Florida Scientist

Volume 38 Summer, 1975 No. 3

CONTENTS

QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

FLORIDA SCIENTIST

QUARTERLY JOURNAL OF THE FLORIDA ACADEMY OF SCIENCES

Editor: Harvey A. Miller
Department of Biological Sciences
Florida Technological University
Orlando, Florida 32816

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 Treasurer. Both individual and institutional members receive a subscription to the FLORIDA SCIENTIST. Direct subscription is available at $10.00 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 from members of the Academy may be given priority. Instructions for preparation of manuscripts are inside the back cover.

Published by the Florida Academy of Sciences
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

Harvey A. Miller, Editor

Vol. 38 Summer, 1975 No. 3

Biological Sciences

TEMPORAL PATTERNS OF RESOURCE ALLOCATION AND LIFE HISTORY PHENOMENA

MERCEDES S. FOSTER

Department of Biology, University of South Florida, Tampa, Florida 33620[1]

ABSTRACT: *A life history consists of maintenance, growth and reproductive activities. Presumably, these activities have conflicting requirements for limited resources of time, energy and specific nutrients. It is proposed that the amount of a resource required by an individual of a given species for any particular event probably fluctuates only within well prescribed limits. Therefore, if sufficient resource is available over a given period of time to allow for the successful completion of two or more resource costly events, then evolutionarily, the species has determined a temporal pattern for partitioning that resource among those events. The temporal pattern of allocation displayed should encompass the strategy optimal for the organism in its environment. This proposal is applied to temporal patterns of resource allocation to the molt and breeding portions of the avian life cycle. When large numbers of avian species from several geographic regions are considered, several highly adaptive patterns emerge.*

LIFE HISTORY patterns may vary considerably both within and between species (e.g., Johnson, 1963; Ricklefs, 1972). If one assumes that life history phenomena are subject to natural selection, then a life history should represent the optimum strategy for the organism in its particular environment, i.e., that which will allow it to maximize its genetic contribution to subsequent generations. Gadgil and Bossert (1970) consider this question in detail. They suggest that life history phenomena belong to one of three categories: maintenance, growth, and reproduction. The former two activities are important only as they enhance reproductive success or survival for subsequent reproduction. They also suggest that because time and energy available to an organism are limited, the demands for these resources by the activities in the three categories must conflict. Thus, patterns of the partitioning of time and energy, or in fact any limited resource, among the three activities are of major significance.

Quantitatively, a life history pattern is definable in terms of the relative allocation of resources to its component phenomena. The significance of such quantitative considerations cannot be doubted. However, they represent only one approach to the study of resource partitioning. Of equal or even greater importance to many organisms will be the qualitative and temporal aspects of

[1]Present Address: Museum of Vertebrate Zoology, University of California, Berkeley, California 94720.

resource allocation among maintenance, growth and reproduction. Qualitative analyses describe the specific types of resources allotted to each life history activity and thus could be treated as a subset of quantitative analyses. They have yet to be explored extensively. However, it is not difficult to envision the conflicting demands for protein or other organic or inorganic nutrients of a viviparous parent and its unborn offspring or of the non-reproductive tissues (for growth and/or maintenance) and reproductive tissues (for growth and reproduction) of an individual (Fogden, 1972; Assenmacher, 1973; Farner, 1973; Scott, 1973).

I wish to deal primarily with the temporal aspects of resource allocation—that is, when an organism uses for a specific activity those resources already allotted to it. I will emphasize the importance of these temporal aspects which often are neglected in the face of quantitative considerations. As indicated above, the three categories of life history activities are considered to have conflicting demands for limited resources (Gadgil and Bossert, 1970). Evidence of this conflict consists of examples of life histories in which activities costly in terms of a particular resource are temporally separated. It is accepted generally that mutual exclusion of such activities allows for the most efficient use of the resource in question (e.g., Kendeigh, 1949; Farner, 1958). However, the temporal separation of such demanding activities only implies, but does not establish, that the activities conflict in their requirements, or if they do conflict, that this conflict is the critical factor determining their separation. The scheduling of costly events in relation to each other and to environmental events may reflect selective forces which affect characteristics contributing to fitness in other ways. Thus temporal patterns of resource allocation must be considered in terms of the total environment of the organism, including all other aspects of its life history.

Temporal patterns of resource allocation—One may assume that the amount of resource required by an individual of a given species for any particular costly event fluctuates only within well prescribed limits. And, though circumstances may exist under which one might argue to the contrary, I would also assume that the simultaneous occurrence of two or more costly events requires no more resource than the sum of the amounts required for each activity alone. In other words, no net resource is expended solely as a result of the overlap itself. If sufficient resource is available over a given period of time to allow for the successful completion of two or more costly events, then evolutionarily, the species has developed a temporal pattern for partitioning that resource among those events.

Resource partitioning may be vertical (Fig. 1A) with all of the available resource channeled into a single activity during a specific time period. Thus, the resource costly events are mutually exclusive. Alternatively, a resource may be partitioned horizontally, being divided among two or more costly events at the same time (Fig. 1B). Here the events overlap and tend to be more protracted than in vertical partitioning (Bates, 1908; Johnson, 1963; Snow and Snow, 1964). Overlap need not be complete but can exhibit any degree of intermediacy

(Fig. 1C-D), which may be referred to as restricted horizontal partitioning. Finally, in many species, individuals will be able to overlap resource demanding events facultatively when circumstances selectively favoring their overlap arise. The temporal pattern of allocation displayed by individuals of a species will encompass the strategy optimal for the environment in which they live.

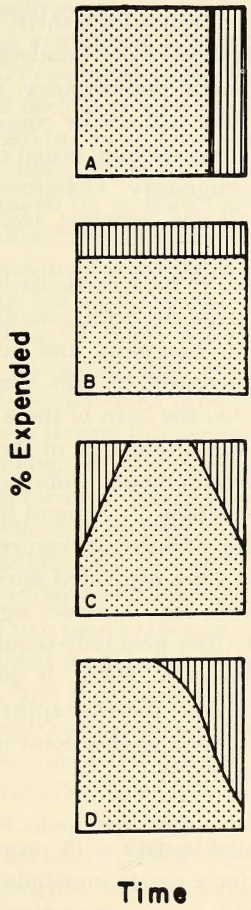

Fig. 1. Patterns of resource partitioning. Areas with vertical lines represent the portion of available resource expended on a particular event over a period of time; dotted areas represent the portion expended on another event. Total amounts expended for each activity (areas) remain constant over total time. Within total time, periods of expenditure for each event vary from pattern to pattern. A. Vertical Partitioning. Costly events are mutually exclusive. B. Horizontal Partitioning. Costly events overlap completely. C.-D. Restricted Horizontal Partitioning. Costly events show partial overlap.

To examine this proposal let us review the temporal allocation of resources to various activities in the avian life cycle. Then patterns of allocation among groups of birds living under widely differing environmental conditions can be compared. The avian life cycle is particularly suitable for consideration because extensive data are available on such cycles. It is important to remember, however, that the analysis presented here with regard to temporal allocation patterns in avian life cycles should be similarly applicable to the life cycles of any other group of animals or plants.

Birds make major resource expenditures for growth, reproduction, migration, molt and "existence activities" (modified from Kendeigh, 1949), the latter three representing various aspects of general maintenance. Because existence activities are performed continuously, they will not be considered. In addition, most birds show no significant growth after reaching sexual maturity, and a large percentage of avian species are non-migratory. Therefore, only the temporal patterns of resource allocation to molt and breeding, two recurring activities, are considered.

Breeding generally is considered to be a particularly demanding activity for birds, though metabolic requirements for both gonadal and behavioral reproductive events are poorly known. Energetic and nutrient requirements for gonadal events, which have been measured for only a few birds, are summarized by Fisher (1972) and King (1972). On the basis of these studies, caloric expenditures appear significant only for the production of the eggs (King, 1972). This also probably is true of nutrient requirements. Unfortunately, the requirements of the behavioral aspects of reproduction ". . . cannot be satisfactorily evaluated at present" (King, 1972). This is true of nutrient requirements as well. Studies of time budgets show, however, that time expended during reproduction to feed mates or young, to defend territories, etc., increases significantly (Verner, 1965; Verbeek, 1972). Because these activities generally require increased flight, itself a highly demanding activity (Alexander, 1968), it generally is assumed that resource requirements for these activities increase appreciably. Weight loss often is noted in individuals of various species at this point in the reproductive cycle (Davis, 1961; Helms, 1968; Fogden, 1972).

Payne (1972) summarizes available data with respect to molt, which most investigators study by measuring increases in metabolic rates for molting versus non-molting birds. Results vary with species, investigator, duration of the molt, etc. Values range from 5 to 57% (Payne, 1972) with those for most passerines falling between 5 and 30%. This metabolic increase is attributable to expenditures for feather growth and to increased expenditures for thermoregulation (Rawles, 1960; Lustick, 1970; Payne, 1972). The nutritional requirements for replacing feathers also have been neglected. Several studies suggest, however, that protein demands are high and amino acid requirements such that many birds must use muscle tissue as a source of these materials for feather growth (Hanson, 1962; Ward, 1969).

TEMPORAL PATTERNS OF MOLTING AND BREEDING—*Temperate Land Birds.* It is in the temperate regions of the world that the classic pattern of mutual exclusion of activities with high resource demands is most pronounced. Studies of the annual cycles of temperate land birds show generally that not only breeding and molt, but also migration are mutually exclusive (Tordoff and Mengel, 1956; Farner, 1958; Stresemann, 1967; Newton, 1968). The physiological mechanisms that control these recurrent events, and thus their separation, either inherently and/or in response to environmental cues, time each event so that it occurs when environmental conditions are optimal for its success and when interference from other activities is minimal. These physiological control mechanisms presumably have evolved in response to the high resource requirements of each activity and the restricted periods of high food availability (Farner, 1964).

Exceptions to such patterns, exist, however. For example, in several species (Wagner, 1957; Kemper, 1959; Ligon, 1971) molt is timed to occur fairly regularly, while breeding is timed by an irregularly abundant resource, either food or nest materials. In addition, such species often are nomadic (ibid.) so that contact with appropriate conditions or available resources also is irregular. Breeding thus becomes more or less opportunistic, birds taking advantage of appropriate conditions regardless of other activities (such as molt) in progress. However, in most birds, energy or other resources necessary for reproduction probably are at critical levels only for a brief part of the nesting cycle, and overlap probably does not occur during this "resource critical" period. This also appears to be true of a number of other temperate forms in which adults may continue to feed fledglings for a few weeks after the onset of the postnuptial molt (Prenn, 1937; Marler, 1956; Eaton, 1957; Dixon, 1962; Evans, 1966; Newton, 1966; Dolnik and Blyumental, 1967; Stresemann *in* Keast, 1968). In these forms selection seems to favor overlap to take advantage of a richer food supply.

Individuals of at least two temperate species (*Nucifraga columbiana, Corvus corax*) may begin the annual molt before they lay their eggs (Mewaldt, 1958; Gwinner *in* Keast, 1968), and their molt may span much of their reproductive period. In both species large body size and long primaries dictate an early onset of molt so that it may be completed prior to a winter period of food scarcity (Stresemann, 1967). Several other species, including some birds of prey, also exhibit extensive overlap (Colquhoun, 1951; Watson, 1962; Raitt and Ohmart, 1966; Stresemann, 1967; Middleton, 1969; Payne, 1972). In most of these forms, molt is prolonged and coincides with a period of favorable temperatures and food supply. Overlap is largely an adaptation ensuring completion of molt prior to migration or periods of food scarcity.

Tropical Land Birds. Tropical birds exist under environmental and behavioral regimes different from those of their temperate counterparts. For example, most species that breed in the tropics are non-migratory thus eliminating a costly activity. In addition, yearly fluctuations in many environmental features such as temperature are negligible. However, restricted periods of high food availability also seem to be the rule in tropical environments probably in response to fluctuations in rainfall. Although food levels perhaps do not fluctuate

to the same degree as in temperate regions, food availability does appear to vary sufficiently to limit the breeding of tropical birds to well defined seasons (Moreau, 1936, 1950; Davis, 1953; Marchant, 1959; Miller, 1963; Fogden, 1972). As in temperate regions, molt and breeding usually are separated temporally.

However, it is becoming increasingly evident that a large proportion of tropical birds overlap molt and breeding (Foster, 1975). Because detailed studies of the ecology and breeding biology of these species are lacking in general, it is not possible to cite specific reasons for overlap in each species. A general model proposed to explain this phenomenon (Foster, 1974) suggests that the enforced termination of one activity (e.g., breeding) to allow for the initiation of a second (e.g., molt), vertical partitioning, would be unfavorable for most individuals in the New World and African tropics where high predation of eggs and nestlings is well documented. Under circumstances of very low nesting success the ability to renest several times will carry a strong selective advantage by increasing the probability of an individual successfully rearing offspring. If a bird molts and breeds simultaneously, it can substantially increase the absolute length of the reproductive period and thereby its potential number of nestings, since it can breed throughout that period designated for molt as well as during the normal breeding period. When these events overlap, molt usually is protracted (Snow and Snow, 1964). However, it need not span the entire molt-reproductive period, so the extent of overlap may vary. Birds successful early in the breeding season may show no overlap. Those particularly unsuccessful may continue to breed throughout their period of molt.

Australian Arid Region Birds. The birds of this area are of particular interest because of the often marked irregularity of their reproductive period. Breeding appears to be timed primarily by rainfall which is unpredictable and generally erratic (McGilp, 1923; Keast and Marshall, 1954; Immelmann, 1971; Serventy, 1971). Despite this, molt occurs in most species on a regular annual basis (Keast, 1968). Thus, when rain falls during the molt period of a species, the potential for molt-breeding overlap exists.

Reports of overlap are numerous (Söderberg, 1918; Carter, 1923, 1923-1924; Serventy and Marshall, 1957; Keast, 1959; Immelmann, 1963). Keast (1968) has reviewed in detail the timing of molt and breeding in a number of Australian dry country species. He reports many instances of overlap, though he did not find it as widespread as some earlier investigators. A number of significant features of molt among Australian birds can be recognized, however. First, molt in general tends to be protracted. Additionally, in several species, the overlap of molt and breeding results in a decrease in the rate of molt. Both would decrease the daily resource requirements for molt and minimize its interference with breeding. Finally, molt is interrupted in a few species.

As Keast (1968) concludes, molt-breeding overlap is particularly advantageous to birds occupying a somewhat unpredictable environment, as it allows them to make maximal use of an abundant food supply.

Interestingly, comparable studies of birds in other arid areas (Moreau, 1950; Marchant, 1963; Immelmann, 1967; Dawson and Bartholomew, 1968; Immel-

mann and Immelmann, 1968) indicate that breeding seasons, though timed by rainfall, are considerably more regular than in Australia.

Shorebirds and Seabirds. The scheduling of molt and breeding in seabirds from tropical, temperate and arctic latitudes has been studied. As with other birds, breeding and molt are largely mutually exclusive (Schreiber and Ashmole, 1970; Ashmole, 1971). This separation may be accomplished in two ways. In some birds, molt and breeding periods alternate (Storer, 1960; Ashmole, 1971). In others, the molt may occupy two periods bracketing reproduction. Thus, when breeding is initiated, molt is interrupted until its completion (Stonehouse, 1962; Ashmole, 1963, 1968; Schreiber and Ashmole, 1970). Presumably this absence of overlap relates to the great amounts of energy and protein required for the production of the large eggs characteristic of seabirds (Romanoff and Romanoff, 1949; Lawrence and Schreiber, 1974), the need for adults to feed often at long distances from the nesting area, and the extremely long period of dependency of the young.

As with other groups, however, exceptions have been noted. At high latitudes, where summers are short and the weather often is severe and unpredictable, molt and breeding overlap in several species (Maher, 1962; Warham, 1962; Holmes, 1966; Stresemann, 1967; Ingolfsson, 1970; Ashmole, 1971). Overlap may be broad (Johnston, 1961), or the bulk of feather replacement may follow the main breeding effort (Holmes, 1971). Some species thus are able to complete two resource costly events during the short period of maximum food production. Similar adaptations are found among temperate forms (Murphy, 1936; Johnston, 1956; Payne, 1965). Tropical species which exhibit overlap do so irregularly; molt and breeding are timed so that they usually are independent. However, if conditions that trigger breeding arise while the molt is in progress, both activities may proceed simultaneously (Ashmole, 1962; Schreiber and Ashmole, 1970).

Discussion—When large numbers of avian species are examined, several seasonal patterns of resource allocation between molting and breeding emerge. All appear adaptive for the birds in the areas where they occur. The best known and probably most common pattern is vertical resource partitioning. Here events requiring large expenditures of resources are temporally separated to minimize physiological strain and to insure most efficient use of productive energy. This pattern is found among all types of birds from all geographic areas. In most temperate land birds the separation of breeding and molt probably is reinforced by the occurrence of a long distance migration. Breeding terminates prior to molt, which in most forms is completed prior to migration. Thus, a minimum of several months is available even to young produced late in the season to grow and mature prior to the time when they must migrate. If molt-breeding overlap were to extend the breeding season, late hatching young would have less time to develop before migration or the onset of winter and would be more likely to perish (Goddard and Board, 1967; Kluyver, 1971). An analagous situation apparently occurs in some Southeast Asian forms in which migration is "replaced" by a severe period of food scarcity (Fogden, 1972).

A second pattern is found in most of the temperate species that show overlap. Many utilize an irregularly abundant food source, and breeding occurs irregularly in response to its appearance. Molt, however, occurs on a regular schedule. If conditions favorable for breeding arise while the birds are molting, they still are capable of breeding. This pattern is found also in many Australian desert birds and some seabirds.

Species with very low nest success due to high predation or other causes, particularly those of the African or New World tropics, commonly exhibit the third pattern. Here, molt-breeding overlap serves to extend the potential reproductive period by allowing breeding to continue through the period devoted to molt. Thus, when necessary, repeated renesting is possible.

In both the second and third patterns, overlap is facultative. In species that respond to irregularly occurring conditions favorable for breeding, essentially all or none of the individuals will exhibit overlap in any given breeding season. Whether or not an individual of a species having the third pattern exhibits overlap will depend upon his own degree of nesting success. Thus the number of individuals showing overlap in any given season will vary. In both these instances, resource partitioning may be horizontal or restricted horizontal.

The fourth pattern is found in species whose food supply is extremely abundant, but only over a period of limited duration. In these forms, molt may encroach on breeding to a varying degree so that both events may be completed within the favorable season. This encroachment may be manifest by a shortening of the reproductive period or by an overlap of molt and breeding. The pattern is particularly common among high latitude shorebirds and seabirds, though it also occurs in some temperate land and sea forms. Resource partitioning may be horizontal, but usually is restricted horizontal.

Conclusions—It often is assumed that in all organisms selection favors the separation of events with large demands for resources as a physiological adaptation. At the same time, however, selection is acting to better adapt the organism to the particular environment in which it lives. The direction in which selection moves will depend upon the ecological characteristics of the area. Some selective forces will operate to reinforce the separation, that is the vertical distribution of resources among costly events. Others will act antagonistically, in favor of horizontal resource partitioning and overlap. The resulting temporal distribution will represent a compromise between the opposing selective pressures. Thus it is not surprising to find several temporal patterns of resource allocation. Temporal as well as qualitative and quantitative aspects of resource partitioning are adaptive and will contribute to the fitness of an organism in a particular environment.

