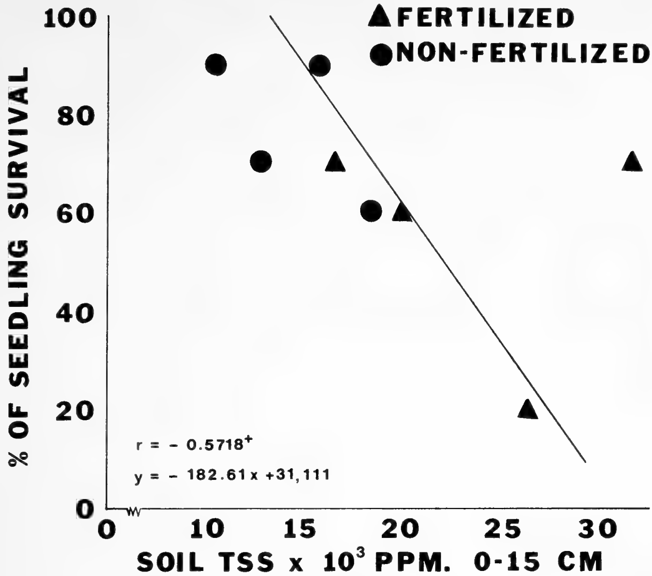

FIG. 3. Seedling survival of cauliflower at various soil TSS content. °significant at the 5% probability level.

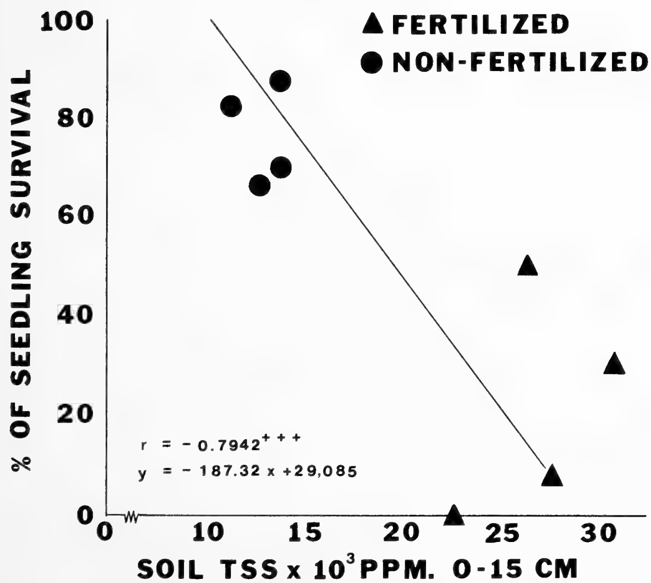

FIG. 4. Seedling survival of kohlrabi at various soil TSS content. °°°significant at the 0.1% probability level.

Yield per plant of the surviving seedlings in the fertilized plots was smaller than in the nonfertilized plots. The smaller per plant yield, combined with the reduced transplant survival, resulted in significantly higher per hectare yields in crops grown on residual fertilizers alone (Table 4).

Discussion—High concentration of salt in the soil or in the irrigation water may cause injury to plants by reducing the Ψ value of the soil (i.e., increasing osmotic pressure, and causing an imbalance of the specific ion supply) (Bernstein and Hayward, 1958; Bernstein, 1964). The effect of high salt levels in the irrigation water on the yield and on the changes in the mineral composition of several vegetable crops were reported earlier (Ayers et al., 1951; Bernstein and Ayers, 1953a and b). Salt levels tend to increase in the top 2-3 cm of the soil because of evaporation and capillary rise of the soil water to the surface (Spencer, 1945; Bernstein and Hayward, 1958). Salt concentration is even greater in raised beds. Seeds planted in the top layer of the soil therefore are in an environment where the Ψ_s of soil prevents the germination of seeds. In the experiments reported here the extra fertilizer applied to the soil increased soil TSS to such an extent that carrot, green onion, and lettuce seeds failed to germinate and only a few of the radish seeds germinated (Table 3). In the split-plots which received no additional fertilizers, germination of carrot seeds was practically reduced to nil at –3.24 bars. Vegetable crops are known to have different degrees of sensitivity to salt concentration in soils (Bernstein, 1964). I found carrots to be the most sensitive to soil salinity among the direct seeded crops, followed by lettuce, green onion, and radish, respectively.

Salt tolerance of cole crops varied with the subspecies. Cabbage was least affected by high TSS levels. Regression lines of broccoli and cauliflower for % of seedling survival at various TSS levels are almost identical (Figs. 1 and 3), and kohlrabi seedlings were the most sensitive to salinity. Seedlings are usually transplanted 6-7 cm deep in the soil and their roots are in a less saline environment than are seeds in the upper 2 cm of the soil. Young plants often show salt injury on their stems at soil surface level, or just below, where soil Ψ_s values greatly exceed the Ψ_s values of plant cells and cause plasmolysis. The high soil TSS content found by Marlowe and Geraldson (1976) in the upper 0-5 cm soil depth of the harvested tomato fields would cause reduction in field stand of some transplanted vegetable crops and would prevent seed germination of others. High rate of fertilizer application is not restricted to the production of tomatoes. Tucker et al. (1968) found high fertilizer use in the Sanford area of central Florida for cabbage and celery crops. The present works tends to support the results found by researchers earlier (Hayslip et al., 1964); Kretschmer et al., 1963) which show that residual fertilizers remaining in the soil after a fall tomato crop are sufficiently high for the production of a spring crop. Thus, the possibility exists of utilizing the residual nutrients by planting a second crop without the application of additional fertilizers. A survey of the land for soil TSS content should be made, however, in every case when planting of a second vegetable crop is attempted after a fall crop, to determine the intensity and balance of residual plant nutrients.

Acknowledgements—This work was supported by a grant-in-aid from the Florida Tomato Exchange which is gratefully acknowledged.

LITERATURE CITED

Ayers, A. D., C. H. Wadleigh, and L. Bernstein. 1951. Salt tolerance of six varieties of lettuce. Proc. Am. Soc. Hort. Sci. 57:237-242.

Baker, D. E., and L. Chesnin. 1975. Chemical monitoring of soils for environmental quality and animal and human health. Adv. in Agron. 27:305-374.

Bernstein, L. 1964. Salt tolerance of plants. USDA Infor. Bull. No. 283.

__________, and A. D. Ayers. 1953a. Salt tolerance of five varieties of carrots. Proc. Am. Soc. Hort. Sci. 61:360-365.

__________. 1953b. Salt tolerance of five varieties of onions. Proc. Am. Soc. Hort. Sci. 62:367-370.

__________, and H. E. Hayward. 1958. Physiology of salt tolerance. Ann. Rev. Plant Physiol. 9:1958.

Brooke, D. L. 1978. Costs and returns from vegetable crops in Florida, season 1976-77 with comparisons. Univ. of Florida, IFAS Economic Infor. Rept. 85.

Geraldson, C. M. 1957. Soil soluble salts–determination of an association with plant growth. Proc. Florida State Hort. Soc. 70:121-126.

__________. 1966. Effect of salt accumulation in sandy spodosols on tomato production. Proc. Soil and Crop Sci. Soc. of Florida 26:6-12.

Hayslip, N. C., E. M. Hodges, D. W. Jones, and A. E. Kretschmer, Jr. 1964. Tomato and pangolagrass rotation for sandy soils of south Florida. Univ. of Florida Agri. Exp. Sta. Circ. S-153.

Kretschmer, A. E., Jr., N. C. Hayslip, and W. T. Forsee, Jr. 1963. Spring field corn and sorghum production after fall vegetables. Univ. of Florida Agri. Exp. Sta. Circ. S-145.

Little, T. M., and F. Jackson Hills. 1975. Statistical Methods in Agricultural Research. ed. 2., Univ. of California, Davis.

Marlowe, G. A., Jr., and C. M. Geraldson. 1976. Results of a soluble salt survey of commercial tomato fields in southwest Florida. Proc. Florida State Hort. Soc. 89:132-135.

Otte, J. A. 1976. Calculating costs and breakeven prices for full bed plastic mulch staked tomatoes. Univ. of Florida, IFAS Economic Infor. Rept. 59.

Salisbury, F. B., and C. Ross. 1969. Plant Physiology. Wadsworth Publ. Co., Inc., Belmont, California.

Spencer, E. L. 1945. Vertical movement of salts in soils as affected by irrigation practices. Proc. Florida State Hort. Soc. 58:246-249.

Tucker, C. A., W. R. Llewellyn, and J. NeSmith. 1968. Balance fertilization of vegetable crops through computerized intensity and balanced soil testing. Proc. Florida State Hort. Soc. 81:201-208.

United States Salinity Laboratory Staff. 1954. Diagnosis and improvement of saline and alkali soils. USDA Handbook 60.

Westgate, P. J. 1950. Effects of soluble soil salts on vegetable production at Sanford. Proc. Florida State Hort. Soc. 63:116-123.

Florida Sci. 42(1):43-51. 1979.

Biological Sciences

FIRST NORTH AMERICAN CONTINENTAL RECORD OF THE LONGFIN MAKO (*ISURUS PAUCUS* GUITART MANDAY)

JON W. DODRILL (1) AND R. GRANT GILMORE (2)[1]

Institute of Marine Sciences, University of North Carolina, Morehead City, North Carolina 28557 (1); Harbor Branch Foundation, Inc., RR 1, Box 196, Fort Pierce, Florida 33450 (2)

ABSTRACT: *A female longfin mako* (Isurus paucus) *was found in the surf at Melbourne Beach, Brevard County, Florida, 28 December 1975. This is the first North American record for this circum-tropical species and is the first account of a specimen from continental shelf waters anywhere. Pigmentation pattern, pectoral fin length, and comparative jaw examinations with* I. oxyrinchus *of similar size were used to verify the identification.*[*]

THE LONGFIN MAKO (*Isurus paucus*) Guitart Manday 1966 is a little known pelagic mackerel shark (family Lamnidae) reported from tropical–subtropical oceanic regions of the Indian, Pacific, and western north Atlantic Oceans (Guitart Manday, 1966 and 1975; Garrick, 1967). *Isurus paucus* records in the western Atlantic have been restricted to short range pelagic fishery longline landings from the NW coast of Cuba. In this Cuban fishery, the longfin mako was the sixth most common shark of the 11 shark species reported in the 1972–1973 landings (Guitart Manday, 1975). Longfin makos were caught as solitary individuals and have never accounted for more than 7% of the Cuban shark fishery landings. In the Cuban fishery most longfin makos were hooked at depths of 60-120 fathoms, infrequently at 10-50 fathoms, with all captures occurring seaward of the shelf edge. The few stomachs examined contained squid and unspecified pelagic fishes (Guitart Manday, pers. comm.). The only reproductive data documented have been 2 embryos taken from a Cuban female of unspecified length (Guitart Manday, 1975). The single embryo measured (920 mm TL) had a greatly swollen stomach, suggesting possible oviphagy, which occurs in other lamnids (e.g., *Lamna nasus*, Bigelow and Schroeder, 1948). The longfin mako embryo is larger than those of the shortfin mako (*Isurus oxyrinchus*) which appear in larger litters and become free-swimming as small as 68 cm TL (Garrick, 1967).

A live adult female *I. paucus* with a missing left eye was discovered partially grounded in the surf at Melbourne Beach, Brevard County, Florida (28° 00′ 05″N, 80° 31′ 20″W) at dawn on 28 December 1975 (Fig. 1). Several colored photographs were taken within an hour of its discovery; the jaws were removed,

[1]Contribution no. 109 from the Harbor Branch Foundation, Inc., Fort Pierce, Florida.

[*]The costs of publication of this article were defrayed in part by the payment of charges from funds made available in support of the research which is the subject of this article. In accordance with 18 U. S. C. § 1734, this article must therefore be hereby marked "*advertisement*" solely to indicate this fact.

Fig. 1. (A) Right lateral view of 268 cm SL *Isurus paucus* from Melbourne Beach, Florida, 28 December 1975 (B) Ventral view of same.

cleaned, and photographed. Unfortunately, it was too large to move and an incoming tide swept the carcass away before additional examinations could be made. The shark was estimated to be between 312–334 cm TL, based upon a lateral view photo of the shark with an individual of known height standing immediately behind the specimen. The visual estimates of the several surf fishermen who discovered the shark also fall into this size range.

The characters used to distinguish this specimen from the shortfin mako were the nearly black dorsal coloration, the extensive blue-grey ventral pigmentation, the large eye, the relatively long rounded pectorals, tapering only slightly toward the tip, and the anterior teeth characters in both jaws. This longfin mako observation represents the first continental shelf record for this species anywhere in the world and the first record for the North American coast. On the evening preceding the *I. paucus* stranding (27 December 1975), a shark sportfisherman fishing from the beach 3.0 km S of the stranding site caught a large eye. The eye, impaled on one of the hooks, was reeled in after a brief run obviously made by a large fish.