Acknowledgments—I wish to thank Marvin R. Alvarez, Frank E. Friedl, Charles E. King, Roy W. McDiarmid, Andrew J. Meyerriecks, Gerald G. Robinson and Glen E. Woolfenden who read the manuscript and offered critical comments and suggestions. I also am indebted to Ing. Eladio Carmona B., Ing. Mauro Molina U., and Carlos Gutiérrez B. of the Costa Rican Ministry of Agriculture and Jorge Campabadal of the Organization for Tropical Studies for other assist-

ance. Andrew D. Shumaker kindly aided in the preparation of the figure. Portions of this work were completed during the tenure of a National Science Foundation Predoctoral Fellowship and a grant from the Frank M. Chapman Memorial Fund of the American Museum of Natural History.

LITERATURE CITED

ALEXANDER, R. M. 1968. Animal Mechanics. Sidgwick and Jackson. London.

ASHMOLE, N. P. 1962. The black noddy *Anous tenuirostris* on Ascension Island Pt. 1. General biology. Ibis 103b:235-273.

_____. 1963. Molt and breeding in populations of the sooty tern *Sterna fuscata*. Postilla 76:1-18.

_____. 1968. Breeding and molt in the white tern (*Gygis alba*) on Christmas Island, Pacific Ocean. Condor 70:35-55.

_____. 1971. Sea bird ecology and the marine environment. Pp. 224-286. *In* FARNER, D. S., J. R. KING, AND K. C. PARKES (eds.). Avian Biology 1. Academic Press. New York.

ASSENMACHER, I. 1973. Discussion. Pp. 68-73. *In* FARNER, D. S. (ed.). Breeding Biology of Birds, Natl. Acad. Sci. Washington, D. C.

BATES, G. L. 1908. Observations regarding the breeding-seasons of the birds in Southern Kamerun. Ibis 9:558-570.

CARTER, T. 1923. Supplementary notes on some birds from Western Australia and from Dirk Hartog Island. Ibis 65:218-228.

_____. 1923-1924. Birds of the Broome Hill district. Emu 23:125-142, 223-235, 306-318.

COLQUHOUN, M. K. 1951. The Wood-Pigeon in Britain. H. M. S. O. London.

DAVIS, J. 1961. Some seasonal changes in morphology of the rufous-sided towhee. Condor 63:313-321.

DAVIS, T. A. W. 1953. An outline of the ecology and breeding seasons of birds of the lowland forest region of British Guiana. Ibis 95:450-467.

DAWSON, W. R., AND G. A. BARTHOLOMEW. 1968. Temperature regulation and water economy of desert birds. Pp. 357-394. *In* BROWN, G. W. (ed.). Desert Biology, Academic Press. New York.

DIXON, K. L. 1962. Notes on the molt schedule of the plain titmouse. Condor 64:134-139.

DOLNIK, V. R., AND T. I. BLYUMENTAL. 1967. Autumnal premigratory and migratory periods of the Chaffinch (*Fringilla coelebs coelebs*) and some other temperate-zone passerine birds. Condor 69:435-468.

EATON, S. W. 1957. A life history of *Seiurus noveboracensis*. Sci. Studies St. Bonaventure Univ. 19: 7-36.

EVANS, P. R. 1966. Autumn movements, moult and measurements of the lesser redpoll *Carduelis flammea cabaret*. Ibis 108:183-216.

FARNER, D. S. 1958. Photoperiodism in animals with special reference to avian testicular cycles. Biol. Colloq. Oregon St. Coll. 19:17-29.

_____. 1964. The photoperiodic control of reproductive cycles in birds. Amer. Scientist 52:137-156.

_____. 1973. Informal discussion. Pp. 74-75. *In* FARNER, D. S., (ed.). Breeding Biology of Birds, Natl. Acad. Sci. Washington, D. C.

FISHER, H. 1972. The nutrition of birds. Pp. 431-469. *In* FARNER, D. S., J. R. KING, AND K. C. PARKES (eds.). Avian Biology 2. Academic Press. New York.

FOGDEN, M. P. L. 1972. The seasonality and population dynamics of equatorial birds in Sarawak. Ibis 114:307-343.

FOSTER, M. S. 1974. A model to explain molt-breeding overlap and clutch size in some tropical birds. Evolution 28:182-190.

_____. 1975. The overlap of molting and breeding in some Costa Rican birds. Condor (in press).

GADGIL, M., AND W. H. BOSSERT. 1970. Life historical consequences of natural selection. Amer. Nat. 104(935):1-24.

GODDARD, S. V., AND V. V. BOARD. 1967. Reproductive success of red-winged blackbirds in north central Oklahoma. Wilson Bull. 79:283-289.

HANSON, H. C. 1962. The dynamics of condition factors in Canada geese and their relation to seasonal stresses. Arctic Inst. N. Amer. Tech. Pap. 12.

HELMS, C. W. 1968. Food, fat, and feathers. Amer. Zool. 8:151-167.

HOLMES, R. T. 1966. Molt cycle of the red-backed sandpiper (*Calidris alpina*) in western North America. Auk 83:517-533.

_____. 1971. Latitudinal differences in the breeding and molt schedules of Alaskan red-backed sandpipers (*Calidris alpina*). Condor 73:93-99.

IMMELMANN, K. 1963. Drought adaptations in Australian desert birds. Proc. XIII Internatl. Ornithol. Cong. 2:649-657.

_____. 1967. Untersuchungen zur endogenen und exogenen steuerung der jahresperiodik afrikanischer vögel. Verh. Deut. Zool. Ges. Heidelberg 1967:340-357.

_____. 1970. Environmental factors controlling reproduction in African and Australian birds—a comparison. Ostrich, Suppl. 8:193-204.

_____. 1971. Ecological aspects of periodic reproduction. Pp. 342-389. *In* FARNER, D. S., J. R. KING AND K. C. PARKES (eds.). Avian Biology 1. Academic Press. New York.

_____, AND G. IMMELMANN. 1968. Zur fortpflanzungsbiologie einige vögel in der Namib. Bonn Zool. Beitr. 19:329-339.

INGOLFSSON, A. 1970. The moult of remiges and rectrices in great black-backed gulls *Larus marinus* and glaucous gulls *L. hyperboreus* in Iceland. Ibis 112:83-92.

JOHNSON, N. K. 1963. Comparative molt cycles in the tyrannid genus *Empidonax*. Proc. XIII Internatl. Ornithol. Cong. 2:870-883.

JOHNSTON, D. W. 1956. The annual reproductive cycle of the California gull, I. Criteria of age and the testis cycle. Condor 58:134-162.

_____. 1961. Timing of annual molt in the glaucous gulls of northern Alaska. Condor 63:474-478.

KEAST, A. 1959. Australian birds: their zoogeography and adaptations to an arid continent. Pp. 89-114. *In* KEAST, A., R. L. CROCKER and C. S. CHRISTIAN (eds.). Biogeography and Ecology in Australia. Monographiae Biologicae no. 8.

_____. 1968. Moult in birds of the Australian dry country relative to rainfall and breeding. J. Zool. London 155:185-200.

KEAST, J. A., AND A. J. MARSHALL. 1954. The influence of drought and rainfall on reproduction in Australian desert birds. Proc. Zool. Soc. London 124:493-499.

KEMPER, T. 1959. Notes on the breeding cycle of the red crossbill (*Loxia curvirostra*) in Montana. Auk 76:181-189.

KENDEIGH, S. C. 1949. Effect of temperature and season on energy resources of the English sparrow. Auk 66:113-127.

KING, J. R. 1972. Energetics of reproduction in birds. Pp. 78-107. *In* FARNER, D. S. (ed.). Breeding Biology of Birds, Natl. Acad. Sci. Washington, D. C.

KLUYVER, H. N. 1971. Regulation of numbers in populations of great tits (*Parus m. major*). Proc. Adv. Study Inst. Dynamics Numbers Pop. (Oosterbeek, 1970), pp. 507-523.

LAWRENCE, J. M., AND R. W. SCHREIBER. 1974. Organic material and calories in the egg of the brown pelican, *Pelecanus occidentalis*. Comp. Biochem. Physiol. 47A:435-440.

LIGON, J. D. 1971. Late summer-autumnal breeding of the piñon jay in New Mexico. Condor 73: 147-153.

LUSTICK, S. 1970. Energy requirements of molt in cowbirds. Auk 87:742-746.

MAHER, W. J. 1962. Breeding biology of the snow petrel near Cape Hallett, Antarctica. Condor 64:488-499.

MARCHANT, S. 1959. The breeding season in S. W. Ecuador. Ibis 101:137-152.

_____. 1963. The breeding of some Iraqui birds. Ibis 105:516-557.

MARLER, P. 1956. Behaviour of the chaffinch *Fringilla coelebs*. Behav., Suppl. 5:147-150.

MCGILP, J. N. 1923. Birds of Lake Frome district, South Australia. Emu 22:237-243, 274-287.

MEWALDT, L. R. 1958. Pterylography and natural and experimentally induced molt in Clark's nutcracker. Condor 60:165-187.

MIDDLETON, A. L. A. 1969. The moult of the European goldfinch near Melbourne Victoria. Emu 69:145-154.

MILLER, A. H. 1963. Seasonal activity and ecology of the avifauna of an American equatorial cloud forest. Univ. California Publ. Zool. 66:1-78.

MOREAU, R. E. 1936. Breeding seasons of birds in East African evergreen forest. Proc. Zool. Soc. London 1936:631-653.

_____. 1950. The breeding seasons of African birds—1. land birds. Ibis 92:223-267.

MURPHY, R. C. 1936. Oceanic birds of South America, vol. II. Macmillan Co. New York.

NEWTON, I. 1966. The moult of the bullfinch *Pyrrhula pyrrhula*. Ibis 108:41-67.

_____. 1968. The temperatures, weights, and body composition of molting bullfinches. Condor 70:323-332.

PAYNE, R. 1965. The molt of breeding Cassin auklets. Condor 67:220-228.

———. 1972. Mechanisms and control of molt. Pp. 104-155. *In* Farner, D. S., J. R. King, and K. C. Parkes (eds.). Avian Biology 2. Academic Press. New York.

Prenn, F. 1937. Beobachtungen zur Lebensweise der Felsenschwalbe (*Riparia rupestris*). J. Ornithol. 85:577-586.

Raitt, R. J., and R. D. Ohmart. 1966. Annual cycle of reproduction and molt in Gambel quail of the Rio Grande valley, southern New Mexico. Condor 68:541-561.

Rawles, M. E. 1960. The integumentary system. Pp. 190-240. *In* Marshall, A. J. (ed.). Biology and Comparative Physiology of Birds 1. Academic Press. New York.

Ricklefs, R. E. 1972. Latitudinal variation in breeding productivity of the rough-winged swallow. Auk 89:826-836.

Romanoff, A. L., and A. J. Romanoff. 1949. The Avian Egg. John Wiley. New York.

Schreiber, R. W., and N. P. Ashmole. 1970. Sea-bird breeding seasons on Christmas Island, Pacific Ocean. Ibis 112:363-394.

Serventy, D. L. 1971. Biology of desert birds. Pp. 287-339. *In* Farner, D. S., J. R. King, and K. C. Parkes (eds.). Avian Biology 1. Academic Press. New York.

———, and A. J. Marshall. 1957. Breeding periodicity in western Australian birds: with an account of unseasonal nestings in 1953 and 1955. Emu 57:99-126.

Scott, M. L. 1973. Nutrition in reproduction—direct effects and predictive functions. Pp. 46-68, 73-74. *In* Farner, D. S. (ed.). Breeding Biology of Birds. Natl. Acad. Sci. Washington, D.C.

Snow, D. W., and B. K. Snow. 1964. Breeding seasons and annual cycles of Trinidad land-birds. Zoologica 49:1-39.

Söderberg, R. 1918. Results of Dr. E. Mjoberg's Swedish scientific expeditions to Australia 1910-1913. XVIII. Studies of the birds in north west Australia. Kungl. Svenska Vetenskapsakad. Hadl. 52:1-116.

Stonehouse, B. 1962. The tropic birds (genus *Phaethon*) on Ascension Island. Ibis 103b:124-161.

Storer, R. W. 1960. Evolution in the diving birds. Proc. XII Internatl. Ornithol. Cong. pp. 694-707.

Stresemann, E. 1967. Inheritance and adaptation in moult. Prox. XIV Internatl. Ornithol. Cong. pp. 75-80.

Tordoff, H. B., and W. R. Dawson. 1965. The influence of daylength on reproductive timing in the red crossbill. Condor 67:416-422.

———, and R. M. Mengel. 1956. Studies of birds killed in nocturnal migration. Univ. Kansas Publ. Mus. Nat. Hist. 10:1-44.

Verbeek, N. A. M. 1972. Daily and annual time budget of the yellow-billed magpie. Auk 89:567-582.

Verner, J. 1965. Time budget of the male long-billed marsh wren during the breeding season. Condor 67:125-139.

Wagner, H. O. 1957. The molting periods of Mexican hummingbirds. Auk 74:251-257.

Warham, J. 1962. The biology of the giant petrel *Macronectes giganteus*. Auk 79:139-160.

Watson, G. E. 1962. Molt, age determination, and annual cycle in the Cuban bobwhite. Wilson Bull. 74:28-42.

Florida Sci. 38(3):129-139. 1975.

THE SOUTHERN DISTRIBUTION OF THE MANY-LINED SALAMANDER, *STEREOCHILUS MARGINATUS*

Steven P. Christman and Howard I. Kochman

Department of Zoology, University of Florida, Gainesville, Florida 32611

Abstract: *The species is reported for the first time from Florida and additional stations are cited for Georgia.*

The plethodontid salamander, *Stereochilus marginatus* (Hallowell), has been reported from bald cypress and gum swamps along the Atlantic Coastal Plain from southern Virginia to Georgia (Rabb, 1966). *Stereochilus* is a small, secretive salamander, seldom observed, and in general collected only with some difficulty. Consequently, the limits of its geographic distribution in the southern United States are poorly known, and its occurrence in Georgia (including the type-locality in Liberty County) has been questioned (Neill, 1957; Conant, 1958; Rabb, 1966). Recently, Wharton et al. (1973) have reported the discovery of *Stereochilus* from southeastern Georgia near the upper reaches of the Okefenokee Swamp. They cite their southerly range extension as the first record of the species from the Gulf of Mexico drainage.

Recent collecting in Georgia by Gerald Williamson and members of the Savannah Science Museum Herpetology Club, and by D. Bruce Means and the writers has established the fact that *S. marginatus* is widespread throughout the Georgia Coastal Plain. In addition, we have now collected it from two localities in northern Florida, representing the first records of the species from that state.

Stereochilus marginatus is now known from Baker County, Florida, and the following counties in Georgia: Effingham, Chatham, Bryan, Liberty, Long, Wayne, Glynn and Ware. Its distribution is probably continuous throughout the Atlantic Coastal Plain from South Carolina to northern Florida. Figure 1 shows the known localities of *Stereochilus marginatus* in Georgia and Florida.

The Florida localities reported herein are drained by a small tributary of the St. Mary's River, and are thus a part of the Atlantic drainage. Whether or not the Ware County, Georgia, locality reported by Wharton et al. (1973) is a part of the Gulf drainage is probably moot. The upper Okefenokee is a flat, low-lying swamp, and no doubt the waters of the Satilla (Atlantic drainage) and the waters of the Suwannee (Gulf drainage) intermingle during periods of high water. *Stereochilus* has not, however, been found in apparently suitable habitat of the Suwannee River drainage, just 10 miles south of the Baker County localities.

Nine specimens of *S. marginatus* from Baker County (UF 32561-32569) and one from Ware County (UF 32560) have been deposited in the Florida State

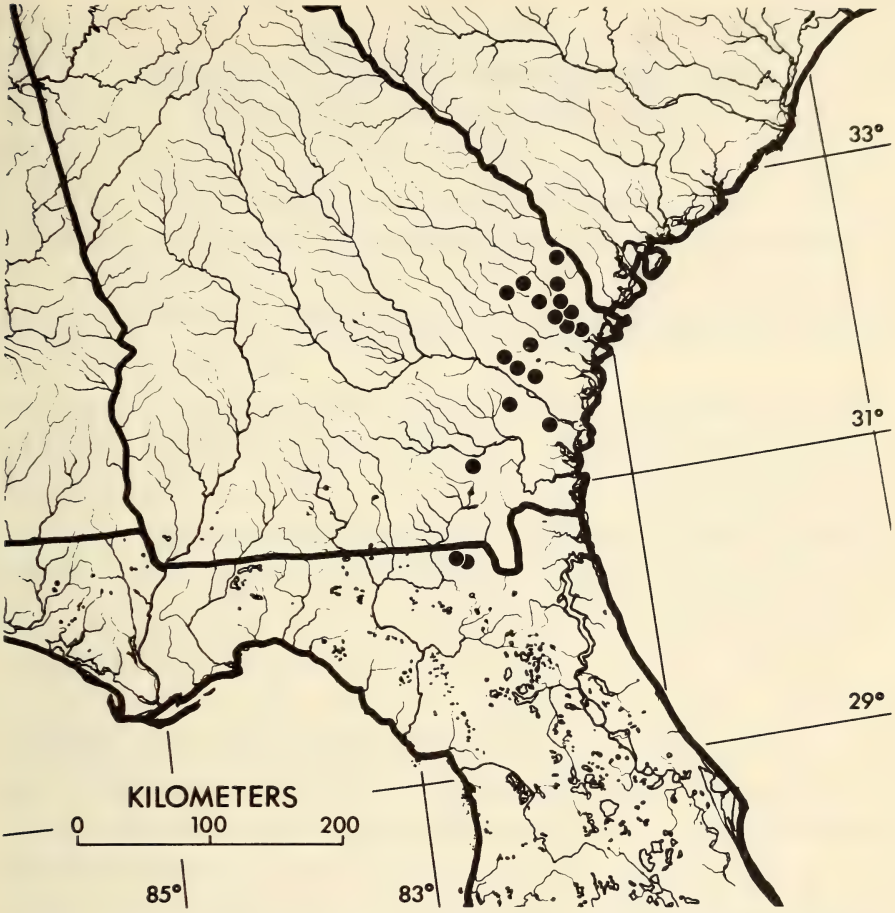

Fig. 1. Distribution of the many-lined salamander, *Stereochilus marginatus*, in Georgia and Florida.

Museum. Seven specimens from Liberty County are in the personal collection of D. Bruce Means, and 179 specimens from seven counties in Georgia are housed at the Savannah Science Museum.

ACKNOWLEDGMENTS—We thank Gerald Williamson of the Savannah Science Museum for supplying us with most of the locality records of *Stereochilus* in Georgia.

LITERATURE CITED

CONANT, R. 1958. A Field Guide to Reptiles and Amphibians of the United States and Canada East of the 100th Meridian. Houghton Mifflin Co., Boston.

NEILL, W. T. 1957. Distributional notes on Georgia amphibians and some corrections. Copeia 1957(1):43-47.

RABB, G. B. 1966. *Stereochilus* and *S. marginatus*. Cat. Amer. Amphib. Rept. p: 25.1-25.2.

WHARTON, C. H., T. FRENCH, AND C. RUCKDESCHEL. 1973. Recent range extensions for Georgia amphibians and reptiles. HISS News J. 1(1):22.

FIRST RECORDS OF TWO PERCID FISHES IN FLORIDA FRESHWATERS

Ralph W. Yerger and Hal A. Beecher

Department of Biological Science, Florida State University, Tallahassee, Florida 32306

Abstract: *A male* Stizostedion canadense *was taken from the Apalachicola River and a male* Ammocrypta asprella *was collected from the Escambia River.*

The expanding list of fishes known from the freshwaters of Florida was discussed by Yerger and Suttkus (1962). They noted that virtually all of the recent additions were collected in the Panhandle region of western Florida, and predicted that future surveys of the larger rivers would likely disclose additional unrecorded species. The state list has been augmented greatly in the past decade by the introduction of more than three dozen species of exotic, tropical fishes into the southern half of the peninsula (Courtenay et al, 1974). We now report the occurrence of two additional species of the perch family (Percidae) in north-western Florida, one an introduction, the other an apparently indigenous form.