The *I. paucus* specimen exhibited several external features which prior to this record were only hypothesized for large longfin makos. The dusky coloration on the ventral surface of the Melbourne Beach longfin mako is much more extensive than previously reported for the smaller specimens. The entire ventral surface is a dusky blue–grey with two exceptions. The pectoral undersides are white except for the proximal and distal margins which have a narrow band of dark pigmentation along the edges. The center of the belly area from the axil of the pectorals slightly more than half way back to the pelvics remains white as do the ventral posterior tips of the pelvics. A photograph provided by John G. Casey, National Marine Fisheries Service, of a fresh *I. oxyrinchus* (367.5 cm TL) taken off Montauk, Long Island shows that large shortfin makos lack the narrow band of black pigment around the ventral proximal and distal pectoral edges. In large fresh *I. oxyrinchus,* the throat area from a point even with the corners of the mouth to a point even with the second gill slit as well as the ventral body surface from the pelvics to the lower caudal pit are creamy white. In large *I. paucus* this area has a dusky hue. Use of a dark ventral snout coloration, a major feature used by Garrick (1967) to separate *I. paucus* and *I. oxyrinchus* at sizes below 220 cm TL may be insufficient to distinguish large *I. paucus* from large *I. oxyrinchus.* The ventral surface of the snout and around the upper portion of the mouth appear dark in the photos of 336.5 and 350.7 cm southern California *I. oxyrinchus* (Applegate, 1966 and 1977) and the 367.5 cm Montauk shortfin mako. However, because the photos were black and white it could not be determined if this dark area were actual pigmentation or an artifact due to blood accumulation in the dermal surface capillaries, causing a discolored appearance.

Although relatively longer than the pectoral length of large shortfin makos, the large longfin mako pectoral length may not increase in proportion with the head length. Due to the slightly oblique nature of Fig. 1, a precise pectoral length as a percent of the head length in this specimen could not be made except that it exceeded 82%, but almost certainly did not approach 100% as was noted by Garrick (1967) for smaller *I. paucus.* Pectoral length as a percent of head length for a 357.5 cm and a 367.5 cm shortfin mako were 70.7 and 76.8%, respectively (John G. Casey, pers. comm.).

A detailed comparative examination was made between the preserved jaws of the Melbourne *I. paucus* (312-334 cm TL) and a large *I. oxyrinchus* (350.7 cm TL; LACMNH 32667) of comparable size from the California coast. For comparative purposes tooth measurements were made as shown in Fig. 2. The tooth base width (Fig. 2, BW) was measured from points on either side of the tooth base where the enamel was first exposed from under the basal cartilage covering. This measurement was made at this location because cartilage over the remainder of the basal portion of the tooth in intact jaws did not reveal a definite

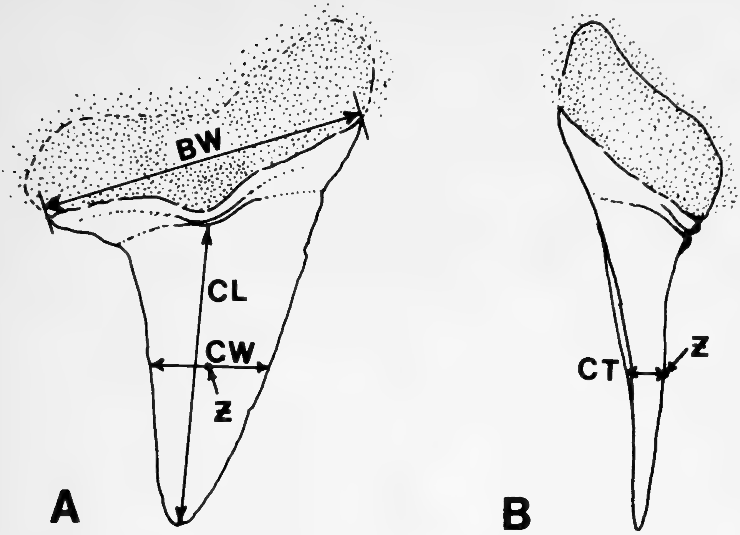

Fig. 2. Tooth measurements were made as shown in this diagram. (A) BW = base width; CL = cusp length; CW = cusp width always at point Z, the halfway mark along CL. (B) CT = tooth thickness at point Z.

tooth base border and therefore did not allow an accurate measurement (to 0.1 mm). Cusp length (CL) was measured from a distinct basal depression on the tooth front to the tip of the cusp. The cusp width (CW) and thickness (CT) measurements were made at point Z at one half of the cusp length (Fig. 2). Tooth cusp lengths were comparable in both jaw specimens examined for the first 5 teeth on either side of the upper and lower jaws, *I. paucus* (mean cusp length: 23.1 mm; range: 13.1-30.7 mm) and *I. oxyrinchus* (mean cusp length: 24.2 mm; range: 12.2-32.8 mm).

Relative size of the tooth base width, cusp thickness and cusp width to the cusp length differed between both species (Fig. 3). The tooth base width, relative to the tooth cusp length, for the first 5 teeth on either side in both the upper and lower jaws is greater in *I. paucus* (mean: 102%; range: 75-125%) than in *I. oxyrinchus* (mean: 86%; range: 51-120%). In *I. oxyrinchus* the tooth base width in the fourth upper jaw teeth is considerably narrower (relative to the tooth cusp length) than the third or fifth teeth. This character is lacking in *I. paucus*. The tooth cusp thickness (CT), relative to the cusp length, at point Z (Fig. 2B) for the first 5 teeth on either side in both the upper and lower jaws is wider in *I. paucus* (mean: 34%; range: 32-37%) than in *I. oxyrinchus* (mean: 30%; range: 26-35%). The greatest difference in cusp width between both species was in the second lower jaw teeth; this tooth width made up 28% of the cusp length in *I. oxyrinchus*, and 36-37% in *I. paucus*. Besides these measured differences, the third anterior tooth on both sides of the upper jaw differs in shape as described by Garrick (1967) (Fig. 4). The third upper tooth in *I. oxyrinchus* is asymmetrical and oblique in shape. The characteristic gape between the third and fourth upper jaw teeth is seen in *I. oxyrinchus* but not in our *I. paucus* jaw although it is present