1. *Stizostedion canadense* (Smith)—Sauger. A male, 241 mm standard length, was caught on hook and line in the Apalachicola River at Chattahoochee, Gadsden County, on February 3, 1962, by E. A. Burkett while fishing from the catwalk just below the Jim Woodruff Dam. This fish was identified by John T. Brown and W. Keith Byrd, former employees of the Florida Game and Fresh Water Fish Commission, and later donated to the Florida State University Fish Collection (FSU Catalog no. 7592). The sauger is not native to Georgia (Dahlberg and Scott, 1971) or to Florida. The species was introduced into Bartlett's Ferry and Oliver reservoirs (Chattahoochee River) near Columbus, Georgia, by the Georgia Game and Fish Division in January 1961 (John T. Brown and Don Johnson, personal communications). The Florida fish undoubtedly represents an individual which made its way downstream approximately 125 miles from the site of introduction. To the best of our knowledge, no other saugers have been taken in Florida waters. Several have been recovered from Lake Seminole, the reservoir formed by the Jim Woodruff Dam, but the sauger stockings in the Chattahoochee River of Georgia are considered to be unsuccessful (Don Johnson, personal communication).

2. *Ammocrypta asprella* (Jordan)—Crystal darter. The range of the crystal darter extends from southern Minnesota and Wisconsin to Ohio and south to Tennessee, Arkansas, Oklahoma, Louisiana and Mississippi (Moore, 1968), and to several rivers in the Mobile Bay drainage of Alabama (Smith-Vaniz, 1968). During an ecological survey of the Escambia River, a subadult male 63 mm standard length (FSU No. 21354), was collected during the night of April 7-8, 1972 by

W. C. Hixson, Charles A. Lowery, and Gilbert McGhee using a boat-mounted electric shocker. The collection site was the main channel of the Escambia River, approximately 1.6 km downstream from the bridge on State Highway 4, about 2.7 km east of Century, Escambia County. Although the precise collection site could not be determined because of the nature of the night operation, the specimen was taken from waters 2-5 m deep, and over a clay-mud to sand bottom with some gravel. Other darters collected in this general locality were *Ammocrypta beani, Percina caprodes, P. nigrofasciata, P. uranidea, Etheostoma davisoni, E. swaini, E. histrio,* and *Etheostoma* species (orangeside darter). The 13 month survey included 75 hr of electrofishing and numerous seine hauls. The locality was revisited in the spring of 1973 but attempts to seine additional specimens were fruitless.

The crystal darter was not listed by Bailey, Winn, and Smith (1954) in their report on the fishes of the Escambia River. The collection of a single specimen raises the question whether this species is native to the system or whether it was introduced. We consider its introduction improbable because the species is not a common baitfish, food fish, or aquarium species. More likely it is indigenous, but because it inhabits large flowing streams and frequents strong currents (Smith-Vaniz, 1968), and because its population density is probably low at the periphery of its range, collection of the crystal darter would be an uncommon event in this drainage system.

ADDENDUM—Since the submission of the original manuscript, two additional adult specimens of *Ammocrypta asprella* were collected from the Escambia River on 28 November 1974 by Hal Beecher, John Stowe, and Dave Buecker. Both specimens (FSU 23033 and 23345) were seined on slip banks at consecutive sharp bends in the river, in the same vicinity as the first specimen reported in the paper. The bottom consisted of many pebbles (1-2 cm in diameter) over fine clay-sand. Fishes collected in the same seine haul with FSU 23033 included *Carpiodes velifer, Notropis texanus, N. venustus, N. longirostris, Hybopsis amblops, Ericymba buccata, Ammocrypta beani,* and *Etheostoma* species (orangeside darter).

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.

COURTENAY, W. R., JR., H. F. SAHLMAN, W. W. MILEY II, AND D. J. HERREMA. 1974. Exotic fishes in fresh and brackish waters of Florida. Biol. Conservation 6:292-302.

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

MOORE, G. A. 1968. Fishes. *In*: BLAIR, W. F., A. P. BLAIR, P. BRODKORB, F. R. CAGLE, AND G. A. MOORE. Vertebrates of the United States. 2nd ed. McGraw-Hill. New York.

SMITH-VANIZ, W. F. 1968. Freshwater Fishes of Alabama. Auburn Univ. Agr. Exp. Sta. Auburn, Ala. vii + 211 p.

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

Florida Sci. 38(3):142-143. 1975.

THE FLORIDA SPINY LOBSTER FISHERY

A White Paper[1]

Gary L. Beardsley, T. J. Costello, Gary E. Davis,
Albert C. Jones, and David C. Simmons

American Institute of Fishery Research Biologists,
75 Virginia Beach Drive, Miami, Florida 33149

Abstract: *The Florida spiny lobster fishery is faced with declining catch rates resulting from increasing fishing pressure by commercial and recreational fishermen. Conflicts between users have developed and economic returns, at least to the commercial fishery, are not optimal. Management action is suggested. Phase 1 of a management program should allocate the resource in an effective manner between recreational and commercial interests, adopt uniform interstate regulations to protect the resource, and augment the collection of fishery statistics for both recreational and commercial harvests. Phase 2 of the program should establish a management scheme to obtain the optimum sustainable yield.*

Spiny lobsters, *Panulirus argus*, presently attract thousands of recreational divers to the Florida Keys and provide Florida's commercial fishermen with their second most valuable catch, valued at about $15 million in 1974. Both the sport and commercial lobster fisheries were established in southern Florida by 1920. It was not until the late 1940's that the commercial trap fishery began to grow rapidly. Increases in the recreational harvest began in the late 1950's, with the explosive growth of skin diving in that period. These two interests now actively compete for the limited number of lobsters available in Florida waters. As a result of the enormous growth of these two groups and their respective harvests, a decrease in the lobster stocks has become evident in recent years. New measures are required if we expect to harvest a sustained yield from the available stocks, while at the same time perpetuating the lobster resource and maximizing its contribution to Florida's economy.

Florida's legal regulations involving gear restrictions, seasons of capture, and condition and size of animals pertain to only one species of spiny lobster, *Panulirus argus*, which is distributed from Bermuda and North Carolina to Brazil. Other species of spiny lobster are present in Florida's marine environment, but form only a minor proportion of the total lobster catch.

THE PROBLEMS

1. *Declining Abundance.* What data are available indicate that there have been serious declines in the catch per unit of fishing effort in recent years (Seaman and Aska, 1974). Divers find that areas which previously had good lobster

[1]This paper has been approved by the membership of the Florida District of the American Institute of Fishery Research Biologists, and constitutes a position paper from that organization.

fishing now have few lobsters. Commercial fishermen who in early years operated only 200 traps now use as many as 2000 traps to make the same harvest. In our opinion, based on communication with both fishermen and scientists, this intensified fishing pressure creates an exploitation rate for the Florida population that is high enough so that most lobsters at or near legal size in the Florida Keys are being caught each year.

2. *Low Economic Return.* One cause of the decline in catch rates has been the continuing increase in effort in the commercial and recreational fisheries. Unregulated entry has allowed addition of more and more gear to a fishery which is already harvesting near maximum yields. More gear brings higher costs and, with a less than equivalent increase in overall harvests, lower net financial returns to individual fishermen. State of Florida records show an increase of more than 1000% in the number of lobster traps fishing in the 1969-70 season as compared to the number of traps fishing in the 1955-56 season. For the same period total catch increased only 100%. Present earnings and net financial returns of commercial vessels are not high (Noetzel and Wojnowski, 1975; Dept. Food and Resource Economics, Univ. Florida, 1975, unpublished data). Under existing conditions, neither the commercial nor the recreational fishery can be expected to meet its full economic potential. Commercial fishermen are being forced out of the fishery because of low return on their investment, and income derived from recreational diving in south Florida is in danger of being reduced.

The rapidly intensifying conflict between recreational and commercial interests in the fishery must be resolved so the lobster resource may provide maximum benefit to society. If these problems are not addressed soon, not only may the ability of the fishermen to economically harvest this high quality protein source for society be eliminated, but the reproductive potential of the population may be reduced.

3. *Ineffective Regulations.* The present management scheme of Florida prohibits taking gravid females, all animals with carapace lengths less than 76 mm (3 inches), and all animals during the peak breeding season, April through July; and also restricts the type of fishing gear used. These regulations have the primary purpose of protecting the lobster stocks as biological entities, but do little or nothing to improve the economics of the industry. Furthermore, enforcement of these few rules is difficult because of the large area involved and the high potential gain/penalty ratio for the offender. Trap theft is a major problem. The success of the management scheme is also limited by the political boundaries of Florida's territorial waters, which have no rational relationship with the natural distribution of *P. argus.* Management is ineffectual in controlling the local high seas harvest or the international recruitment potentials.

4. *Inadequate Fishery Statistics.* Any management scheme, other than complete laissez faire, requires detailed, accurate record keeping of both recreational and commercial harvests. Recreational harvest statistics do not exist. Present commercial harvest figures alone are inadequate to manage the fishery. Measures of fishing effort, the age and size structure of the population, detailed geographical and temporal information on the harvest, and an economic profile of the industry are required to monitor the fishery.

5. *Lack of Natural History Information.* Basic biological information is not available to manage the fishery for optimum sustainable yield (OSY), defined as the largest net economic return consistent with the biological capabilities of the stock, as determined on the basis of all relevant economic, biological, and environmental factors (Roedel, 1975). Until the population dynamics, growth rates in the wild, migratory patterns, age at maturity, and fecundity are better understood, no reliable estimate of the crop of lobsters that may be optimally harvested will be possible. Also, many facets of the life history of *P. argus* are not known with the accuracy and precision needed to recommend specific management strategies. For example, is enhancement of postlarval survival by the use of artificial habitats feasible? What is the biological capacity of various habitats for both adult and juvenile lobsters?—and how can this information be applied to obtain the optimal use of the resource for both recreational and commercial interests?

Lobsters which eventually grow up and are harvested in the Florida fishery may have originated from outside Florida waters. There is good reason to believe that during the several months that young lobsters live in the surface waters of the open ocean, many of them drift hundreds or thousands of miles away from where they were hatched. If Florida's fishery depends on recruitment from distant areas, it is important that other states and nations, as well as Florida, take steps to insure that their lobster populations are managed in such a way that successful reproduction is assured. Resolution of this question of source of recruits will require scientific investigations of the identity of larvae of the palinurid family and of their behavior.

MANAGEMENT ACTION NEEDED

The management action program recommended here is two phased. Phase 1 can be instituted at the present time, and consists of (1) the *allocation of the resource* in an effective manner, (2) the adoption of *uniform regulations,* and (3) the collection of necessary *fishery statistics.* Phase 1 has as its goal the establishment of management control over the fishery. Phase 2 is a subsequent phase of the management action program which can be initiated *after* certain biological and economic information requirements are met. Phase 2 has as its goal the establishment of an optimum sustainable yield fishery.

PHASE 1. 1. *Allocate the Resource.* Immediate consideration should be given for some form of allocation of the Florida lobster resource in order to increase the economic profitability of the fishery. A moratorium on commercial fishing permits might be a first step in stabilizing the number of units of gear in the commercial fishery at a level consistent with good fisheries management and fair dollar return to the fishermen. Allocation also is a means of optimizing the return from the recreational fishery. Management by limited entry operates successfully in the lobster fisheries of western Australia (Anonymous, 1974b; Bowen, 1971). It has recently been introduced or proposed for the salmon fisheries of Alaska and British Columbia and the lobster fisheries of Maine, the maritime provinces of Canada, and Turks and Caicos (Campbell, 1973; Dow, et al., 1975;

State of Alaska, 1974; R. Stevens, personal communication, May 22, 1973). There is ample legal precedent for basing management programs on the economic well-being of the industry as well as on protection of the resource. The greatest benefits of management are in cost reduction to the industry rather than through increased production from the resource base (Herrington, 1972). In Florida, organized groups of commercial fishermen have recently expressed a desire to adopt limited entry schemes for lobster (Seaman and Aska, 1974). These fishermen are acutely aware of, and suffer from, the economic effects of declining catch rates and the associated increased costs and effort necessary to maintain the present level of catch.

Inherent in any allocation scheme must be a partitioning of the resource between recreational and commercial interests. The competing interests of commercial trap fishermen and recreational divers must be resolved. The lobster fishery is a livelihood to some. To others its recreational use represents a needed respite from their daily routines and a valuable addition to the local economy. These uses need to be placed in perspective and potential conflicts resolved.

Allocation will require certain socio-economic decisions concerning who should benefit from publicly owned resources. Once these decisions are made and implemented, the remaining management decisions are purely technical ones. These technical decisions concern mainly the legal regulations and the management data necessary to operate the system. We believe that these technical decisions can be made from information which is already available or which can be acquired at reasonable cost and effort. Thus, if an allocation scheme is agreed upon and adopted, management can be implemented immediately.

2. *Adopt Uniform Regulations.* The international nature of this fishery must be recognized in all attempts at management, and uniformity of regulations established between all states and nations involved in harvest of spiny lobsters. Fortunately, several Caribbean countries, including the Bahamas, have modeled their conservation laws after those of Florida. While general uniformity of regulations is desirable, it is recognized that specific details may vary from area to area. In 1975 a proposal was submitted to the United States Congress (94th Congress, 1st Session, H.R. 2473) to provide uniform interstate regulations to protect juvenile and egg-bearing spiny lobsters. Uniform laws are an important first step towards providing an adequate basis for protection of the biological resource.

3. *Collect Detailed Fishery Statistics.* Detailed fishery statistics must be gathered for both sport and commercial harvests. These should include: (1) the quantity and value of the spiny lobster catch by trip, area of capture, and method of capture; (2) a measure of fishing effort for each trip; (3) length or weight frequency description of the catch; (4) vessel identification/description information; (5) operating costs and net economic return for the commercial and recreational fisheries. These data must be available on a timely basis (maximum 30-day delay) to effectively monitor and manage the harvest.

Phase 2. Phase 2 of the management program envisions the establishment of a fishery based on optimum sustainable yield. The present situation in the lobster fishery, vis-a-vis management for OSY, is analogous to a city manager

having to provide services, plan for future growth, and meet fiscal responsibilities of any of the major cities in Florida without having adequate information on (1) the size of the population of his city, (2) the rate of movement into or out of the city, (3) the age and sex distribution of the population, (4) the socio-economic profile, or (5) the monies available from which he must budget. Phase 2 will require additional research before the most appropriate management action can be initiated. Suggested topics for research are:

1. *Monitor Juvenile Population.* A promising approach to a realistic management scheme is through monitoring of postlarval and juvenile recruitment, as is done in the Australian lobster fishery (Anonymous, 1974a; Bowen, 1971). Predictions a year or more in advance of the numbers of fishable lobsters based on postlarval or juvenile abundance are free of variations in egg production, oceanic current effects, larval mortality, or settlement habitat conditions. Since recruitment may be partially independent of local adult population densities, this approach should provide accurate predictions of available yield with little additional input. Development of an adequate postlarval or juvenile monitoring program is of high priority in the research needs of the fishery.

2. *Study Natural History.* Basic information is needed about the growth rates of spiny lobsters in the wild, their migratory and seasonal movements, fecundity, age at maturity, behavioral responses to divers, and changes in the environment. These observed facts must then be integrated with a population monitoring program. Some of these data presently are being collected concurrently with *in situ* surveys and scientifically managed trapping-tagging studies of the fisheries (Seaman and Jones, 1975). Other information is available only from populations unaffected by harvest pressures. For example, south Florida's underwater parks, some of which are presently closed to lobster fishing, might be utilized for determination of habitat carrying capacity, impact of various management strategies on natural populations, and undisturbed rates of production. Such closed areas also protect a component of the population that will produce larvae for neighboring fisheries and adult recruitment to adjacent areas.

3. *Determine Larval Abundance and Distribution.* The ultimate source of recruitment to the Florida spiny lobster fishery remains an enigma. Problems of research on the pelagic larvae of spiny lobsters are formidable but solutions, although ultimately necessary, are not immediately imperative. Information on postlarval and juvenile recruitment is more readily available and may be sufficient for short-term management needs. Resolution of larval research problems and development of indices of phyllosome abundance might enable long-range forecasts of future fishery productivity to be made. Improved knowledge of phyllosome biology would also greatly assist development of larval rearing techniques for scientific and commercial purposes.

4. *Continue Cooperative Programs.* The present close contact should continue between State, Federal, University, and private interests involved in spiny lobster research and management. Standardization of data collection and establishment of a common "data bank," presently in progress, will provide an up-to-date, complete source of basic biological, fishery, and economic data for re-

searchers and managers. In view of the pan-Caribbean distribution of spiny lobsters, and because of our dependency upon other Caribbean spiny lobster populations for postlarval recruitment, it is imperative that good management practices be fostered throughout the species' range.

CONCLUSION

The spiny lobster resource is not at present providing maximum benefit to the people of the State of Florida. The fishery suffers from excess effort and low catch rates. Allocation of the resource, adoption of uniform regulations, and establishment of a program to collect detailed fishery statistics are suggested as immediate actions. Management of the fishery for optimum sustainable yield should be an ultimate goal, and is suggested as a second phase of the management program. Management based on these concepts can provide substantial benefits, including stabilized annual production, increased economic efficiency, and reduced user conflict.

ACKNOWLEDGMENTS—This White Paper was prepared by the Committee of five authors, A. C. Jones, Chairman. The authors wish to express their sincere appreciation to the many scientists and industry members who participated in the two conferences on spiny lobster held in 1974 (Seaman and Aska, 1974; Seaman and Jones, 1975). Discussions at these conferences laid the groundwork and interest in this report. Subsequent discussions with some of the participants, especially Dr. Richard Warner, added to the ideas. Nevertheless, the opinions expressed in this White Paper are the sole responsibility of the authors.

LITERATURE CITED

ANONYMOUS. 1974a. 1973-74 rock lobster season. Australian Fisheries 33(9):2.

_____. 1974b. Fisheries Act operates from January 1975. Australian Fisheries 33(12):6-7.

BOWEN, B. K. 1971. Management of the western rock lobster (*Panulirus longpipes cygnus* George). Proc. Indo-Pacific Fish. Coun. 14(II):139-153.

CAMPBELL, B. A. 1973. License limitations regulations: Canada's experience. J. Fish. Res. Board Canada 30:2070-2076.

DOW, R. L., F. W. BELL AND D. M. HARRIMAN. 1975. Bioeconomic relationships for the Maine lobster fishery with consideration of alternative management schemes. NOAA Technical Report NMFS SSRF-683. pp. 44.

HERRINGTON, W. C. 1972. Management of fishery resources for optimum returns. Would it work in the Gulf of Mexico? Proc. Gulf Caribbean Fish. Inst. Ann. Sess. 24:33-41.

NOETZEL, B. G. AND M. G. WOJNOWSKI. 1975. Costs and earnings in the spiny lobster fishery, Florida Keys. Marine Fish. Rev. 37(4):25-31.

ROEDEL, P. M. (ed.) 1975. Optimum sustainable yield as a concept in fisheries management. American Fish. Soc. Spec. Publ. 9:pp. 89.

SEAMAN, W., JR. AND D. Y. ASKA. (eds.) 1974. Research and information needs of the Florida spiny lobster fishery. State Univ. Syst. Florida Sea Grant Program Rept. 74-201:pp. 64.

_____ AND A. C. JONES. (eds.) 1975. Review of Florida spiny lobster research. State Univ. Syst. Florida Sea Grant Program. pp. 52.

STATE OF ALASKA, Commercial Fisheries Entry Commission. 1974. Proposed regulations, limited entry: Report to the fishermen of Alaska. July 15, 1974. pp. 26. Juneau.

BENTHIC ALGAE OF THE ANCLOTE ESTUARY I. EPIPHYTES OF SEAGRASS LEAVES

David Ballantine and Harold J. Humm

Department of Marine Science, University of Puerto Rico, Mayaguez, Puerto Rico 00708; and Department of Marine Science, University of South Florida, St. Petersburg, Florida 33701

Abstract: *Sixty-six species of benthic algae are recorded as epiphytes on the 4 species of seagrasses that form extensive beds in the Anclote estuary near Tarpon Springs, Florida Gulf coast. Monthly field observations and collections were made at 6 representative stations from January to September, 1971. About 65% of all benthic algae that grow attached in the area occur as seagrass epiphytes.* Ceramium byssoideum *fa.* alternatum *is newly described.*

The broad continental shelf of the Florida Gulf coast from the Keys to Apalachicola supports the most extensive seagrass beds of the North American continent. Since there are few rocky outcrops on the inner shelf where most seagrasses occur, the leaves of seagrasses are the most important substrate for benthic algae in depths of less than 10 m (Humm 1956, 1973).

As part of a general environmental research project in the Anclote River estuary at Tarpon Springs (Baird et al., 1972), a study of algal epiphytes of seagrass leaves was carried on from January to September, 1971, a time period that included all significant seasonal changes of the flora for the year.

Three seagrasses occur in abundance in the area studied and along the entire Florida Gulf coast: *Thalassia testudinum* König (turtle grass), *Syringodium filiforme* Kützing (manatee grass), and *Diplanthera wrightii* (Ascherson) Ascherson (shoal grass). A fourth species, *Halophila engelmannii* Ascherson is occasional, usually mixed with *Thalassia.* A fifth species, *H. baillonis* Ascherson, has not been recorded from the Anclote estuary but is occasional along the Florida Gulf coast, especially in deeper water (10 to 100 m). The latter two have no common name.

In view of the similarity of the marine environment over the inner continental shelf of the Florida Gulf coast and the Anclote River estuary, it is believed that the seagrass epiphytes recorded here will include an overwhelming majority, perhaps 90%, of the species occurring in other seagrass beds between Fort Myers and Apalachicola.

Environment—*Area.* If the Anclote River estuary is delimited by North Anclote Key (as the NW corner), by Bailey's Bluff (as the NE corner), by Piney Point (as the SE corner), by the south end of Anclote Key (as the SW corner), then the total area is about 28 sq km (12.3 sq miles). This area is approximately a square of about 5.2 km (3.5 miles) about 40% of which or 11.2 sq km (4.9 sq miles), is covered by seagrasses (Zimmerman et al., 1973) as determined by aerial photography (Feigl and Pyle, 1973).

Zonation. Along the mainland side of the Anclote estuary, the seagrasses exhibit four zones, from the beach outward, as follows: zone 1, *Diplanthera,* from

low intertidal (spring tides) to a few cm depth, averaging about 30 m wide; zone 2, *Thalassia,* from about 100 to 300 mm depth, a band averaging 35 m wide; zone 3, *Syringodium* (dominant) with some *Thalassia* and *Diplanthera* mixed with it in a band about 0.70 to 1.5 m deep, the zone about 400 m wide; zone 4, *Diplanthera,* with a small amount of *Syringodium,* as an outer narrow band beginning about 700 m out at a depth of about 0.17 m to more than 1 m in the clearer parts of the estuary (Zimmerman et al., 1972).

Physical Factors. Salinity of surface water in Anclote estuary during 1971 ranged from 26 to 32°/oo, based upon samples taken once a month. Salinities below 30 were recorded in April, September, October, and November. While sampling was too infrequent to obtain the full perturbations, the data show that Anclote estuary is similar to the adjacent Gulf of Mexico and that evaporation and tidal mixing in the area almost cancel the fresh water contribution from the Anclote River. Rainfall during 1971 was lower than 13 cm per mo in the area except for July (23), August, and September (43 each).

Surface water temperatures ranged from a low of 11.2°C during February, 1971, to a high of about 32° during the summer and a decline to 17° in November. From January through April, water temperature of the adjacent Gulf was 2-3 degrees higher; during summer and fall the difference was only about 1 degree.

Tidal current velocities in the estuary ranged from about 0.15 to 0.40 m per sec at times other than slack tide. The tidal amplitude of spring tides was 0.8 m but this was often exceeded or reduced by wind direction and velocity.

Light penetration in waters of the Anclote estuary was determined by means of a transmissometer employing either a 0.1 m or a 1 m light path. In general, from 45 to 60% of light striking the water surface penetrated to a depth of 0.1 m. The clearest water was usually in the northwest sector of the area (Pyle et al., 1973).

Nutrients are relatively low in the Anclote estuary (Johansson and Hopkins, 1973) and are more characteristic of inshore Gulf waters than of estuaries of the Florida Gulf coast. The area is little disturbed and relatively unaffected by the town of Tarpon Springs or the metropolitan areas of Tampa and St. Petersburg.

PROCEDURES—Six stations were established in the Anclote estuary in order to insure a sampling of all the obvious types of seagrass communities, and to insure repeated collecting in a selected area to determine seasonal changes. Collections were made at monthly intervals at each station within a 10 m radius of a buoy placed to mark the station location.

Stations 1, 2, and 3 were located in the northern segment of the Anclote estuary from an in-shore point near the U. S. Air Force radar station and extending westward to the outer margin of seagrass stands. These three stations were located to represent the different types of seagrass communities found along this transect.

Station 1 was established about 20 m from the mean low water line (west) in zone 1 and included the in-shore margin of the seagrass community. *Diplanthera* was the most abundant plant but there was some *Thalassia* in the outer part of

the station area. *Halophila* was also present, but sparse. The depth was from 0.2 m to 1 m, depending upon the tidal cycle.

Station 2 was established about 600 m from shore (west) where there was a dense stand of *Thalassia* with an admixture of *Syringodium*, typical of zone 2. *Diplanthera* and *Halophila* were also present in low abundance. The depth ranged, with tidal level, from 1 to 2 m.

Station 3 was established near the outer margin of the seagrass community about 1000 m from the shore line (west). *Diplanthera* was the most abundant seagrass, but the other three were present in low abundance, typical of zone 4.

Stations 4, 5, and 6 were located in the western and southern parts of the Anclote estuary on the basis of a careful reconnaissance for the purpose of locating representative types of seagrass stands differing from stations 1-3.

Station 4 was established on an extensive shallow flat on the north side of the boat channel leading from the mouth of the Anclote River. *Diplanthera* was the dominant seagrass but there were small, scattered patches of *Thalassia*. The station was representative of zone 1 but differed from station 1 in its nearness to the river mouth and consequent exposure to periods of reduced salinity, stronger currents, and greater turbidity. The depth at station 4 generally ranged, with tide, from about 0.3 m to 1 m, but during January large areas of station 4 were exposed to the air during spring low tides when there was a strong NE wind. At the same time, the seagrasses were exposed to subfreezing temperatures resulting in considerable death of the erect branches and leaves of a small, pure stand of *Halophila* that was present near station 4.

Station 5 was established about 1000 m south of station 4 off the SW side of Rabbit Key. *Syringodium* and *Thalassia* were the dominants, and the station was representative of zone 3. *Diplanthera* and *Halophila* were also present. Water clarity was the greatest of any station. The depth varied with the tides from 1-2 m.

Station 6, near the western margin of Anclote estuary, was located about 100 m off the eastern shore of Anclote Key at the southern end of Dutchman Key. *Thalassia* was the only seagrass and the station was typical of zone 2 but differed from station 2 in that the turbidity was greater at station 6 because of the presence of fine sediments and strong tidal currents. The depth ranged, with tide, from about 0.5 to 1.3 m.

The location of each station is shown in figure 1.

Voucher specimens of all algal species in the annotated list which follows have been deposited in the herbarium of the Department of Marine Science, St. Petersburg Campus, University of South Florida.

Discussion—Since *Diplanthera* is somewhat more euryhaline and eurythermal than any other western Atlantic species of seagrass, it extends farther up salinity gradients into estuaries such as Tampa Bay and Charlotte Harbor, and also extends farther north along the Atlantic coast, at least to North Carolina. The other species of seagrasses in the Anclote estuary are not known to extend north of Cape Canaveral on the Atlantic coast. All are basically continuous around the Gulf of Mexico except where their distribution is interrupted, at least

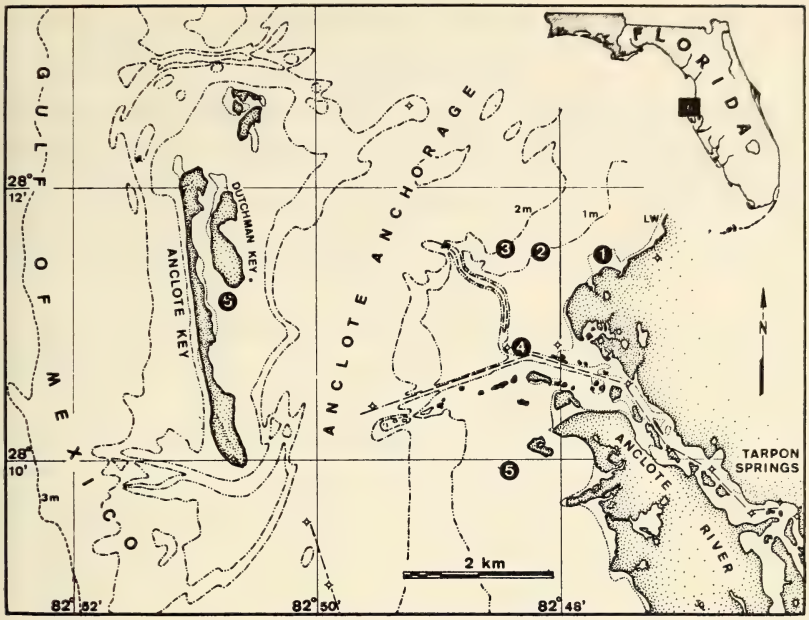

Fig. 1. Map of the Anclote estuary showing location of the six stations at which field studies and collections were made. The inset of the State of Florida in the upper right corner shows the area of the map by means of a square.

in shallow water, by river discharge (Humm 1956). It appears that *Diplanthera* does not compete well with *Thalassia* and *Syringodium* in areas that are more or less optimum for the latter species. Where *Thalassia* and *Diplanthera* are mixed, the habitat is probably suboptimum for *Thalassia*. Where *Diplanthera* is in a pure stand, the environment may be subminimal for *Thalassia*. In the Anclote estuary along the outer margin of the seagrass beds, an outer band of *Diplanthera* is often found beyond the outermost *Thalassia*. This pattern does not occur in all seagrass areas of the Florida coast and has not often been described.

Halophila engelmannii is usually found mixed with *Thalassia* and then rather sparsely so. However, one small area of *Halophila* in pure stand was found near station 4. *Halophila baillonis* has not been found in the Anclote estuary during the present work, although it is to be expected.

Comparison with Miami. Humm (1964) recorded 113 epiphytes of *Thalassia* in the Miami area, with special reference to Biscayne Bay. In this report, a total of 66 species has been recorded on all seagrasses, but in a much smaller area. Of the 66 species recorded at Anclote, 51 (about 75%) were also recorded by Humm at Miami, indicating a high degree of similarity between these populations of benthic algal epiphytes on seagrasses. About 65% of the benthic algae occurring in the Anclote estuary occur as seagrass leaf epiphytes.

Host Specificity. While some species of algae were found upon only one species of seagrass in this study, a careful consideration of the host-epiphyte data suggests that there is little host specificity. *Myriotrichia subcorymbosa* and *Stictyosiphon subsimplex* appear to be much more abundant, in most areas, on *Di-*

planthera than on any other seagrass. This observation, however, seems to be related to the fact that both these species grow best in the shallowest water occupied by seagrasses where there are only pools during spring low tides rather than an adaptation to *Diplanthera* leaves. The deepest *Diplanthera* beds did not support these species. *Cladosiphon occidentalis* was more abundant on *Thalassia* than on other seagrasses, but the reason appears to be its adaptation to somewhat deeper water rather than to *Thalassia* leaves. Most species of algae occurred on all species of seagrasses in proportion to the abundance of each seagrass.

ANNOTATED LIST OF EPIPHYTIC ALGAE

A key to the identification of all species in the list that follows is found in Dawes' (1974) Marine Algae of the West Coast of Florida.

CYANOPHYTA

Order Coccogonales

Determinations in the order Coccogonales are based upon the revision of the coccoid Myxophyceae by Drouet and Daily (1956).

Family Chroococcaceae

Anacystis aeruginosa Drouet and Daily. Forming microscopic, gelatinous colonies on the older leaves of *Thalassia* and occasionally on *Syringodium* and *Diplanthera* at stations 1 and 5. Best developed in areas of low current velocity and low wave action, as it is readily dislodged from the leaves.

Anacystis dimidiata Drouet and Daily. This species rarely forms colonies of more than a few cells and is often found as a solitary cell or one that has recently divided and the daughter cells still have flattened adjacent faces. It is microscopic, widely distributed, but found in this study on *Diplanthera* and *Thalassia* at station 1 only.

Anacystis montana (Lightfoot) Drouet and Daily. Forming bright green patches on all species of seagrasses at stations 1, 2, 3, 5, and 6. This species is primarily a fresh water one but it will grow in estuaries. In the Anclote area it probably comes down the river as temporary plankton and becomes affixed to various solid surfaces, including seagrass leaves.

Agmenellum thermale (Kützing) Drouet and Daily. This is another bluegreen that occurs as plankton, attached lightly to solid surfaces, and lives in intertidal sand. In the Anclote area it was found only once on the surface of a *Syringodium* leaf from station 5. Since it is microscopic and requires high magnification to recognize, it is easily overlooked despite its wide distribution.

Family Chamaesiphonaceae

Entophysalis conferta Drouet and Daily. Common at all stations and at all seasons of the year on *Diplanthera, Thalassia* and *Syringodium* attached directly to the seagrass leaves and also as epiphytes of many other algae that grow epiphytically on the seagrasses. The colonies are microscopic.

Entophysalis duesta (Meneghini) Drouet and Daily. This species penetrates limestone and was found at all seasons and at all stations within the calcareous tubes of serpulid worms and the tests of Bryozoa (*Schizoporella*) on *Thalassia, Syringodium,* and *Diplanthera.* The cells of *E. deusta* tend to be oval or spherical outside limestone whereas inside limestone they tend to simulate filamentous growth. In the past, the external cells have been placed in the genus *Xenococcus* and the internal filament-like strands in the genus *Hyella* (Tilden, 1910; Desikachary, 1959).

Order Hormogonales

Family Oscillatoriaceae

The classification of the Oscillatoriaceae used here is that of Drouet (1968). The various synonyms or ecophene names of Drouet's species found in the Anclote area are indicated by their old names in order that ready reference may be made to the older literature and also in order to indicate which ecophenes of Drouet's species were present at Anclote.

Microcoleus lyngbyaceus (Kützing) Crouan. Records for this assemblage of ecophenes are given under the ecophene names below.

Lyngbya confervoides Gomont. Producing mostly horizontal masses of long filaments with a distinct sheath on blades of *Thalassia* at stations 1 and 6, year around but most abundant during late summer.

Lyngbya majuscula Gomont. Clusters of filaments on *Thalassia* and *Syringodium* at stations 2, 3, 4, and 5. It was observed at station 5 at all seasons of the year, but only sporadically at the other stations. Best development occurred in July and August. This is the largest ecophene of the species in marine waters; its trichomes reach 60 μm diam or more.

Lyngbya semiplena Gomont. This slender ecophene was found at all stations and at all seasons on the three common species of seagrasses, *Thalassia, Syringodium,* and *Diplanthera.* During the summer months, however, it developed in great abundance, forming skeins of filaments that almost covered the seagrass leaves, especially in the more shallow water stations and especially over stands of *Diplanthera.* It readily tolerates temperatures of 38° C or more.

Oscillatoria lutea C. Agardh. Forming gelatinous patches on the leaves of seagrasses at all seasons at most stations. Probably present at all stations the year around. The plant masses are usually yellow-brown or olive; the trichomes coiled or entangled in this strictly marine species, formerly *Lyngbya lutea* (C. Agardh) Gomont.

Porphyrosiphon notarisii (Meneghini) Kützing. This species was present as the ecophene, *Oscillatoria nigroviridis,* on *Thalassia* at station 2 in May. It was more abundant throughout the estuary on shells and mangrove roots in shallow water.

Schizothrix arenaria (Berkeley) Gomont. This species was present as two of its ecophenes, *sensu* Drouet 1968, as follows:

Oscillatoria laetevirens Gomont was found on *Thalassia* and *Diplanthera* at station 5 only during winter and summer, although it is probably present the year around. Its slender trichomes tend to be grouped into small cushions or pads on the grass leaves and also on bottom sediments in grass beds. Occasionally it occurs in a thin *Phormidium*-like membrane of appressed trichomes.

Microcoleus chthonoplastes Thuret, while most abundant on muddy sand bottom sediments in the intertidal zone also occurred on *Thalassia* and *Diplanthera* leaves at station 1 as thin, membranous layers of filaments several months during the year but especially in late winter.

Schizothrix calcicola (C. Agardh) Gomont. This species, as three ecophenes, was one of the most widely distributed bluegreens in the Anclote area. It was present at all stations on all species of seagrasses throughout the year.

Lyngbya digueti Gomont occurred as a microscopic turf on *Diplanthera* and *Thalassia* at stations 1 and 2, probably the year around. Its filaments were attached to the horizontal, basal parts that were curled and entangled, but the upright parts were straight and vertical.

Lyngbya epiphytica Hieronymus was most often encountered spiralling around filamentous epiphytes of all three common species of seagrasses, especially *Polysiphonia, Ceramium, Cladophora* and filamentous bluegreens. While not recorded at all stations and all seasons, it was probably present, as it is easily overlooked.

Plectonema terebrans Bornet and Flahacult is an ecophene of *S. calcicola* that bores into

limestone. It was found on *Thalassia* and *Syringodium* within the calcareous tubes or tests of serpulid worms and encrusting Bryozoa to which it usually imparts a greenish tinge. It was present at all stations the year around.

Schizothrix mexicana Gomont. Two ecophenes of *S. mexicana* were found in the Anclote area, though neither was abundant.

Lyngbya gracilis Gomont formed small tufts of filaments on all 3 seagrasses, *Diplanthera, Thalassia,* and *Syringodium,* at all times of the year and at stations 1, 2, and 3. Though widely distributed, it was never very abundant.

Lyngbya sordida, an ecophene that produces large trichomes (15-30 μm diam.) was found only on *Thalassia* at station 1; the filaments were in fasciculate tufts. It is not typical as an epiphyte.

Spirulina subsalsa Oersted. On leaves of all seagrasses at stations 1, 2, and 5 during May and July in the form of small bright bluegreen patches. Part of the collections fitted the ecophene *S. major* Gomont, as the spirals were loose, the turns several microns apart.

Family Rivulariaceae

Calothrix crustacea Schousboe and Thuret. This species is often an epiphyte and occurred on all species of seagrasses at Anclote and at all stations throughout the year. It formed small, blackish tufts when well developed, but often the growth was microscopic. This name now includes many species in a number of genera, *sensu* Drouet, 1973. Some of these plants had heterocysts at the base only and would have been referred to *C. confervicola* (Roth) C. Agardh in the older literature.

RHODOPHYTA

Order Bangiales

Family Bangiaceae

Asterocystis ramosa (Thwaites) Gobi. Though not recorded for August, *Asterocystis* appears to be year around with a peak of abundance during spring. On all 4 species of seagrasses, and at all stations except number 3.

Erythrocladia subintegra Rosenvinge. Forming microscopic red discs on *Thalassia* and *Diplanthera* during May, June, and July at station 5. It was probably present at other stations and during other months.