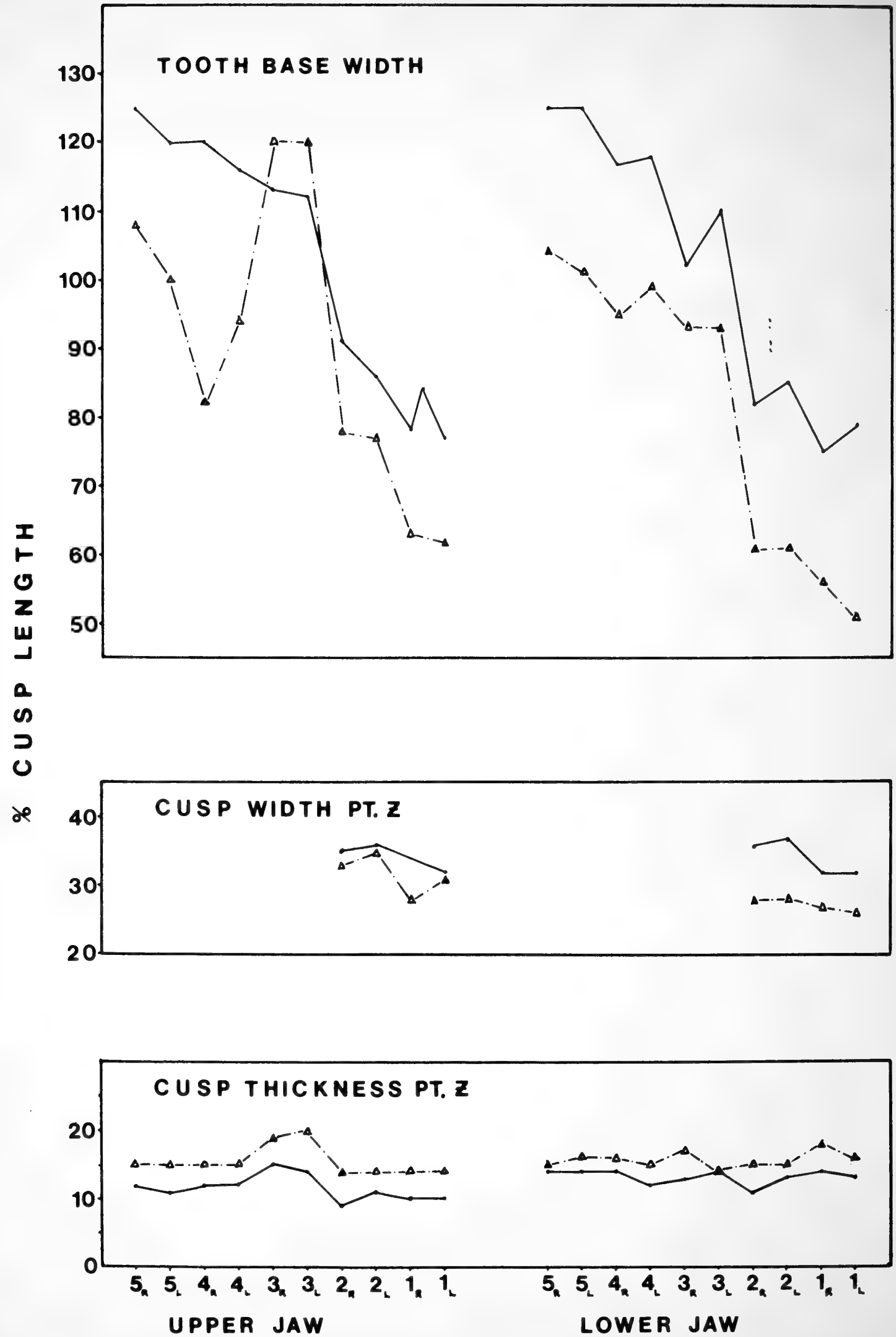

Fig. 3. Tooth proportion measurements expressed as a percentage of cusp length for *Isurus paucus* (—) and *I. oxyrinchus* (.—.—). Teeth are numbered from the symphysis and subscripts indicate left (L) or right (R) side.

in smaller specimens of *I. paucus* (Garrick, 1967). The length of the cutting edge on the cusp is nearly identical in both *I. paucus* and *I. oxyrinchus* teeth examined. This character was predicted to be similar in larger isurid specimens (Garrick, 1967; Applegate, 1977). There are 4-6 rows of functional and nonfunctional teeth in the *I. paucus* jaw examined, while the *I. oxyrinchus* jaw examined (LACMNH 32667) had 3-4 rows. The tooth count for our *I. paucus* is $\frac{12 + 12}{12 + 12}$, and $\frac{12 + 12}{13 + 13}$ for *I. oxyrinchus* (LACMNH 32667).

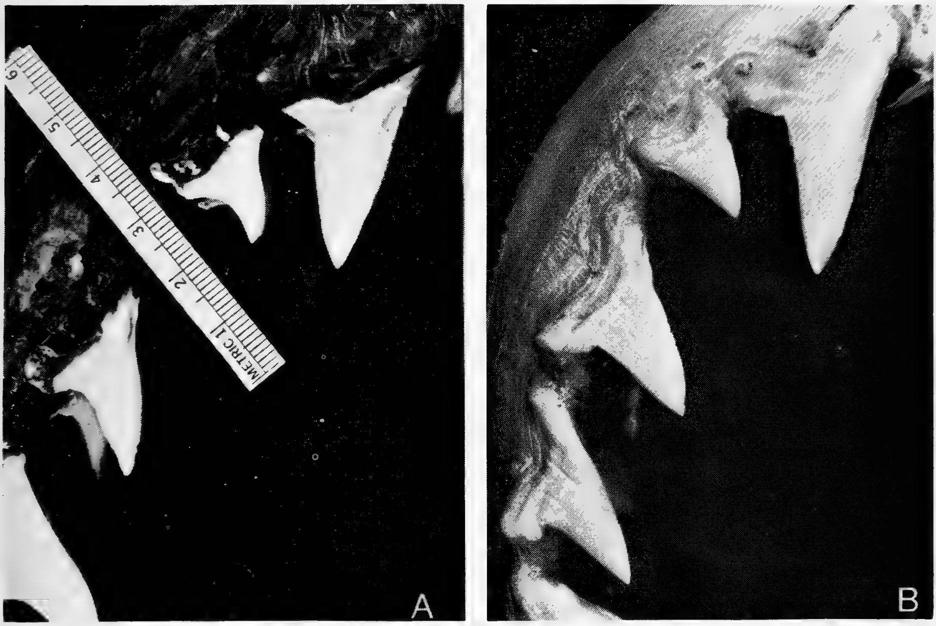

Fig. 4. Photo of the upper right jaw of (A) *Isurus oxyrinchus* and (B) *I. paucus*. Teeth 2 through 4 can be seen in both jaws.