Erythrotrichia carnea (Dillwyn) J. Agardh. The most common member of the family in the Anclote area. Present on all species of seagrasses at all stations the year-around. During spring, when best developed, it often forms a fine red fuzz on the margin of *Diplanthera* and *Thalassia.*

Goniotrichum alsidii (Zanardini) Howe. Occasional on all 4 seagrasses and recorded once or more at stations 1, 2, 5, and 6 every month except January and May. Probably present the year around.

Order Nemalionales

Family Acrochaetiaceae

Acrochaetium sargassi Bφrgesen. On all 4 seagrasses at all stations during January, March, April, July, and August. Although this species was originally described by Bφrgesen on *Sargassum* in the Virgin Islands, it is known from a variety of algae. It was reported for Tampa Bay on *Thalassia* by Dawes (1967).

Acrochaetium thureti (Bornet) Collins and Hervey. On *Thalassia* and *Diplanthera* at stations 1 and 2, in May. This species has been reported by Taylor (1957, 1960) only from Massachusetts and Bermuda. Aziz (1965), however, found it at Beaufort, N. C., on *Gelidium crinale* and in Biscayne Bay, Miami, on *Caulerpa prolifera.*

Acrochaetium crassipes Bφrgesen. On *Diplanthera* at stations 2 and 3, April and May. This warm water species was classified as *Kylinia crassipes* (Bφrgesen) Kylin by Taylor (1960, p. 300) but we follow the opinion of Aziz (1965) who interpreted the genus *Acrochaetium* in the sense of Rosenvinge (1909).

Order Cryptonemiales

Family Squamariaceae

Peyssonnelia rubra (Greville) J. Agardh. On *Syringodium* at station 2, March. This species is usually on stones or shells and is usually well below low tide.

Family Corallinaceae

Fosliella atlantica (Foslie) Taylor. Abundant at all seasons and all stations on all species of seagrasses, at times almost completely covering the leaves, especially of *Thalassia*. This calcareous, encrusting epiphyte promotes the attachment of other epiphytic algae by offering a better substratum than the seagrass leaves themselves.

Fosliella farinosa (Lamouroux) Howe. Perhaps as abundant as *F. lejolisii* and as widely distributed, but here recorded on *Thalassia* and *Diplanthera* at stations 1 and 2 during July and August. This plant is often 2 or 3 cells thick and has colorless, swollen cells (trichocytes) terminating the cell rows. These 2 species probably reduce significantly the photosynthesis on the seagrass leaves when present in abundance.

Jania adhaerens Lamouroux. Mostly on the basal portion of leafy branches of all 4 seagrasses, but also on their leaves, at stations 1, 2, 3, and 4. Recorded for January, February, March, May, and July, but probably present the year around.

Family Hypneaceae

Hypnea musciformis (Wulfen) Lamouroux. Occasional in the form of small plants on all 3 kinds of seagrasses the year around at stations 2, 3, 4, 5, and 6, and sometimes station 1. These plants apparently break off the seagrass leaves before they get very large in response to periods of windy weather. Drifting plants often reattach to seagrass leaves by means of the hooked tips on the branches that have a tendency to enwrap anything they come in contact with very promptly if it is small enough for them to surround. Thus the abundance of *Hypnea* on seagrass beds varies with weather conditions. Large quantities may accumulate during periods of calm weather, most of which is washed ashore or out to sea during periods of windy weather. *Hypnea* grows rapidly during warm weather. It produces an abundance of kappa carrageenan as the principal cell wall constituent and for this reason is of considerable economic value.

Hypnea spinella (C. Agardh) Kützing. This small, slender species is uncommon at Anclote, having been found on *Thalassia, Syringodium,* and *Diplanthera* at stations 2, 5, and 6 only during July and August.

Order Rhodymeniales

Family Champiaceae

Champia parvula (C. Agardh) Harvey. Common on all 4 seagrasses at stations 1, 2, 3, 4, and 6 from January to April and in July and August.

Order Ceramiales

Family Ceramiaceae

Centroceras clavulatum (C. Agardh) Montagne. A common epiphyte on all 4 species of seagrasses the year around at all stations.

Ceramium byssoideum Harvey. Typical plants of this species were not common but occurred on *Diplanthera* at stations 1, 2, and 4. What is considered a form of this species was very common. It is described below.

Fig. 2. Photograph of *Ceramium byssoideum* forma *alternata* showing the alternate branching that distinguishes this form from the species in which the branching is dichotomous.

Ceramium byssoideum forma *alternatum* forma nova

C. byssoideum byssoideum persimilis, sed ramulis alternatis differt.
This form was similar to the species in all major respects including nodal cortication and various dimensions but differed in having distinctly alternate branching rather than dichotomous branching with the associated forcipate tips. This newly described form was found the year around on all 4 species of seagrasses. The type specimen has been deposited in the herbarium of the Department of Marine Science, University of South Florida, St. Petersburg (Accession number 974).

Ceramium fastigiatum (Roth) Harvey, forma *flaccidum* Peterson. This species was common and recorded from all 4 seagrasses at all months during which collections were made except January and March at stations 1, 2, and 5.

Griffithsia tenuis C. Agardh. Found only 3 times, during May, June, and July at stations 2 and 5 on *Syringodium* only.

Griffithsia globulifera Harvey. Found only once at station 2 on *Thalassia* in February.

Spyridia filamentosa (Wulfen) Harvey. One of the most common red algal epiphytes throughout the year at all stations and on all species of seagrasses. This species often originates on seagrass leaves but is torn loose by windy weather before the plants are very large. Like *Hypnea, Spyridia* also develops hooked tips at the apex of some branches and these have the ability to enwrap seagrass leaves, especially *Syringodium* and *Diplanthera,* or other algae when they come in contact for a few hours. Thus drifting plants may become reattached to seagrasses. This species also readily produces adventitious attachment organs from any axis in response to contact of sufficient duration. The peak of abundance is reached during late spring.

Family Dasyaceae

Dasya pedicellata (C. Agardh) C. Agardh. Found only once in the April collection on *Syringodium* from station 2, a small, sterile plant.

Family Rhodomelaceae

Polysiphonia havanensis Montagne. Occasional on all seagrasses at stations 1, 2, and 5 during April, May, July, and August. Best developed in spring.

Polysiphonia echinata Harvey. One of the most common red algal epiphytes, recorded from all species of seagrasses at all times of the year but best developed during March and April. During the warmer months of the year the main axes of the plants were mostly 70-100 µm in diam., but in winter and spring they were about 150 µm.

Herposiphonia tenella (C. Agardh) Ambronn. Recorded during July and August on *Diplanthera, Thalassia,* and *Syringodium* at stations 1, 5, and 6. This plant has a creeping main axis with erect, determinate branchlets.

Lophosiphonia saccorhiza Collins and Hervey. Recorded on all 4 seagrasses January through August at stations 1, 2, 5, and 6. This species also has a creeping main axis and erect, determinate branchlets, the tips of which are curved, with trichoblasts on the convex side. Humm (1964) comments on the uncertainty of this determination.

Chondria collinsiana Howe. This small species is typically an epiphyte. It was found from January through August at stations 1, 2, 4, 5, and 6 on all 4 species of seagrasses. It was not recorded for Tampa Bay by Dawes (1967).

Chondria dasyphylla (Woodward) C. Agardh. This and the following species are rarely epiphytes but occasionally attach to seagrass leaves. Small plants were found a few times at stations 1 and 5 in January, May, and July on all 4 seagrasses. Larger plants break loose or, in the case of old seagrass leaves, cause the entire leaf to break off.

Chondria tenuissima (Goodenough and Woodward) C. Agardh. Found only once on *Diplanthera* at station 2 in the January collection.

Laurencia obtusa (Hudson) Lamouroux. Found once on *Diplanthera* during January at station 2.

Laurencia poitei (Lamouroux) Howe. Found occasionally on *Thalassia* and *Syringodium*, at stations 2, 5, and 6 in February and during spring and summer. This and the previous species are rarely epiphytes and do not grow to maturity on seagrass leaves.

PHAEOPHYTA

Order Ectocarpales

Family Ectocarpaceae

Giffordia rallsiae (Vickers) Taylor. Occasional during February and April at station 2 on *Diplanthera* and *Syringodium*. This is a tropical member of the genus known throughout the West Indies and Caribbean Sea, so its presence only during winter and spring is puzzling.

Giffordia mitchellae (Harvey) Hamel. Abundant during winter and spring, but present the year around (except during July?) at all stations and on all species of seagrasses. This is a temperate species with a wide latitudinal distribution from the tropical Atlantic to Nova Scotia. In its southern range it is most abundant during winter and spring, but in its northernmost range it is a plant of summer and fall.

Order Sphacelariales

Family Sphacelariaceae

Sphacelaria furcigera Kützing. Collected during spring and summer only on *Thalassia* and *Syringodium* at stations 2, 5, and 6. It occurred around the base of the upright branches of the seagrass and not on the leaves.

Sphacelaria tribuloides Meneghini. On basal parts of the upright branches of *Thalassia* and *Syringodium* from stations 2 and 6 during March, May, and July. It was probably present the year around.

Order Chordariales

Family Chordariaceae

Cladosiphon occidentalis Kylin. This species appeared on *Thalassia* in December, was most abundant on this seagrass and occasionally on the other 3 at most stations until early May when it disappeared. During winter and spring it was the most conspicuous brown alga in the area. The form in which it is present during the warmer months is not yet known.

Family Myrionemataceae

Ascocyclus magnusii Sauvageau. Common on *Thalassia* at station 2 during March. It was probably widely distributed during winter and spring, but apparently not present during the summer months. This species forms microscopic discs on the leaf surface. Known from Florida to New England but in its northern range it is a plant of spring and summer. Taylor (1960) and Earle (1969) list it as *A. orbicularis* Magnus.

Order Dictyosiphonales

Family Stictyosiphonaceae

Myriotrichia subcorymbosa (Holden) Blomquist. Abundant on *Diplanthera,* especially in the shallow water stations 1 and 2 the year around; occasional on *Thalassia* and *Syringodium.* It is often the most common epiphyte on *Diplanthera,* forming a fine brown fuzz or fringe. Although it is abundant throughout the West Indies and around the entire Florida coastline, Taylor (1960) reports it for North Carolina only and (1957) from Maryland to Massachusetts, both as *Ectocarpus subcorymbosus* Farlow *emend.* Holden.

Stictyosiphon subsimplex Holden. Abundant on all 3 seagrasses, but especially on *Diplanthera,* during winter (from November) and spring (until early May) at all stations but especially at the shallow water stations just below mean low tide. This species occurs from the West Indies to Nova Scotia. In its southern range it is present during winter and spring; in its northern range it is ephemeral, and present during the fall or during spring and fall, almost exclusively on the fresh and brackish water grass, *Ruppia.* Taylor (1957) reported it for Connecticut and southern Massachusetts only; it is not listed in his 1960 publication. Fiore (1970) has shown that this species is the sporophyte and *Myriotrichia subcorymbosa* the gametophyte of a plant that exhibits a life history influenced by environmental conditions. He has proposed a name change for this plant in a forthcoming publication. Earle (1969, figs. 98, 105, 107) provides excellent illustrations of this species and discusses its distribution in the Gulf of Mexico.

CHLOROPHYTA

Order Ulotrichales

Family Pleurococcaceae

Pseudotetraspora antillarum Howe. Found from January to May at stations 1, 2, and 5 on all 4 species of seagrasses. Young plants frequently appeared to become established on the seagrass leaves at the vortex of the spirals of calcareous tubes (about 1 mm diam.) of a serpulid worm.

Family Gomontiaceae

Gomontia polyrhiza (Lagerheim) Bornet and Flahault. Creeping on the surface of the leaves of *Thalassia* and *Diplanthera* and penetrating empty surface cells of the host. The filament of the alga is markedly constricted at the point of penetration of the cell and the cells are generally irregular, reaching a maximum diam. of 20 μm, considerably greater than filaments that penetrate limestone, a common characteristic of this species. It was found during July only at stations 5 and 6, but since it is a microscopic species easily overlooked, it may be present at Anclote the year around. While previously reported as penetrating wood (Bornet and Flahault, 1888), apparently this is the first report of this species penetrating seagrass leaves.

Family Chaetophoraceae

Entocladia viridis Reinke. This is another microscopic species that creeps within the surface polysaccharide of a great variety of larger algae. Though recorded only during July as an epiphyte of *Polysiphonia echinata* from a *Thalassia* leaf, it is very likely that it is a year-around alga in the surface layer of larger species at all stations and from all species of seagrasses.

Phaeophila dendroides (Crouan) Batters. Found upon the leaves of all 4 seagrasses and occasionally upon larger algae that were seagrass epiphytes; stations 1, 2, 5, and 6 in the July and August collections, but probably the year around. This microscopic species, though very common, is easily overlooked.

Ulvella lens Crouan. Recorded on *Thalassia* leaves at stations 1 and 2 during May only. This species is also microscopic, easily overlooked, and probably occurs on all species of seagrasses at all stations the year around.

Order Ulvales

Family Ulvaceae

Enteromorpha chaetomorphoides Bφrgesen. Although this is a tropical species, it was recorded during January and February only at station 4 on *Thalassia* and *Diplanthera* but wrapped around or entangled among the seagrasses rather than attached.

Enteromorpha clathrata (Roth) J. Agardh. Although this is a common, year-around species in the area, it was found epiphytic only on *Thalassia* and only during April at station 4.

Enteromorpha prolifera (Müller) J. Agardh. Another year around and abundant species that reaches a peak of development during winter and spring. It was recorded as an epiphyte, however, only during January at stations 1 and 4 on *Diplanthera, Thalassia,* and *Syringodium.* A number of juvenile *Enteromorpha* plants were not recorded because of the lack of critical characters that would permit reasonably confident determinations.

Order Cladophorales

Family Cladophoraceae

Chaetomorpha brachygona Kützing. Though not found attached to seagrasses it was present entangled among the leaves at all seasons at stations 2 and 5.

Cladophora sericea (Hudson) Kützing. Small plants were common the year around but most abundant during winter and spring at all stations except number 3 and on all species of seagrasses. These plants would mostly fall within the range of *C. gracilis, C. glaucescens,* or *C. flexuosa sensu* Collins (1909) and Taylor (1957, 1960). The monograph of van den Hoek (1963) has been followed in this determination.

Rhizoclonium hookeri Kützing. Found on *Syringodium* and *Halophila* at station 2 in January and February.

Rhizoclonium kerneri Stockmayer. Common from May to August and probably during the fall on all species of seagrasses at stations 1, 2, 3, 5, and 6. This almost microscopic plant often forms a green fuzz on seagrass leaves.

Order Siphonales

Family Derbesiaceae

Derbesia vaucheriaeformis (Harvey) J. Agardh. Found during all seasons on *Halophila, Syringodium,* and *Diplanthera* at station 5 only. *Halicystis osterhoutii,* said to be another form of this plant, has not been reported along the Florida Gulf Coast. It may occur on rocky areas off shore in deep water.

Caulerpa prolifera (Forsskal) Lamouroux. While not an epiphyte of a seagrass in the same sense as other species listed in this paper, a small plant of *C. prolifera* was collected attached to the basal portion of an erect branch of *Thalassia* at station 5 in May. A cluster of rhizoids at the base of the plant held a clump of sediment but the plant was not attached to the bottom. The *Caulerpa* zygote or "seed" material may have originally lodged upon the *Thalassia* plant.

Acknowledgments—Grateful acknowledgment is made to Florida Power Corporation of St. Petersburg for a graduate research stipend and expense funds that made this work possible.

LITERATURE CITED

Aziz, K. M. S. 1965. *Acrochaetium* and *Kylinia* in the Southwestern North Atlantic Ocean. Ph.D. Dissert. Duke Univ. Durham, N.C.

Baird, R. C. (ed.) 1972. Anclote Environmental Project Report for 1971. Dept. Marine Sci. Univ. S. Florida. pp. 251. (Mimeographed)

Bornet, E., and C. Flahault. 1888. Note sur deux nouveaux genres d'algues perforantes. J. de Bot. 2:161-165.

Collins, F. S. 1909. The green algae of North America. Tufts College Stud. (Sci. Ser.) 2(3):79-480.

Dawes, C. J. 1967. Marine algae in the vicinity of Tampa Bay, Florida. Privately reproduced. pp. 150 + 9 pl.

_____. 1974. Marine Algae of the West Coast of Florida. Univ. Miami Press. Coral Gables.

Desikachary, T. V. 1959. Cyanophyta. Indian Council of Agricultural Research. New Delhi.

Drouet, F., and W. A. Daily. 1956. Revision of the coccoid Myxophyceae. Butler Univ. Bot. Stud. 12:1-218.

_____. 1968. Revision of the classification of the Oscillatoriaceae. Acad. Nat. Sci. Philadelphia Monogr. 15:1-370.

_____. 1973. Revision of the Nostocaceae with Cylindrical Trichomes. Hafner Publ. Co. New York.

Earle, Sylvia A. 1969. Phaeophyta of the eastern Gulf of Mexico. Phycologia 7:71-254.

_____. 1972. Benthic algae and seagrasses. *In* Bushnell, V. C. (ed.). Serial Atlas of the Marine Environment. Folio 22:15-18 + pl. 6. Amer. Geogr. Soc. New York.

Feigl, J. L., and T. E. Pyle. 1973. Application of aerial photography to the study of seagrass beds and turbidity in a Florida estuary. *In* Anclote Environmental Report for 1972. Dept. Marine Sci. Univ. S. Florida. Appendix 3B:199-204. (Mimeographed)

Fiore, J. 1970. Life History Studies of Phaeophyta from the Atlantic Coast of the United States. Ph.D. Dissert. Duke Univ. Durham, N.C.

Hoek, C. van den. 1963. Revision of the European Species of *Cladophora*. E. J. Brill. Leiden.

Humm, H. J. 1956. Sea grasses of the northern Gulf coast. Bull. Mar. Sci. 6:305-308.

_____. 1964. Epiphytes of the sea grass, *Thalassia testudinum*, in Florida. Bull. Mar. Sci. 14:306-341.

_____. 1973. Seagrasses. *In* Jones, J. I. et al. (eds.). A Summary of Knowledge of the Eastern Gulf of Mexico. pp. IIIC-1 to IIIC-10. Amer. Petrol. Inst. Washington, D.C.

_____, and Sylvia Earle Taylor. 1961. Marine Chlorophyta of the upper west coast of Florida. Bull. Mar. Sci. 11:321-380.

Johansson, R. J. O., and T. L. Hopkins. 1973. Primary productivity. *In* Anclote Environmental Report for 1972. Dept. Marine Sci. Univ. S. Florida pp. 48-59. (Mimeographed)

Pyle, T. E., J. C. McCarthy, and G. M. Griffin. 1973. Reconnaissance mapping of turbidity in estuaries. *In* Anclote Environmental Report for 1972. Dept. Marine Sci. Univ. S. Florida. Appendix IB:189-196. (Mimeographed)

Rosenvinge, L. K. 1909. The marine algae of Denmark. Part I, Rhodophyceae I. Kgl. Dansk Vidensk. Selsk. Skrifter, Nat. og. Mathem, Af. 7, Raekke, 7(1):1-151.

Taylor, W. R. 1957. Marine Algae of the Northeastern Coast of North America. Rev. ed. Univ. Michigan Press. Ann Arbor.

_____. 1960. Marine Algae of the Eastern Tropical and Subtropical Coasts of the Americas. Univ. Michigan Press. Ann Arbor.

Tilden, J. E. 1910. Minnesota Algae, Vol. I. The Myxophyceae of North America and Adjacent Regions Including Central America, Greenland, Bermuda, the West Indies, and Hawaii. Univ. Minn. Bot. Ser. 8:1-328.