Garrick (1967) states that there is a change with growth in the shape of the first dorsal fin in *I. oxyrinchus* and probably in *I. paucus*. The juvenile makos possess broadly rounded first dorsal fins which become increasingly angular with growth. The larger shortfin makos possess a first dorsal with a pointed apex (Applegate 1966 and 1977). The Melbourne Beach *I. paucus* illustrates that it is possible for very large *Isurus paucus* to have a broadly rounded first dorsal fin. Garrick (1967) noted that the smaller *I. paucus* tend to be more slender and lighter than *I. oxyrinchus* of similar total length. This does not appear to hold true for larger specimens where there may be some weight variation. Although the Melbourne Beach *I. paucus* appeared somewhat slender, Guitart Manday (pers. comm.) reports an unmeasured *I. paucus* from the Cuban fishery cooperative which weighed 473 kg comparable in weight to the largest shortfin makos taken in the Pacific, Atlantic, or Gulf of Mexico (Applegate, 1977; Casey, pers. comm.; Bigelow and Schroeder, 1948).

ACKNOWLEDGEMENTS—We thank Clarence Reimer of Floodwood, Minnesota and Frank Long for *I. paucus* jaw and photo loans. Camm Swift of the Los Angeles County Museum of Natural History kindly loaned the comparative material for *I. oxyrinchus*. George Kulczycki of the Harbor Branch Foundation Laboratory painstakingly made over 400 detailed photos of jaws examined. We would like to acknowledge helpful correspondence with John G. Casey of the National Marine Fisheries Service, and Senor Dario Guitart Manday of the Instituto de Oceanologia, Havana, Cuba.

ADDENDUM

After the preparation of this manuscript, 2 additional *I. paucus* specimens from the Florida east coast have been examined. Both were collected on drifting longlines set for swordfish (*Xiphias gladius*) over depths of 200 to 400 m near the western edge of the Florida straits between Jupiter Inlet, Palm Beach County and Sebastian Inlet, Brevard County. One specimen caught by William Minuth of Fort Pierce on 20 April 1978 was identified from the severed head. A second specimen caught 19 May 1978 by George Giannikopoulos of Fort Pierce is the largest *I. paucus* on record to date measuring 417 cm in total length.

LITERATURE CITED

APPLEGATE, S. P. 1966. A possible record-sized bonito shark, *Isurus oxyrinchus* Rafinesque from Southern California Waters. Calif. Fish Game. 52:204-207.

__________. 1977. A new record sized bonito shark *Isurus oxyrinchus* Rafinesque from Southern California. Calif. Fish Game. 63:126-129.

BIGELOW, H. B., AND W. C. SCHROEDER. 1948. Fishes of the western north Atlantic. Part I. Lancelets, cyclostomes, and sharks. Mem. Sears Fdn. Mar. Res.:1-576.

GARRICK, J. A. 1967. Revision of sharks of genus *Isurus* with description of a new species (Galeoidea, Lamnidae). Proc. U. S. Natl. Mus. 118:663-690.

GUITART MANDAY, D. 1966. Nueva nombre para una especie de tiburon del genus *Isurus* (Elasmobranch: Isuridae) de aguas Cubanas. Poeyana, ser. A.:1-9.

__________. 1975. Las pesquerias pelagico-oceanicas de corto radio de accion en la region noroccidental de Cuba. Oceanogr. Inst., Acad. of Sci., Havana, Cuba. Seria Oceanologica.:1-41.

Florida Sci. 42(1):52-58. 1979.

RECORDS FOR EIGHT TEXAS MAMMALS—*Kenneth T. Wilkins*[1], *William J. Boeer, Duke S. Rogers, and William S. Modi,* Department of Wildlife and Fisheries Sciences, Texas A&M University, College Station 77843.

ABSTRACT: *Range extensions and county records are reported for 8 species of small mammals in Texas.*

DURING recent field studies in Texas, 6 species of mammals were collected in areas outside their previously reported ranges (Davis, 1974). County records for the silver-haired and hoary bats are also reported herein. Specimens are listed below by species with appropriate catalogue numbers and museum acronyms: TCWC, Texas Cooperative Wildlife Collection, Texas A&M University; UTAVC, Collection of Vertebrates, University of Texas at Arlington; MWU, Midwestern University; and KU, Museum of Natural History, University of Kansas.

Lasionycteris noctivagans—On April 1976, 2 males (UTAVC M-1661; UTAVC uncat.) were netted over Gorman Creek about 1/4 mi from its confluence with the Colorado River approximately 4 mi SSE Bend, San Saba County. Tall pecans and sycamores are the predominant trees occurring along the limestone rimrock bounding this spring-fed creek.

Davis (1974) reported silver-haired bats from Culberson County in Trans-Pecos Texas and from Hockley and Lubbock counties in the Panhandle. This species also is known from the Texas Gulf Coast in Galveston County (Martin, 1977). The specimens from Bend represent the second record from the Edwards Plateau; the first was from Medina County (Blair, 1952). This migratory species is distributed throughout most of North America but is not common anywhere in Texas; all known specimens probably were migrants.

Lasiurus cinereus—On 4 October 1976, a hoary bat (UTAVC uncat.) was found hanging in a backyard shed in a residential section of Arlington, Tarrant County. Although within the range Davis (1974) described for the species, this is the second locality of record in north-central Texas. The nearest reported specimens are from Wichita Falls, Wichita County, approximately 100 mi NW of Arlington (Dalquest, 1968), and on the Edwards Plateau in Blanco County more than 150 mi SSW of Arlington (Davis, 1974).

Nycticeius humeralis—Four female evening bats (UTAVC uncat.) netted 4 mi SSE Bend, San Saba County, on 10 April 1976 showed no signs of reproductive activity. On 27 May 1976, 3 additional specimens (2 females, TCWC 30340-41; 1 male, TCWC 30342) were collected; on the evening of capture 1 female gave birth to 2 young, whereas the other carried 2 embryos. Davis (1974) reported records of occurrence of *Nycticeius* nearest this locality to be 90 mi SE in Kerr County and 140 mi E in Brazos County.

Perognathus flavus—The capture of a male Merriam's pocket mouse (TCWC 26125) on 16 October 1971 at a locality 1 mi E Francitas, Jackson County, constitutes the species' easternmost occurrence in Texas. Davis (1974) reported the eastern boundary of its range to be in Bee County, about 90 mi W of Francitas.

Oryzomys palustris—One female (TCWC 30656) with 4 embryos was taken on 20 May 1976 in a low-lying, intermittently marshy, old field in Bryan, Brazos County, at a locality 1/2 mi N of the intersection of Highway 6 bypass and FM 158. A male rice rat was collected on 29 January 1977 in a similar situation 7 mi S and 4 mi W College Station, Brazos County. The nearest reported localities are 50 mi E in Walker County and 65 mi S in Colorado County (Davis, 1974).

---

[1] Present address of Wilkins: Department of Zoology, University of Florida, Gainesville, Florida 32611.

Reithrodontomys montanus—Two specimens taken in early May 1976 near Madisonville, Madison County (TCWC 30336female, 1 mi S intersection Highway 21 and Interstate 45; TCWC 30337male, 1/2 mi S same intersection), represent extensions of the known range for this species 30 mi eastward and 40 mi northeastward from previously known localities in Robertson and Brazos counties, respectively (Davis, 1974). The male was taken in the median of Interstate 45 and the female in a moderately grazed pasture adjacent to the same highway. Both areas supported sparse to moderate stands of little bluestem and paspalum. Neither individual showed signs of reproductive activity.

Reithrodontomys humulis—Two male harvest mice were collected in the vicinity of Fairfield, Freestone County, on 19 January 1974 (TCWC 27652) and 1 March 1975 (TCWC 30137). Waggoner (1975) noted that this species prefers habitats in abandoned fields characterized by sparse stands of three-awn and bluestem grasses. The only reported occurrences of this species in Texas are in Nacogdoches County and Brazoria and Fort Bend counties at distances 85 mi E and 170 mi S Fairfield, respectively (Davis, 1974).

Neotomoa albigula—Between October 1976 and May 1977, 12 white-throated woodrats (TCWC 30860-61, others uncat.) were collected by us 12 mi SE Comstock, Val Verde County, at the base of a limestone bluff where the predominant vegetation was guajillo and mesquite. Seven additional specimens housed in other collections also represent noteworthy records. One male (MWU 9098) was captured 3 mi W Comstock, Val Verde County. The Val Verde County specimens represent a range extension of about 110 mi from the documented records in Brewster and Kimble counties (Davis, 1974). One female (MWU 7472) and 2 male (MWU 6025, 7471) rats of this species were collected 16 mi NW Seymour, Baylor County, approximately 50 mi SE of the nearest recorded locality in Cottle County (Davis, 1974). Three specimens (KU 68421-22, 68426) were trapped 2 mi S and 11 mi E Pringle, Hutchinson County, about 90 mi N of the nearest record in Armstrong County (Davis, 1974).

Acknowledgments—We are indebted to the following individuals for allowing us to examine specimens housed in collections under their direction: David J. Schmidly (TCWC), John L. Darling (UTAVC), Walter W. Dalquest (MWU), and Robert S. Hoffmann and E. Raymond Hall (KU). Thanks are due to Dr. Schmidly for reviewing earlier drafts of the manuscript.

LITERATURE CITED

Blair, W. F. 1952. Bats of the Edwards Plateau in central Texas. Tex. J. Sci. 4:95-98.

Dalquest, W. W. 1968. Mammals of north-central Texas. S.W. Nat. 13:13-21.

Davis, W. B. 1974. The Mammals of Texas. Texas Parks and Wildlife Dept., Austin.

Martin, C. O. 1977. A noteworthy record of the silver-haired bat in Texas. Tex. J. Sci. 28-356.

Waggoner, K. V. 1975. The effect of strip-mining and reclamation on small mammal communities. M.S. Thesis. Texas A&M Univ. College Station.

Florida Sci. 42(1):59-60. 1979.

DISCOVERY OF THE PERCID GENUS *AMMOCRYPTA* (PISCES) IN THE APALACHICOLA DRAINAGE, FLORIDA—*Wayne C. Starnes and Lynn B. Starnes*, Department of Zoology, University of Tennessee, Knoxville, Tennessee 37916; and Division of Forestry, Fisheries, and Wildlife Development, Tennessee Valley Authority, Norris, Tennessee 37828.

ABSTRACT: *The collection of* Ammocrypta bifascia *from the Apalachicola River below Woodruff Dam, Florida, represents the first recorded occurrence of the genus* Ammocrypta *in this major drainage and constitutes an important eastward range extension for sand darters in the Gulf coastal region.*

WILLIAMS (1975) illustrated the range of the sand darter genus *Ammocrypta* as extending eastward in the Gulf coastal tributaries of Florida through the Choctawhatchee drainage. He described the form which occurs therein, and in other systems east of the Mobile drainage, as a new species, *A. bifascia*, the Florida sand darter, a form closely allied to the more westerly naked sand darter, *A. beani* Jordan. *Ammocrypta* does not appear on the list of Apalachicola River fishes prepared by Yerger (1977). On 24 June 1977, the authors collected a 48.7 mm standard length female specimen of *A. bifascia* near the east bank of the Apalachicola River approximately 400 m below Woodruff Dam, Gadsden County, Florida (Florida State Museum UF 24415). This constituted one of the first records of *Ammocrypta* in this major and more easterly system which drains a great portion of western Georgia and smaller portions of Alabama and Florida. The sand darter was collected from an area of sand-gravel substrate with moderate current from a depth of about 1 m. Flow from Woodruff Dam at the time was 336 cms, river stage 13.6 m (Corps of Engineers data). The only associated darter species was *Percina nigrofasciata.*

Subsequent to our collection of *Ammocrypta* from the Apalachicola River, we have learned of a prior unreported specimen collected 11 August 1974, by H. A. and B. H. Beecher (Florida State Univ.) from a more downstream locality, a steep sandbank along the east shore of the river approximately 0.4 km N of Florida Highway 20, Liberty County (53.8 mm SL Male, FSU 23263). The following meristic data for both Apalachicola specimens closely approximate that of western Florida *A. bifascia* with the exception of higher lateral line counts: dorsal fin elements, IX-11; anal fin elements, I-10; left pectoral fin rays, 12; lateral line scales, 73 and 75; transverse scale rows, 3 and 5 (methods of Williams, 1975). The caudal peduncles are unscaled midventrally.

The collection of two temporally and geographically separated specimens of *A. bifascia* from the Apalachicola River suggests that their presence was not due to bait introductions. Darters are seldom, if ever, used as bait by local fishermen. It seems more plausible that Florida sand darters occur naturally in this drainage as a result of coastwise dispersal during sea level reductions in the late Pleistocene or possibly were introduced through lateral stream captures or common flooding between tributaries of the Apalachicola drainage and the adjacent Choctawhatchee drainage to the west. Bailey, Winn, and Smith (1954) and Yerger and Suttkus (1962) discuss the apparent faunal break which exists between the Choctawhatchee and Apalachicola drainages. *Ammocrypta* can no longer be regarded as a constituent of this distribution pattern.