Zimmerman, R. J., R. A. Dietz, T. E. Pyle, S. W. Rogers, N. J. Blake, and H. J. Humm. 1973. Benthic community—seagrasses. *In* Anclote Environmental Report for 1972. Dept. Marine Sci. Univ. S. Florida. pp. 115-141. (Mimeographed)

Florida Sci. 38(3):150-162. 1975.

ELEMENTAL ANALYSIS OF SELECTED MERRITT ISLAND PLANTS

David H. Vickers, Roseann S. White, and I. Jack Stout

Department of Biological Sciences, Florida Technological University, Orlando, Florida 32816

Abstract: *Samples of mature leaves from various plant species were collected from experimental plots located at Kennedy Space Center during August 1973 and April 1974. Concentrations of the following elements were measured in each of the samples using atomic absorption techniques: K, Na, Ca, Mg, Fe, Mn, Zn, Cu, and Al. The concentrations of B and Mo were found to be below the sensitivity of the method.*

Elemental composition of selected plant species at Kennedy Space Center was determined to establish base levels so that future studies could be initiated to discover whether solid fuel rocket launchings cause perturbations in the quantities of elements commonly recognized as essential for normal plant growth and development. The complexity of comparative mineral nutrition of plants has been reviewed extensively by Gerloff (1963). The 10 primary elements essential to all plants are: carbon (C), hydrogen (H), oxygen (O), nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sulfur (S), magnesium (Mg) and iron (Fe). At least 5 other elements, manganese (Mn), zinc (Zn), boron (B), copper (Cu), and molybdenum (Mo) are required in minute amounts for the growth of most plants and sodium (Na), aluminum (Al), silicon (Si), chlorine (Cl), gallium (Ga), vanadium (V), and cobalt (Co) have been shown to be essential for the normal growth of some species of plants. However, not all species require the same elements or the same concentrations of elements, and some species even accumulate elements to concentrations that are toxic to other plant species.

Materials and Methods—Plant material was collected from two areas on north Merritt Island, Florida. Sample areas 1-8 are located on a poorly drained site with a hardpan and seasonal flooding is typical. The plant community is similar to that found over much of Florida and referred to as pine flatwoods (Edmisten, 1963) but the community sampled is unique in not having a pine overstory. Sample areas 9-16 are located on a deep, well-drained soil which does not flood. The plant community is best characterized as scrubby flatwoods (Laessle, 1942:29).

Smith (1962) reviewed mineral analysis of plant tissue and determined that: a) leaf samples most accurately reflect the elemental composition of the whole plant; and b) the elemental content of mature leaves is less in a state of flux than that of young leaves. He reported that 25 selected leaves from a citrus tree will give a valid measure of the elemental composition of the entire plant. We accepted his findings and sampled accordingly.

Mature terminal leaves from each of the chosen plant species were collected in August 1973 near the end of the rainy season. Foliar leaching should have

equilibrated by this time. Species sampled included saw palmetto (*Serenoa repens*), *Quercus minima, Q. pumila, Q. myrtifolia,* and *Q. chapmanii.* Limited samples were taken of wax myrtle (*Myrica cerifera*), *Ilex glabra,* and *Lyonia fruticosa,* since they did not occur on all experimental plots. Three of the species (*S. repens, Q. chapmanii,* and *Q. myrtifolia*) were also sampled in April of 1974, as was the additional species, *Q. virginiana.* Leaf material in the April sample had been set at the end of the dry season and probably little foliar leaching had occurred.

Leaves were picked with new disposable plastic gloves and frozen until analyzed. The samples were dried at 110°C for 24 hr and weighed to the nearest mg. The method of Kometani, et al. (1972) was used to ash plant samples for atomic absorption analysis. Tissues were placed in acid washed borosilicate beakers and heated at 300°C for 30 min in order to prevent flaming and loss of matter which results from heating at higher temperatures. The samples were then heated at 550°C for 1 hr. This procedure reduced the plant tissues to an inorganic ash which was extracted twice with w/w nitric acid. The extract was heated almost to dryness and brought up to a final volume of 10 ml with distilled water. The concentrations of 11 elements (K, Na, Ca, Mg, Fe, Mn, Zn, Cu, Al, B, Mo) were measured in each of these samples using a Perkin-Elmer Model 303 Atomic Absorption Unit (Perkin-Elmer Corp., 1966).

RESULTS—A summary of all data is presented in Table 1. The two columns indicate the August 1973 and April 1974 sampling dates respectively. The most extensive data exist for saw palmetto. In all cases the concentrations of boron and molybdenum were below the lower limits of detection for the method employed, i.e., 22 and 2 ppm respectively.

Data presented in Table 1 follow the same general pattern reported for other plant tissues. The majority of the cations present in all of the 9 species analyzed could be accounted for by Na, K, Ca, and Mg. The extreme variation within species makes it almost impossible to make any definite statements as to seasonal variations and differences among plots of the same species. The atomic absorption unit used for these determinations is $\pm 5\%$ accurate and if one allows another $\pm 5\%$ for weighing and dilution errors, a total variance of $\pm 10\%$ might occur. In many cases, the variance greatly exceeded 10%. One can conclude that considerable variation occurs naturally from plot to plot and from plant to plant. Seasonal variations are also to be considered (Woodwell, 1974). For example, data for *Serenoa repens* clearly show that the potassium concentration of spring growth (April 1974) is significantly greater than late summer growth (August 1973); while sodium exhibits the opposite behavior.

Two species (*Serenoa repens* and *Quercus minima*) were collected extensively over 16 experimental plots representative of pine flatwoods (plots 1-8) and scrubby flatwoods (plots 9-16). Data from the two areas were compared with no significant differences found. It would appear the physical location of these species did not significantly affect mineral content.

In order to see species differences element by element more clearly, data presented in Table 1 have been plotted on Fig. 1-9 as ppm of a given element

TABLE 1. Elemental concentration (ppm/g dry tissue) of leaf tissue from selected plant species collected on North Merritt Island, Florida.

	Potassium		Sodium		Calcium		Magnesium	
Species	Aug.[a]	Apr.	Aug.	Apr.	Aug.	Apr.	Aug.	Apr.
A. *Serenoa repens*	5100	9100	3800	2400	830	1100	1500	1440
std. dev.	±1200	±1900	±1700	±840	±230	±270	±410	±310
B. *Ilex glabra*	4300	-	2400	-	2700	-	970	-
	-		-		-		-	
C. *Lyonia fruticosa*	5600	-	870	-	6300	-	1500	-
std. dev.	±3500		±330		±2700		±270	
D. *Myrica cerifera*	2800	-	3400	-	10,000	-	7000	-
std. dev.	±610		±310		±1600		±1200	
E. *Quercus chapmanii*	8100	8700	2600	420	9900	5300	3800	1600
std. dev.	±2300	±1800	±1600	±82	±4600	±950	±2100	±150
F. *Q. minima*	5700	-	2600	-	8000	-	2300	-
std. dev.	±2400		±4300		±3400		±1300	
G. *Q. myrtifolia*	5100	6200	900	530	7200	4300	2600	1600
std. dev.	±1100	±1100	±400	±180	±3500	±790	±560	±74
H. *Q. pumila*	5200	-	800	-	18,000	-	2400	-
std. dev.	±2500		±270		±7000		±70	
I. *Q. virginiana*	-	8300		760	-	2200	-	1700
std. dev.		±450		±230		±390		±100

	Iron		Manganese		Zinc		Copper		Aluminum	
	Aug.[a]	Apr.	Aug.	Apr.	Aug.	Apr.	Aug.	Apr.	Aug.	Apr.
A. *Serenoa repens*	19	23	16	30	7.7	13	1.9	3.7	5.0	7.8
std. dev.	±6.8	±6.9	±3.1	±9.6	±2.8	±3.3	±.82	±1.2	±.91	±3.2
B. *Ilex glabra*	3.9	-	43	-	24	-	8.8	-	100	-
	-		-		-		-		-	
C. *Lyonia fruticosa*	6.4	-	43	-	21	-	7.0	-	61	-
std. dev.	±1.8		±27		±9		±3.2		±34	
D. *Myrica cerifera*	6.6	-	34	-	27	-	6.2	-	87	-
std. dev.	±1.4		±11		±5.5		±1.4		±26	
E. *Quercus chapmanii*	74	55	77	64	22	19	5.2	6.2	47	24
std. dev.	±15	±11	±26	±31	±2.7	±2.8	±1.3	±1.4	±18	±6.2
F. *Q. minima*	69	-	55	-	26	-	8.7	-	120	-
std. dev.	±40		+25		±7.3		±9.6		±190	
G. *Q. myrtifolia*	64	53	100	140	29	30	4.1	5.4	51	35
std. dev.	±26	±21	±16	±26	±3.0	±6.0	±1.0	±.53	±8.0	±14
H. *Q. pumila*	8.5	-	41	-	31	-	6.9	-	81	-
std. dev.	±6.4		±33		±.71		0		±2.8	
I. *Q. virginiana*	-	63	-	104	-	34	-	11	-	41
std. dev.		±8.7		±140		±5.4		±2.8		±15

[a]Samples from August, 1973 and April, 1974.

per g dry tissue versus plant species. The figures are self explanatory so only points of special interest are discussed below.

Potassium (Fig. 1). As already noted, potassium content of palmetto tissues is much higher in April than in August. All 5 oak species included in this study contained 5,000 to 9,000 ppm potassium. As in palmetto, the concentration of K was higher during April than in August for *Q. chapmanii* and *Q. myrtifolia*. *Myrica cerifera* contained the least amount of potassium of all 9 species analyzed.

Sodium (Fig. 2). Sodium was less abundant during April than in August in *S. repens*, *Q. chapmanii*, and *Q. myrtifolia* in opposition to K increases. *Myrica cerifera*, which contained the least amount of K, contained one of the highest Na contents. The oaks, as a group, were about the same as *Lyonia fruticosa* with respect to Na content, being only about 1/3 to 1/4 that of palmetto. *Quercus chapmanii* contained much more Na during August 1973 than did the rest of the oaks but by April 1974 had fallen to a very low value.

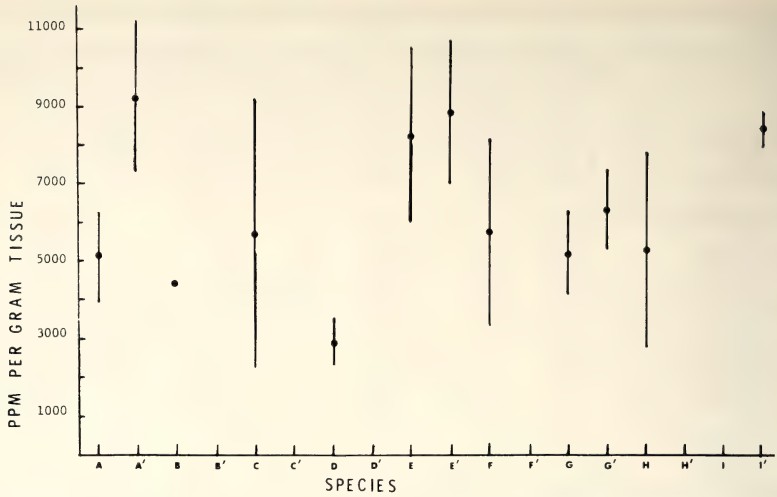

Fig. 1. Potassium content of leaves of native plants of Kennedy Space Center. Species code is provided in Table 1. Samples A-I were collected in August, 1973 and samples A′-I′ in April, 1974. Data are shown as means ± one standard deviation.

Calcium (Fig. 3). Palmetto contained very small amounts of calcium at all times, whereas the other plant species as a group had significantly higher levels. *Quercus pumila* had the highest Ca content of all 9 species. One oak species (*Q. chapmanii*) showed a decrease in Ca during the spring, while a second (*Q. myrtifolia*) showed an increase. The observed seasonal changes, however, were not as great as those for Na and K.

Magnesium (Fig. 4). Magnesium plays a critical role in plant metabolism as it is required for chlorophyll synthesis as well as in many essential enzymatic systems. The Mg content of palmetto was about the same during August and

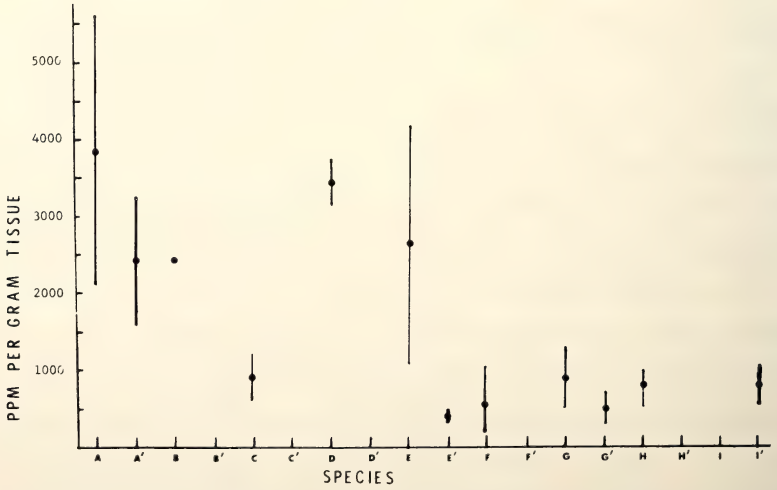

Fig. 2. Sodium content of leaves of native plants of Kennedy Space Center. See Fig. 1 for explanation.

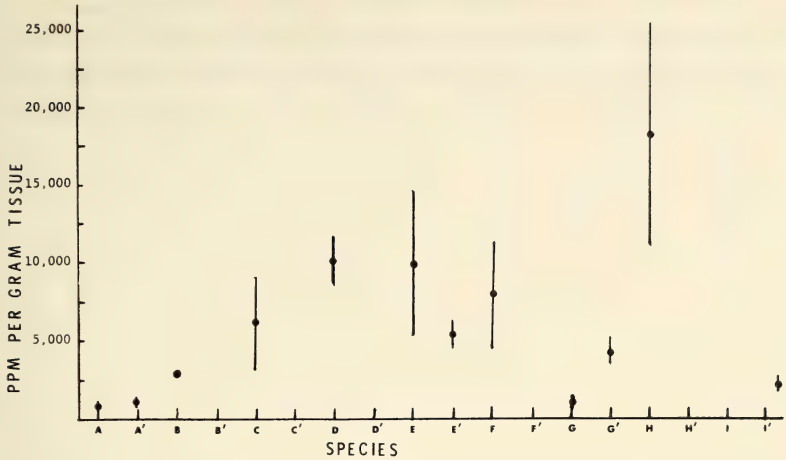

Fig. 3. Calcium content of leaves of native plants of Kennedy Space Center. See Fig. 1 for explanation.

April. *Quercus chapmanii* and *myrtifolia* both showed significant increases in Mg during August as compared to April although the variability in tissue concentrations was much less during April than in August. *Myrica cerifera* averaged 7,000 ± 1,200 ppm Mg, which was much higher than the other 8 plant species. Most other species ranged about 2,000 ppm Mg.

Iron (Fig. 5). The oaks, with the exception of *Q. pumila,* were considerably higher in Fe content than the 4 other species tested. Seasonal variations from

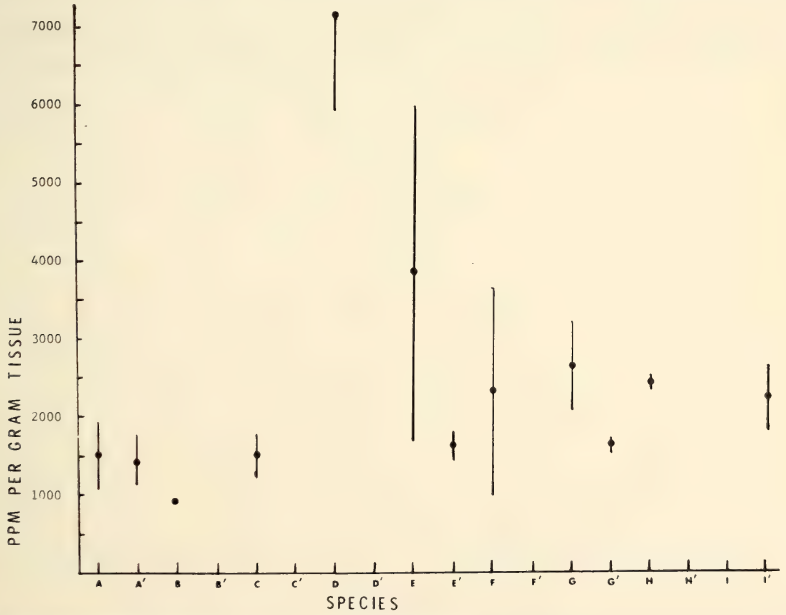

Fig. 4. Magnesium content of leaves of native plants of Kennedy Space Center. See Fig. 1 for explanation.

August to April seemed to be minor, although decreases were observed during April as compared to August for 2 oak species. *Ilex glabra, Lyonia fruticosa,* and *Myrica cerifera* contained very little iron, possibly indicating poor uptake of this element by these plants or an ability on their part to survive on limited amounts.

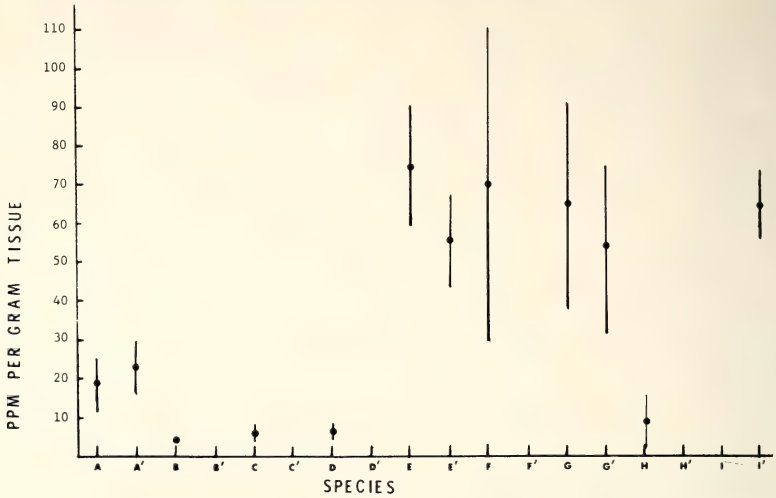

Fig. 5. Iron content of leaves of native plants of Kennedy Space Center. See Fig. 1 for explanation.

Manganese (Fig. 6). As with iron, the oaks showed the highest concentrations of Mn with *Q. pumila* containing the least amount (41 ppm). This species also contained the least amount of iron of the 5 oak species. Except for *Lyonia fruti-*

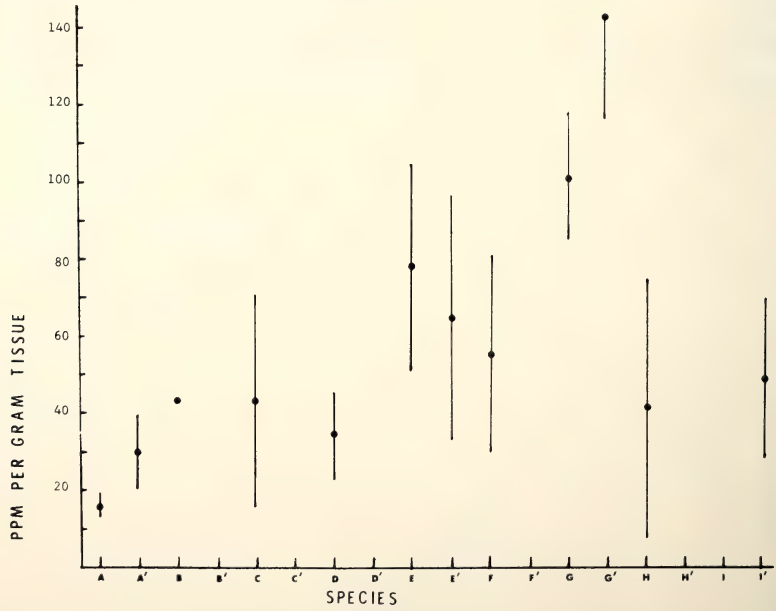

Fig. 6. Manganese content of leaves of native plants of Kennedy Space Center. See Fig. 1 for explanation.

cosa and *Ilex glabra* all species contained less than 40 ppm Mn. Palmetto and *Q. myrtifolia* contained greater amounts of Mn in April than during August, while *Q. chapmanii* contained lesser amounts during April than in August.

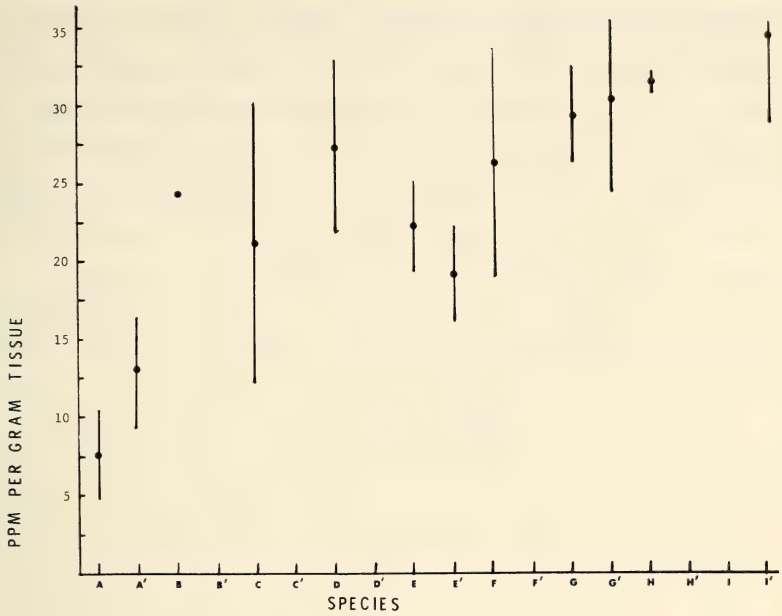

Fig. 7. Zinc content of leaves of native plants of Kennedy Space Center. See Fig. 1 for explanation.

Zinc (Fig. 7). Palmetto contained significantly less Zn than did the other 8 plant species. *Quercus virginiana* contained 34 ppm which was the highest avg recorded for all species. Seasonal variations were minor with 2 species declining

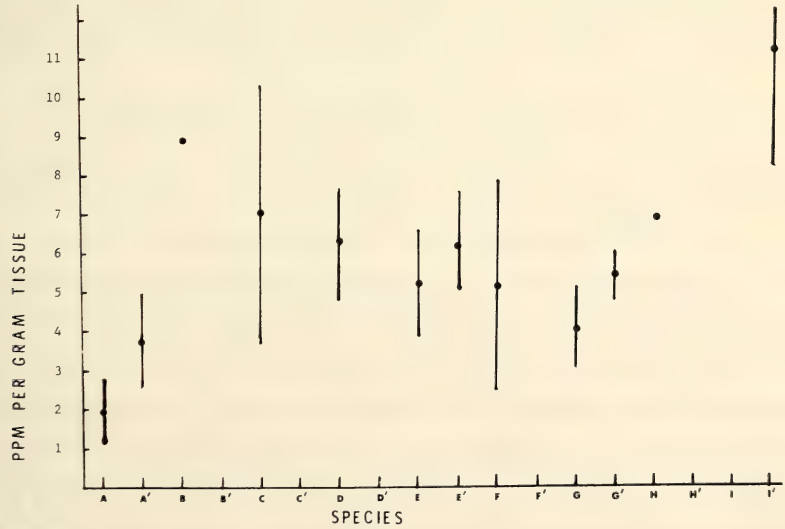

Fig. 8. Copper content of leaves of native plants at Kennedy Space Center. See Fig. 1 for explanation.

in August as compared to April and one increasing. The changes, in either case, were not statistically significant.

Copper (Fig. 8). As was the case with Zn, palmetto contained the least amount of Cu. Most of the other species contained 5-7 ppm Cu. *Quercus virginiana* contained 11 ppm Cu—the highest for any species. Copper content was higher in April than in August for all 3 species studied over both these time periods.

Aluminum (Fig. 9). Aluminum is of particular interest to us because it is the major combustion product of solid rocket fuel. *Serenoa repens* contains very little Al in comparison with the rest of the elements and appears to contain about the same amount in April as in August. *Quercus chapmanii* and *myrtifolia,* on the other hand, contain more Al later in the growing season (August) than during early summer (April). *Myrica cerifera, Ilex glabra* and *Quercus pumila* all contained more than 80 ppm Al. It appears that the single monocot (*Serenoa repens*) is able to exclude or otherwise reduce its Al uptake more effectively than the remaining 8 dicot species.

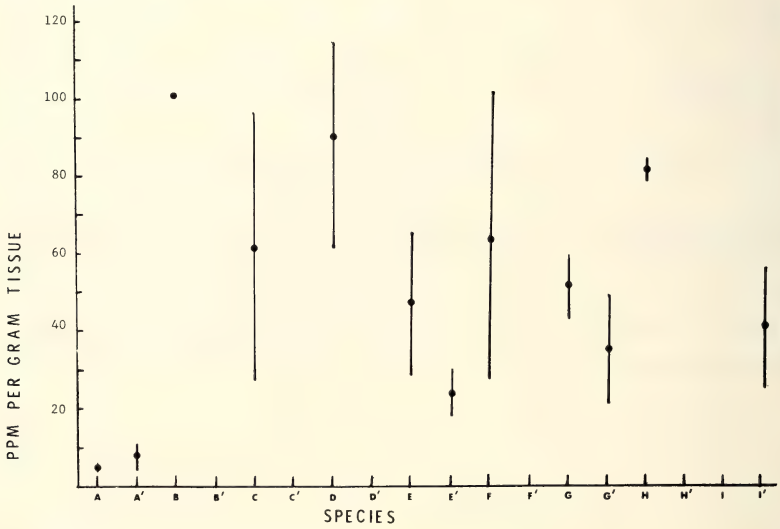

Fig. 9. Aluminum content of leaves of native plants at Kennedy Space Center. See Fig. 1 for explanation.

Discussion—Data obtained in the present study provide a baseline upon which to evaluate future studies of the plants of the area under investigation. Extreme variability was indicated in the mineral content of the plants encountered in the present study. Certain correlations were, however, noted:

Palmetto is quite low in Ca, Zn, Cu, and Al with respect to the other plants. Based on our data, K concentrations appear to be highest in the spring and lowest during the fall; while Na follows an inverse relationship. *Myrica cerifera* had the lowest K content of all 9 species studied and one of the highest Na and Ca contents. *Myrica cerifera* also contained the greatest amount of Mg of all species studied. Although the oaks as a group contained relatively high concentrations of Fe and Mn, *Q. pumila* contained the least amount of these two elements

among the 5 oak species studied. At the same time, *Q. pumila* contained the highest concentration of Ca of all 9 species of plants and one of the higher Al contents. Our observations suggest that the concentration of one element should not be studied in isolation, and that consideration must be given to how the presence or absence of one element relates to other elements.

ACKNOWLEDGMENTS—The authors thank Ms. Carole Hall for technical support in preparation of some of the samples for atomic absorption. The study was made possible only through the financial support and facilities provided by the National Aeronautics and Space Administration, Kennedy Space Center (Grant No. NGR 10-019-009) to Florida Technological University.

LITERATURE CITED

EDMISTEN, J. A. 1963. The Ecology of the Florida Pine Flatwoods. Ph.D. Dissertation. Univ. Florida. Gainesville.

GERLOFF, G. C. 1963. Comparative mineral nutrition of plants. Ann. Rev. Pl. Physiol. 14:107-124.

KOMETANI, T. Y., J. L. BOVE, B. NATHANSON, S. SIEBENBERG, AND M. MAGYAR. 1972. Dry ashing of airborne particulate matter on paper and glass fiber fitters for trace metal analysis by atomic absorption spectrometry. Environ. Sci. Technol. 6:617-620.

LAESSLE, A. M. 1942. The plant communities of the Welaka area. Univ. Florida Pub. 4(1):1-143.

PERKIN-ELMER CORP. 1966. Analytical Methods for Atomic Absorption Spectrophotometry. Perkin-Elmer Corp. Norwalk, Conn.

SMITH, P. F. 1962. Mineral analysis of plant tissue. Ann. Rev. Pl. Physiol. 13:81-108.

WOODWELL, G. M. 1974. Variation in the nutrient content of leaves of *Quercus alba, Quercus coccinea,* and *Pinus rigida* in the Brookhaven Forest from bud-break to abscission. Amer. J. Bot. 61:749-753.

Florida Sci. 38(3):163-171. 1975.

Biological Sciences

RANGE EXTENSIONS FOR, AND AN ABNORMALITY IN, SCORPAENID FISHES COLLECTED OFF THE CAROLINAS

WILLIAM D. ANDERSON, JR., JAMES F. MCKINNEY, AND WILLIAM A. ROUMILLAT

Grice Marine Biological Laboratory, College of Charleston, 205 Fort Johnson, Charleston, South Carolina 29412; and Department of Vertebrate Zoology (Fishes), National Museum of Natural History, Washington, D. C. 20560

ABSTRACT: *Specimens of* Pontinus nematophthalmus, Scorpaenodes tredecimspinosus, *and* Ectreposebastes imus *taken in the western North Atlantic off the Carolinas represent northeastward extensions of the known ranges of these species. A specimen of* Scorpaena agassizi *captured off Cape Lookout, North Carolina, shows abnormalities of the dorsal fin and supporting structures.*

RECENT collections of scorpaenid fishes off North and South Carolina have provided specimens which extend the known ranges of *Pontinus nematophthalmus* (Günther)—the spinythroat scorpionfish, *Scorpaenodes tredecimspinosus* (Metzelaar)—the deepreef scorpionfish, and *Ectreposebastes imus* Garman and a specimen of *Scorpaena agassizi* Goode and Bean—the longfin scorpionfish—with abnormalities of the dorsal fin and supporting structures.

A specimen (62 mm SL) of *Pontinus nematophthalmus* was caught southeast by south of Cape Lookout, North Carolina (34°07.7′N, 76°10.5′W, depth 71 to 143 m, R/V EASTWARD, field no. GMBL 73-65, 2050-2220 hrs, 15 May 1973, by trawl). Eschmeyer (1969) reported the distribution of this species as Florida (R/V OREGON sta. 5301), the Bahamas, throughout the Caribbean, and south to about the Amazon off Brazil in depths of about 82 to 411 m. The collection of the specimen off Cape Lookout represents an extension of the known range of the species of approximately 840 km northeastward along the Atlantic coast of the United States from R/V OREGON station 5301 at 27°18′N, 79°57′W.

Because we have seen no published descriptions of live coloration for *P. nematophthalmus* or of preserved material with appreciable remnants of live coloration, we are including notes made on our specimen 10 days after preservation.

Four "poorly defined saddles" of dusky pigment present beneath dorsal fin (as noted by Eschmeyer, 1969). Body with two orange bars—first beginning near base of pectoral fin and slanting obliquely backward and disappearing at saddle below posterior part of spiny dorsal fin, second beginning above anterior part of anal fin and running almost vertically to disappear in saddle of dusky pigment below soft dorsal fin. Caudal fin with about four orange bars on proximal two-thirds of fin—the posterior three anastomosing. Considerable orange pigment at base of spiny dorsal fin—continuing onto fin membrane at level of ninth and tenth spines; proximal half of soft dorsal fin with numerous patches of orange pigment. Anal fin with orange pigment in an area from third spine through first and second softrays. Left pectoral fin with two oblique bars of orange pigment beginning near dorsal margin, slanting backward, and ceasing at about middle rays of fin; these bars crossing about middle of each ray involved; a small blotch of orange pigment near base of fin covering middle rays. Pelvic fins with areas of orange pigment over softrays three through five. Remainder of specimen pale except for some dusky pigment on distal part of posterior portion of spiny dorsal fin.

A specimen (41 mm SL) of *Scorpaenodes tredecimspinosus* was obtained east southeast of Cape Fear, North Carolina (33°37.4′N, 77°07.5′W, depth 37 to 38 m, R/V EASTWARD sta. 23151, field no. GMBL 73-196, 2040-2112 hrs, 8 November 1973, by trawl). This species is distributed widely in the tropical western Atlantic—localities of capture include Florida, the Bahamas, Dominica, Honduras, Panama, Venezuela, Dutch West Indies, and Los Roques in depths of about 8 to 82 m (Eschmeyer, 1969). The collection of the specimen off Cape Fear represents an extension of the known range of the species of approximately 580 km northeastward along the Atlantic coast of the United States from the most northerly locality (29°09′N, 80°12′W, R/V SILVER BAY sta. 4419) listed by Eschmeyer (1969).

A specimen (60 mm SL) of *Ectreposebastes imus* was collected southeast by east of Charleston Light, South Carolina (32°11′N, 78°56′W, depth 256 m, R/V OREGON II sta. 11732, field no. GMBL 72-42, 1815-1930 hrs, 23 January 1972, by trawl). This species has a very extensive range in tropical and subtropical waters, having been reported from the eastern Pacific, off Hawaii, off Japan, eastern Atlantic, and western Atlantic—off the Mississippi Delta, Honduras, Colombia, Puerto Rico, and northeast Florida (Eschmeyer and Collette, 1966; Eschmeyer, 1969; Maruyama, 1970; Collette and Uyeno, 1972; and Eschmeyer and Randall, in press). Although Eschmeyer and Randall note that *E. imus*

is a near-bottom species, some individuals have been obtained by midwater trawls at considerable distances off the bottom. The capture of the specimen reported herein represents an extension of the known range of the species of approximately 280 km northeastward along the Atlantic Coast of the United States from northeast Florida (29°54.5′N, 80°10′W, R/V OREGON stas. 5233 and 5234).

An abnormal specimen (54 mm SL) of *Scorpaena agassizi* was collected southeast by south of Cape Lookout, North Carolina, in the same tow as the *Pontinus nematophthalmus* discussed above. The usual number of dorsal-fin spines in this species is 12, but our specimen has only eight. A radiograph shows that the spiny dorsal fin and anterior pterygiophores are grossly distorted. The first dorsal-fin spine is quite small and far anterior to the rest of the fin. The second and third dorsal-fin spines are absent, as is the antepenultimate spine even though the pterygiophores with which it would be associated (if it were present) appear normal. We have not been able to determine which spine is the fourth one missing from the usual dorsal complement. In other respects this specimen agrees with the description of *S. agassizi* as given by Eschmeyer (1965). Eschmeyer (1965) noted a similar abnormality in *Scorpaena isthmensis.*

We thank Gene R. Huntsman (National Marine Fisheries Service, NMFS) for inviting two of us to accompany his group on cruises of the R/V EASTWARD and Bennie A. Rohr (NMFS) for aiding our collecting activities aboard the OREGON II. William N. Eschmeyer (California Academy of Sciences) sent us a copy of the pertinent pages of a manuscript that he and John E. Randall have in press. Norman A. Chamberlain (Grice Marine Biological Laboratory, GMBL), Bruce B. Collette (NMFS), and William N. Eschmeyer reviewed the manuscript. The material examined is housed in the collections of the Grice Marine Biological Laboratory. This is contribution number 35 of the Grice Marine Biological Laboratory, College of Charleston.

LITERATURE CITED

COLLETTE, B. B., AND T. UYENO. 1972. *Pontinus niger,* a synonym of the scorpionfish *Ectreposebastes imus,* with extension of its range to Japan. Japanese J. Ichthyol. 19:26-28.

ESCHMEYER, W. N. 1965. Western Atlantic scorpionfishes of the genus *Scorpaena,* including four new species. Bull. Mar. Sci. 15:84-164.

———. 1969. A systematic review of the scorpionfishes of the Atlantic Ocean (Pisces:Scorpaenidae). Occ. Pap. Calif. Acad. Sci. 79:i-iv + 1-143.

———, AND B. B. COLLETTE. 1966. The scorpionfish subfamily Setarchinae, including the genus *Ectreposebastes.* Bull. Mar. Sci. 16:349-375.

———, AND J. E. RANDALL. In press. The scorpaenid fishes of the Hawaiian Islands, including new species and new records. Proc. Calif. Acad. Sci.

MARUYAMA, K. 1970. Some deep-water fishes from off the Tohoku and adjacent regions. Bull. Tohoku Reg. Fish. Res. Lab. 30:43-66. (In Japanese, not seen in translation.)

Florida Sci. 38(3):171-173. 1975.

NOTES ON THE INTRODUCED GECKO *HEMIDACTYLUS GARNOTI* IN SOUTH FLORIDA

ROBERT VOSS

7393 SW 79th Court, Miami, Florida 33143

OCCURRENCE of breeding populations of the gecko *Hemidactylus garnoti* in south Florida was first noted by King and Krakauer (1966) who reported that it had been introduced prior to 1964, and existed in two widely separated localities in Coconut Grove and southwest Miami. Truitt and Ober (1971) subsequently also listed it as occurring in the area. For the past 7 or 8 years I have observed this lizard in and about my home in southwest Miami.

Since 1966, the range of *H. garnoti* has spread, and it is now found throughout most south Miami suburbs. Where found, it is relatively common, strictly nocturnal, and measures 50-60mm (snout-vent). At night, the adult is a uniform ash-grey save for the orange ventral surface of the tail. When discovered in hiding during the day, *H. garnoti* is a darker brownish-grey with lighter mottlings. The newborn young are darker than adults and have lightly banded tails.

Hemidactylus garnoti is most frequently seen on warm nights on lighted walls and on the screens of lighted rooms where it feeds upon the moths attracted there. It actively pursues its prey in a series of short, quick rushes. During the day I have found *H. garnoti* under dead leaves and rocks, and under the bark of trees. Like *H. turcicus,* it squeaks faintly when caught. I have not heard it vocalize on other occasions.

The eggs are nearly round, smooth, white and brittle, measuring 7-10mm in diam. They are laid, invariably in pairs, from June to January in enclosed dry places such as flower pots, gardening gloves, and piles of brick. They are often cemented together, or to some hard surface. After an incubation period of about 60 days, the young hatch. The newborn lizards have a snout-vent length of 24-26mm.

Despite occasional cold winters, *H. garnoti* appears to be doing well in south Florida and its range appears to be expanding. As we have no native nocturnal lizards in the area, *H. garnoti* fills a previously unoccupied niche in which it may be expected to continue to thrive.

Thanks are expressed to Dr. Roger Conant who encouraged publication of these observations.

LITERATURE CITED

KING, W., AND T. KRAKAUER. 1966. The exotic herpetofauna of southeast Florida. Quart. J. Florida Academy Sci. 29:144-154.

TRUITT, J. C., AND L. D. OBER. 1971. A Guide to the Lizards of South Florida. Hurricane Press. Miami.