A. bifascia is rare in the Apalachicola River as evidenced by its total absence from many prior collections taken at the Woodruff Dam locality and elsewhere in the lower river. It may take many years and tremendous effort to develop a complete faunal list for a large river. In the Tennessee drainage for example, *Ammocrypta* was rediscovered at a heavily collected locality 85 yr after its initial discovery, constituting only the second record for the system (Starnes, et al. 1977). Perhaps similar population levels exist in the Apalachicola River approaching densities conducive to collecting only following years of extraordinary reproductive success. Moreover, considerable specialized effort is often necessary to collect *Ammocrypta* which burrow into the sandy substrate; the presence of collectable densities and specialized efforts may seldom coincide. Perhaps concentrated collecting efforts in suitable habitats will yield further specimens from the Woodruff Dam locality and/or from other portions of the drainage, such as the Chipola River or unimpounded stretches of the Flint River in Georgia.

ACKNOWLEDGMENTS—We thank H. A. Beecher and R. W. Yerger (Florida State Univ.) for providing their specimen and data, C. R. Gilbert (Florida State Mus.) for depositing our specimen and comments on the manuscript, D. A. Etnier (Univ. of Tennessee) for additional comments, and Debbie Barton (Tennessee Valley Authority) for typing. William Alley, Army Corps of Engineers, Jacksonville, provided Woodruff Dam discharge data.

LITERATURE CITED

BAILEY R. M., H. E. WINN, AND C. L. SMITH. 1954. Fishes from the Escambia River, Alabama and Florida, with ecologic and taxonomic notes. Proc. Acad. Nat. Sci. Phila. 106:109-164.

STARNES, W. C., D. A. ETNIER, L. B. STARNES, AND N. H. DOUGLAS. 1977. Zoogeographical implications of the rediscovery of the percid genus *Ammocrypta* in the Tennessee River drainage. Copeia. 1977:783-786.

WILLIAMS, J. D. 1975. Systematics of the percid fishes of the subgenus *Ammocrypta*, genus *Ammocrypta*, with descriptions of two new species. Bull. Alabama Mus. Nat. Hist. No. 1.

YERGER, R. W. 1977. Fishes of the Apalachicola River. Pp. 22-33. *In* Proc. of Conf. on Apalachicola Drainage System. Florida Mar. Res. Pub. No. 26.

YERGER, R. W., AND R. D. SUTTKUS. 1962. Records of freshwater fishes in Florida. Tulane Stud. Zool. 9:323-330.

Florida Sci. 42(1):61-62. 1979.

ANOMALOUS OCCURRENCE OF LIP PROJECTION ON *CARPIODES CYPRINUS*

—*Hal A. Beecher*, Department of Biological Science, Florida State University, Tallahassee, Florida 32306[1]

ABSTRACT: *A median lip projection was found on 2* Carpiodes cyprinus *from the Apalachicola River, Florida.*

ONE of the most apparent external distinctions between *Carpiodes cyprinus* and its congeners, *C. carpio* and *C. velifer*, is the presence of a small median knob or nipple-like projection on the lower lip of *C. carpio* and *C. velifer* and its absence in *C. cyprinus* (Hubbs and Lagler, 1958). I report the anomalous occur-

[1]Present address: Oregon Natural Heritage Program, 1234 N.W. 25th, Portland, Oregon 97210.

rence of such a median projection on the lower lip of 2 *C. cyprinus* from the Apalachicola River, Florida.

From April 1976 through April 1977, 137 adult *C. cyprinus* were captured in 18 collections with a boat-mounted electric shocker (230 V, AC) at 2 sites on the Apalachicola River. Most specimens (116 in 11 collections) were collected within 2 km downstream from Jim Woodruff Dam at Chattahoochee, Florida (30 40′N, 84 52′W), while 21 specimens were from 7 collections made in a 9 km stretch of the river upstream from State Road 20 bridge between Bristol and Blountstown, Florida (30 25′N, 85 00′W).

A 28.5 cm SL female (FSU 27024) bearing a small nipple-like projection on the lower lip was 1 of 12 specimens of *C. cyprinus* collected on 9 December 1976 at the Chattahoochee site. A 31.5 cm SL female, also bearing a projection on its lower lip, was 1 of 3 specimens collected on 2 April 1977 at the Bristol site. The latter specimen was destroyed in the course of another study. Respective gill raker counts (52, 54), relative body depths (.386, .368), relative snout lengths (.109, .100) of the two specimens, and a lateral line scale count of 38 for the former specimen confirm the identifications of these specimens as *C. cyprinus*. No other species of *Carpiodes* are known from the Apalachicola drainage, although other species occur in adjacent drainages (Dahlberg and Scott, 1971; Smith-Vaniz, 1968). Thus, it is unlikely that these specimens represent hybrids.

The presence or absence of the median projection on the lower lip is widely used as a taxonomic character, but should be used in conjunction with other characters in the identification of the species of *Carpiodes*.

ACKNOWLEDGMENTS—I thank Tom Lewis, Graham Lewis, Gordon Cherr, Clay Small, Chuck Duggins, and Brooke Beecher for collecting assistance. Tom Lewis and Brooke Beecher made helpful suggestions on the manuscript.

LITERATURE CITED

DAHLBERG, M. D., AND D. C. SCOTT. 1971. The freshwater fishes of Georgia. Bull. Georgia Acad. Sci. 29:1-64.

HUBBS, C. L., AND K. F. LAGLER. 1958. Fishes of the Great Lakes Region. Univ. Michigan Press, Ann Arbor.

SMITH-VANIZ, W. F. 1968. Freshwater fishes of Alabama. Auburn Univ., Agr. Exp. Sta.: 1-211.

Florida Sci. 42(1):62-63. 1979.

DISTRIBUTION AND SIGNIFICANCE OF *STYLOSANTHES HAMATA* (L.) TAUB. IN SOUTH FLORIDA—*John B. Brolmann*, University of Florida, A.R.C., Fort Pierce, Florida 33450[1]

ABSTRACT: *Ecotypes of* Stylosanthes hamata *(L.) Taub. were collected from along the east coast of south Florida. Among these, tetraploid types grew more vigorously than did diploid types. Some of the ecotypes of this native legume have a potential for use as a forage plant in south Florida pastures.*

STYLOSANTHES has received much attention recently because of its increased use as a forage and pasture legume in the tropics and subtropics (Edye et al.,

[1]Florida Agricultural Experiment Station Journal Series No. 1177.

1977). *Stylosanthes hamata* (L.) Taub., S. *calcicola* Small, and S. *biflora* (L.) BSP. are the only known species of *Stylosanthes* indigenous to Florida (Small, 1933). Most of the other 27 known species are indigenous to South America; a few species occur in Africa (Mohlenbrock, 1957). *Stylosanthes hamata* is more widespread in Florida than are the 2 other species. Its natural habitat includes the Florida Keys and a narrow strip (10 km wide) along the coast from Jupiter inlet southward to the Keys.

Stylosanthes hamata grows best on calcareous soils derived from shell debris with pH 7.0-8.5. It has invaded parks, lawns, and median strips on superhighways in south Florida. Its persistence can be accredited to prolific year-round seed production and a deep taproot, which help it to survive in periods of drought. When frost kills the shoots, the plants regenerate from the crown.

Our findings indicate that *Stylosanthes hamata* is predominantly self-pollinated. Growth habit of the various ecotypes ranges from creeping-prostrate to erect. In general, flowers are yellow, but some white blooming accessions have been selected. The seed, which is usually no more than 5 mm long, has a curved beak, a remnant of the persistent style. Ecotypes can be identified by seed form and shape. Forms with short curved beaks have been found at 2 sites only (Ocean Drive and West Way, Riviera Beach; and in the median strip of U. S. 1, 1 mi s of Jupiter). These types are tetraploid (2n = 40). Other native S. *hamata* are diploid. The tetraploid types are adapted to a greater range of soil pH and are more vigorous than are the diploid types.

Although S. *hamata* has not been found north of Jupiter inlet, it is conceivable that earthmoving operations in road construction will carry seed further north. Plants of certain accessions have survived at Fort Pierce and regenerated from seeds in test plots at Gainesville after the severe 1976-77 winter. Observations in field plots and collection sites indicate this legume is readily eaten by rabbits. S. *hamata* also grows naturally throughout the Caribbean Islands where it is highly valued as a forage plant for cattle.

Recently, nearly 50 ecotypes have been collected in south Florida. This collection is currently being evaluated for pasture use. Studies have been carried out on in vitro digestibility, chromosome number, yield, persistence and disease resistance of these native ecotypes at the Agricultural Research Center, Fort Pierce (Brolmann, 1974). Due to the great salt-tolerance of certain ecotypes, S. *hamata* could also be used for replanting sand dune areas which are subject to erosion. Its value as a ground cover and as lawns should be investigated.

LITERATURE CITED

Brolmann, John B. 1974. Growth studies in some new *Stylosanthes hamata* (L.) Taub. selections. Fort Pierce ARC Research Rept. RL-1974-6.

Edye, L. A., W. T. Williams, R. L. Burt, B. Grof, S. L. Stillman, and W. H. Winter. 1977. The assessment of seasonal yield using some *Stylosanthes guyanensis* accessions in humid tropical and sub-tropical environments. Australian J. Exp. Agr. and Anim. Husb. 17:425-434.

Mohlenbrock, Robert H. 1963. Further considerations in *Stylosanthes (Leguminosae)*. Rhodora. 65:245-258.

Small, J. K. 1933. Manual of the Southeastern Flora. Univ. North Carolina Press, Chapel Hill.

Florida Sci. 42(1):63-64. 1979.

INSTRUCTIONS TO AUTHORS

Individuals who publish in the *Florida Scientist* must be active members in the Florida Academy of Sciences.

Submit a typewritten original and one copy of the text, illustrations, and tables. All typewritten material—including the abstract, literature citations, footnotes, tables, and figure legends—shall be double-spaced. Use one side of 8 1/2 × 11 inch (21 1/2 cm × 28 cm) good quality bond paper for the original; the copy may be xeroxed. Margins should be at least 3 cm all around. Number the pages through the Literature Cited section. Avoid footnotes and do not use mimeo, slick, erasable, or ruled paper. Use metric units for all measurements. Assistance with production costs will be negotiated directly with authors of papers which exceed 10 printed pages of text.

ADDRESS follows the author's name.

ABSTRACT—All manuscripts shall have a short, concise, single-paragraphed abstract. The abstract follows immediately the author's address.

ACKNOWLEDGMENTS are given in the body of the text preceding immediately the Literature Cited section.

LITERATURE CITED section follows the text. Double-space every line and follow the format in the current issue.

MANUSCRIPTS of 5 or less, double-spaced typewritten pages should conform to the short article protocol. See recent issue for proper format of both long and short articles.

TABLES shall be typed on separate sheets of paper, double-spaced throughout. Each table shall contain a short heading. Do not use vertical rulings. Maximum character width, including spaces, of tables is 98.0. This includes a minimum space of 5 characters between columns. Tables are charged to authors at $25.00 per page or fraction.

ILLUSTRATIONS—All drawings shall be done in good quality India ink, on good board or drafting paper. Letter by using a lettering guide or equivalent. Typewritten letters on illustrations are unacceptable. Drawings and photographs should be large enough to allow 1/3 to 1/2 reduction in size. Photographs shall be glossy prints of good contrast. Whenever possible, mount photographs in lots size.

The author's name and figure number should be penciled lightly on the back of each figure. Figure legends must be listed on a separate page and *not* on the drawing or photograph. The legend must be double-spaced. Illustrations are charged to authors at $20.00 per page or fraction.

PROOF must be returned promptly. Notification of address change and proofreading are the author's responsibility. Alterations after the type has been set will be charged to the author.

REPRINTS may be ordered from the printer on forms provided when the corrected proofs are returned to the Editor.

Membership applications, subscriptions, renewals, changes of address, and orders for back numbers should be addressed to the Executive Secretary, Florida Academy of Sciences, 810 East Rollins Street, Orlando, Florida 32803.

PUBLICATIONS FOR SALE

by the *Florida Academy of Sciences*

Complete sets. Broken sets. Individual numbers. Immediate delivery. A few numbers reprinted by photo-offset. All prices strictly net. No discounts. Prices quoted include postage.

PROCEEDINGS OF THE FLORIDA ACADEMY OF SCIENCES (1936-1944)
Volumes 1-7—$10.00 per volume; single numbers $3.50
QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES (1945-1972)
Volumes 8-35—$10.00 per volume; single numbers $3.50
FLORIDA SCIENTIST (1973-1975)
Volumes 36-38—$10.00 per volume; single issues $3.50
except for symposium numbers priced separately.
Volumes 39 onward—$13.00 per volume; single numbers $4.25 except for symposium numbers priced separately.
Florida's Estuaries—Management or Mismanagement?—Academy Symposium
FLORIDA SCIENTIST 37(4)—$5.00
Land Spreading of Secondary Effluent—Academy Symposium
FLORIDA SCIENTIST 38(4)—$5.00
Solar Energy—Academy Symposium
FLORIDA SCIENTIST 39(3)—$5.00 (includes do-it-yourself instructions)

Individual orders should be sent with payment. A statement will be sent in response to a bona fide purchase order over $10.00 from a recognized institution. Address all orders to:

The Florida Academy of Sciences, Inc.
The John Young Museum
810 East Rollins Street
Orlando, Florida 32803

Do your friends a favor—invite them to join the Florida Academy of Sciences.