KEY TO THE MOSSES OF PUERTO RICO

Harvey A. Miller and Keith W. Russell

Department of Biological Sciences, Florida Technological University, Orlando, Florida 32816; and Science Library, University of Houston, Houston, Texas 77004

Abstract: *Identification of genera included in Crum and Steere* Mosses of Porto Rico *is simplified by provision of a generic key not included in the original work. The key is artificial and based upon vegetative characters.*

Study of mosses of Puerto Rico in connection with ecological studies of an elfin forest organized by Richard A. Howard (1968) led us to recognize the need for a key to genera of mosses. Crum and Steere (1957) did not provide a key to larger groups in their manual Mosses of Porto Rico and the Virgin Islands thereby limiting its maximum usefulness to those already pretty well grounded in bryology. Accordingly, we undertook preparation of a key to genera as represented by the 268 taxa treated in the manual. Further, we sought to provide for identification of sterile material with the inevitable result that some genera occur more than once in the key where a contrasting pair of characteristics might be represented by different species within a genus. The key is totally artificial and limited to the flora noted. It cannot be reliably used elsewhere—indeed, the Puerto Rican species is sometimes unusual within the genus (e.g., *Tortula*) and could lead to serious mis-identifications in other floras. We hope that the existence of the key will stimulate collecting by students and others resident in Puerto Rico so that we may learn more of its most interesting bryoflora.

We thank Richard A. Howard for the opportunity to participate in the elfin forest study supported by a National Science Foundation grant (GB-3975) to the Arnold Arboretum. Howard A. Crum most kindly reviewed an early draft of the key and provided valuable suggestions.

KEY TO GENERA

The number which precedes the generic name is the page number where the key to species or generic description will be found in Crum and Steere.

1 Branches in fascicles, leaves dimorphous on stems and branches, large empty porose cells in a network of elongate, narrow chlorophyllose cells .... 404. Sphagnum

1 Branches dichotomous or pinnate but not regularly fascicled, leaves rarely dimorphous, leaf cells essentially homogeneous in upper blade 2

2 Plants erect and unbranched or dichotomously so, female sexual buds terminal on main stem (acrocarpous mosses) 3

2 Plants prostrate and usually freely branched, female sexual buds lateral and several on a single stem (pleurocarpous mosses) 57

3 Leaves with numerous lamellae on upper surface of the costa, peristome with a diaphragm and 32 or 64 teeth (Polytrichales) 4
3 Leaves without lamellae on upper surface of the costa, peristome toothed or absent, rarely diaphragmed (Bryales) 5
4 Leaves 3—3.5 mm long, bordered by elongate cells ..... 587. ATRICHUM
4 Leaves 5—7 mm long, not bordered ..... 584. POGONATUM
5 Leaves in two ranks at the insertion, the antical base of the leaf split into conduplicate blades ..... 407. FISSIDENS
5 Leaves in three or more ranks, more or less transversely inserted, leaf blade single throughout 6
6 Leaves whitish, mostly several cells thick with outer layers of enlarged leucocysts with a single ± median layer of reduced chlorocysts, leaf blade reduced and costa comprising most of the leaf (Leucobryaceae) 7
6 Leaves green to blackish or brown, blades unistratose, costa lacking leucocysts 9
7 Leaves with a false costa (stereid band), often toothed on back or with serrulate margins ..... 444. LEUCOPHANES
7 Costa homogeneous throughout, margin of the costa entire 8
8 Leaves plane, oblong above with parallel sides abruptly narrowed to cuspidate tip ..... 444. OCTOBLEPHARUM
8 Leaves grooved, tapered above, tip acute to acicular ..... 441. LEUCOBRYUM
9 Inner basal cells much enlarged and hyaline, sharply differentiated from the blade (Calymperaceae) 10
9 Inner basal cells various, but not hyaline or sharply differentiated 11
10 Leaves almost always with narrow intramarginal bands of transparent linear cells 2—12 cells from margin, sometimes extending only a short distance above the base ..... 446. CALYMPERES
10 Leaves lacking intramarginal bands of elongate cells, unbordered, or bordered at margins only with pale elongate cells, or with serrate wings ..... 452. SYRRHOPODON
11 Leaves ecostate or costa very short, sometimes double 12
11 Leaves costate, costa single 13
12 Leaves narrowly lanceolate, margin serrulate to toothed, plants minute (*Micromitrium*, see Crosby, 1968) ..... 484. NANOMITRIUM
12 Leaves ovate, margins entire, plants medium to large ..... 535. HOOKERIA
13 Leaf cells smooth or papillose only by projecting ends of elongate cells, cells mostly elongate to rhomboid above 14
13 Leaf cells pluripapillate to rounded or conic papillate, cells mostly isodiametric above 36
14 Alar cells sharply differentiated, often pigmented and auriculate 15
14 Alar cells undifferentiated from other basal cells 17
15 Leaves with a hyaline border of elongate cells ..... 439. LEUCOLOMA
15 Leaves unbordered or border faint and not hyaline 16
16 Costa narrow and about the same width over its length, leaves strongly toothed above the expanded base ..... 438. HOLOMITRIUM
16 Costa broad below, tapering to the apex, leaves entire or denticulate near the tip, leaf base auriculate in the alar region but otherwise not expanded ..... 433. CAMPYLOPUS
17 Branching dichotomous or none, rarely in a comal whorl, stems leafy throughout, leafless prostrate primary stem absent 18
17 Branches erect and abundant from a leafless prostrate primary stem 55
18 Leaf cells elongate, thick-walled and papillose by projecting ends 19
18 Leaf cells variously shaped but smooth 20
19 Leaves plicate at base, basal cells linear ..... 493. BREUTELIA
19 Leaves not plicate at base, basal cells rectangular to isodiametric .. 494. PHILONOTIS

20 Leaf cells rounded-quadrate above, at least as wide as long, leaves unbordered 21
20 Leaf cells elongate rectangular to rhomboid, leaves sometimes bordered by a band of elongate cells 23
21 Leaf margin thickened and doubly serrate ..... 492. Rhizogonium
21 Leaf margin one cell thick and entire or singly toothed 22
22 Leaves obovate, sheathing at the base ..... 463. Rhamphidium
22 Leaves not sheathing ..... 474. Barbula
23 Costa subpercurrent to excurrent, leaf blade often narrowed above and subulate 24
23 Costa ending well below the leaf apex, leaf blade broad above and often rounded at the apex 28
24 Leaves with an expanded base and a narrowed tip, often subulate and comprised entirely of a strong excurrent costa 25
24 Leaves ovate to elliptical or obovate, widest above the base, costa percurrent to short-excurrent 32
25 Leaf blade oblong, narrow above and extending around the subpercurrent costa, the obtuse apex toothed ..... 430. Trematodon
25 Leaf blade tapering toward the acute to acuminate tip 26
26 Subulate leaf tip about 3 times longer than leaf base, seta strongly curved ..... 430. Campylopodium
26 Subulate leaf tip less than 2.5 times the length of the leaf base which tapers to tip, seta erect and straight 27
27 Leaves strongly clasping, capsule stomatose, peristome 250—450 μ high ..... 424. Anisothecium
27 Leaves not conspicuously clasping, capsule without stomata, peristome rarely as much as 300 μ high ..... 425. Dicranella
28 Leaves dimorphic, lateral leaves elliptical and dorsal leaves smaller and lanceolate, cells lax, becoming very narrow along the reddish border ..... 486. Epipterygium
28 Leaves all alike, cells lax with unbordered leaves or, if leaves are bordered, then cells firm 29
29 Leaf cells lax, thin-walled, rectangular-rhomboid becoming much enlarged below, leaves unbordered 30
29 Leaf cells firm, rhomboid-hexagonal above, elongate below, leaves distinctly bordered with a band of elongate cells 31
30 Costa ending well below apex, leaves 1.5—2 mm long ..... 431. Wilsoniella
30 Costa usually ending 2—5 cells below apex, leaves 0.3—1.3 mm long ..... 479. Splachnobryum
31 Border 1—3 cells wide all around, leaves not keeled ..... 534. Leskeodon
31 Border 5—15 cells wide at base, 2 cells wide at apex, leaves keeled with a median fold ..... 532. Daltonia
32 Leafy shoots arising from a prostrate, rhizome-like stem, leaves appearing whorled above and more than 10 mm long ..... 487. Rhodobryum
32 Leafy shoots erect, leaves all along stem, though sometimes larger above, not more than 5 mm long 33
33 Leaves plane or nearly so, leaf cells lax and thin-walled, rectangular to oblong, stem green and parenchymatous 34
33 Leaves mostly keeled, leaf cells firm, short-rhomboid to narrowly rectangular, stem usually pigmented and firm 35
34 Leaf margin entire or weakly toothed above, costa subperrent to short-excurrent ..... 483. Funaria
34 Leaf margin denticulate in upper half, costa ending well below apex ..... 483. Entosthodon

35 Stems bearing large reddish propagula, leaf cells oblong-hexagonal, up to 3 times as long as broad ..... 486. BRACHYMENIUM
35 Stems lacking propagula, leaf cells usually more than 3 times as long as broad ..... 488. BRYUM
36 Leaves distinctly bordered by a band of elongate thick-walled cells, alar cells inflated or strongly differentiated ..... 439. LEUCOLOMA
36 Leaves unbordered above or indistinctly so, alar cells undifferentiated 37
37 Branching dichotomous or none, stems leafy throughout, leafless prostrate primary stem absent 38
37 Branches erect and abundant from a prostrate leafless primary stem 53
38 Leaf cells thin-walled, elongate to rhomboid below the apex, basal cells thin-walled and lax 39
38 Leaf cells mostly thick-walled and isodiametric, basal cells often somewhat elongate and usually thick-walled 40
39 Leaf apex broadly rounded on spathulate leaf, costa ending well below apex ..... 481. GYMNOSTOMIELLA
39 Leaf apex obtuse on ovate-lanceolate leaf, costa subpercurrent ..463. RHAMPHIDIUM
40 Leaves with a band of elongate, hyaline thin-walled cells extending up the margin from the leaf base 41
40 Leaves with cells of basal margin undifferentiated or at least not hyaline 42
41 Costa ceasing shortly below leaf apex, upper cells not papillose, leaves 2—2.5 mm long, keeled ..... 479. LUISIERELLA
41 Costa excurrent, often as a mucro, upper cells densely papillose, leaves 3—9 mm long ..... 470. TORTELLA
42 Leaf margins plane when wet, sometimes slightly involute near the tip 43
42 Leaf margins curled, either involute or revolute near the base 46
43 Leaves oblong to lanceolate, gradually tapering to the base 44
43 Leaves long and slender with a somewhat expanded leaf base broader than the blade 45
44 Stems radiculose, leaves keeled ..... 459. ANOECTANGIUM
44 Stems not radiculose, leaves not keeled ..... 473. HYOPHILA
45 Costa excurrent as a hyaline or yellow mucro, leaves usually involute at margins, at least above ..... 466. TRICHOSTOMUM
45 Costa subpercurrent, margins plane ..... 464. TUERCKHEIMIA
46 Leaf margins involute throughout or at the base 47
46 Leaf margins revolute throughout or at the base 49
47 Leaves 1.5—2.0 mm long, leaf tapering to a lanceolate tip ..... 460. HYMENOSTOMUM
47 Leaves 2.0—3.5 mm long above (rarely 1.5 mm below), leaves oblong above from an expanded base 48
48 Leaves sharply keeled above ..... 461. WEISSIA
48 Leaves involute but not sharply keeled ..... 466. TRICHOSTOMUM
49 Leaves bordered by a band of elongate cells ..... 478. TORTULA
49 Leaves unbordered 50
50 Leaf margins denticulate to dentate above, papillae C-shaped ..... 476. BRYOERYTHROPHYLLUM
50 Leaf margins entire, papillae various 51
51 Leaves widest at about the middle, plants small and bud-like, upper leaf cells thin-walled, capsule immersed ..... 477. PHASCUM
51 Leaves widest near the base, plants with elongate stem, upper leaf cells incrassate, capsule exserted 52
52 Costa disappearing below the apex ..... 462. GYMNOSTOMUM
52 Costa percurrent to excurrent ..... 474. BARBULA

53 Leaves bordered at the base by elongate cells, inner basal cells short ..... 498. GROUTIELLA
53 Leaves unbordered all around, basal cells all elongate 54
54 Secondary stems not tomentose, leaves usually 2—6 mm long ..... 500. MACROMITRIUM
54 Secondary stems tomentose, leaves usually 1.5—2.0 mm long ..... 505. SCHLOTHEIMIA
55 Leaves bordered at the base by elongate cells, inner basal cells short ..... 498. GROUTIELLA
55 Leaves unbordered all around, basal cells all elongate 56
56 Secondary stems not tomentose, leaves usually 2—6 mm long ..... 500. MACROMITRIUM
56 Secondary stems tomentose, leaves usually 1.5—2.0 mm long ..... 505. SCHLOTHEIMIA
57 Leaves with costa single 58
57 Leaves with costa double or none 86
58 Leaves dimorphous, lateral leaves large and complanate, dorsal leaves smaller and nearly transversely inserted 59
58 Leaves all of one type and of about uniform size 61
59 Leaves strongly inrolled from tip when dry ..... 506. HELICOPHYLLUM
59 Leaves somewhat contorted but not inrolled when dry 60
60 Lateral branch leaves bordered, costa ending about 3/4 leaf length ..... 554. HYPOPTERYGIUM
60 Leaves not bordered, costa excurrent ..... 507. RHACOPILUM
61 Leaf cells papillose 62
61 Leaf cells smooth 69
62 Leaf cells isodiametric or short and up to 3 times longer than broad 63
62 Leaf cells elongate to linear, at least 5 times longer than broad 65
63 Paraphyllia absent, leaves 1.5—2.0 mm long ..... 564. STEREOPHYLLUM
63 Paraphyllia present, usually abundant, leaves less than 1.2 mm long 64
64 Apical cells of branch leaves bearing single sharp papilla ..... 558. HAPLOCLADIUM
64 Apical cells of branch leaves bearing 2 or more papillae ..... 556. THUIDIUM
65 Leafy stem complanate with flattened branches ..... 527. POROTRICHUM
65 Leafy stem not flattened, with leaves equally distributed around the stem 66
66 Leaves acute to acuminate, upper margins plane ..... 511. LEUCODONTOPSIS
66 Leaves attenuated to a slender hairpoint, upper leaf margin often undulate 67
67 Cells pluripapillate ..... 519. PAPILLARIA
67 Cells unipapillate 68
68 Branches terete, densely foliate, branch leaves abruptly acuminate forming a jointed hair point ..... 520. METEORIUM
68 Branches slightly flattened, laxly foliate, branch leaves gradually acuminate forming a filiform, flexuose-crispate point ..... 521. AEROBRYOPSIS
69 Leaf cells above isodiametric to short-ovate or rhomboid, up to 3 times longer than broad 70
69 Leaf cells linear, at least 5 times longer than broad 77
70 Leaf margins distinctly bordered by a band of elongate cells 71
70 Leaf margins unbordered 72
71 Border 1—3 cells wide all around, leaves not keeled ..... 534. LESKEODON
71 Border 5—15 cells wide at base, 2 cells wide at apex, leaves keeled with a median fold ..... 533. DALTONIA
72 Leaf gradually tapered to an acute to slenderly acuminate tip 73
72 Leaf broadly rounded to truncate or obtuse at the tip 75

73 Leaf margin somewhat inrolled, entire to minutely serrulate above ..... 509. ACROCRYPHAEA
73 Leaf margin plane, crenulate by bulging cells 74
74 Costa extending 2/3 to 3/4 of leaf, margins crenulate toward tip, cells rhomboid ..... 555. HELICODONTIUM
74 Costa extending 1/2 to 2/3 of leaf, margins entire or subserrulate at branch tips, cells oblong-linear ..... 555. FABRONIA
75 Leaves ovate becoming narrower toward the apex ..... 527. POROTRICHUM
75 Leaves oblong, about the same width to near the truncate apex 76
76 Leaves truncate to emarginate at apex ..... 524. NECKEROPSIS
76 Leaves broadly rounded and toothed at apex ..... 525. HOMALIA
77 Leaf margin entire or serrate in the upper half 78
77 Leaf margin strongly toothed nearly to the base 96
78 Leaves plicate below 79
78 Leaves plane to concave but not plicate below 80
79 Leaves 1.5—2.0 mm long, costa ending at, or slightly above, mid-leaf ..... 561. BRACHYTHECIUM
79 Leaves 3—4 mm long, costa ending in acumen ..... 509. DENDROPOGONELLA
80 Upper leaf margins inrolled below, abruptly acuminate tip borne on a broadly oval blade ..... 516. SQUAMIDIUM
80 Upper leaf margins plane, leaf tip acute to acuminate from ovate or oblong blade 81
81 Alar cells short, rounded to quadrate, sometimes yellow 82
81 Alar cells undifferentiated 85
82 Costa percurrent or nearly so 83
82 Costa ending near mid-leaf 84
83 Leaf axils usually bearing filiform microphyllous branchlets, leaves imbricate when dry ..... 512. PSEUDOCRYPHAEA
83 Leaf axils without microphyllous branchlets, leaves erect spreading .. 514. PIREELLA
84 Alar cells poorly differentiated ..... 514. PIREELLA
84 Alar cells well differentiated ..... 564. STEREOPHYLLUM
85 Leaf margins entire ..... 508. CRYPHAEA
85 Leaf margins serrate or serrulate, at least in upper 1/3 ..... 527. POROTRICHUM
86 Leaves in two ranks (distichous) at insertion on the stem, or leaves dimorphous with dorsal leaves erect and reduced 87
86 Leaves inserted all around the stem and of one type, although some may be complanate but not distichous or dimorphous 88
87 Leaf cells densely papillose, leaves less than 1 mm long ..... 498. ERPODIUM
87 Leaf cells smooth, leaves 2—4 mm long ..... 523. PHYLLOGONIUM
88 Costa extending to beyond mid-leaf 89
88 Costa short, rarely attaining mid-leaf, or none 98
89 Leaves strongly plicate ..... 552. HEMIRAGIS
89 Leaves plane to concave but not plicate 90
90 Leaf cells thick-walled, isodiametric to oval, undifferentiated or slightly longer at the base 91
90 Leaf cells thin-walled to firm, cells rhomboid to linear becoming lax below 92
91 Costae ending well below the leaf apex, without dorsal spines .... 530. PILOTRICHUM
91 Costae subpercurrent, ending abruptly in blunt dorsal spines .. 530. PILOTRICHIDIUM
92 Leaf cells nearly isodiametric or laxly hexagonal 93
92 Leaf cells narrow to nearly linear and prosenchymatous 94
93 Leaves bordered, leaf cells smooth ..... 536. CYCLODICTYON
93 Leaves unbordered, leaf cells usually papillose ..... 538. CALLICOSTELLA
94 Leaf cells bearing 3 or 4 papillae ..... 548. HYPNELLA

94 Leaf cells smooth 95
95 Lateral leaves asymmetric, leaf margins plane ..... 539. HOOKERIOPSIS
95 Leaves uniform, leaf margins recurved, at least in lower 1/2 .. 543. ACTINODONTIUM
96 Costa percurrent ..... 514. PIREELLA
96 Costa ending well below the tip 97
97 Leaves wide-spreading from the stem, leaves more or less plane 522. METEORIOPSIS
97 Leaves erect-spreading from the stem, leaves concave .....562. RHYNCHOSTEGIUM
98 Leaf cells papillate over the lumen or lateral walls, often pluripapillate 99
98 Leaf cells smooth or papillate only by projecting ends of cells 102
99 Alar cells undifferentiated 100
99 Alar cells differentiated with 2 or 3 often inflated and sometimes pigmented 101
100 Leaves concave, oblong-ovate, papillae several, multifid ..... 548. HYPNELLA
100 Leaves complanate, broadly lingulate, small papillae at the upper cell ends and 1 or 2 near the middle of the cell ..... 576. GLOSSADELPHUS
101 Leaf cells unipapillate, leaves with long flexuous tips ..... 574. TRICHOSTELEUM
101 Leaf cells pluripapillose, leaves acute to acuminate ..... 575. TAXITHELIUM
102 Leaf cells laxly rhomboid to elongate above but not linear or narrowly sinuose 103
102 Leaf cells mostly firm, rarely thin-walled, and linear to sinuose 112
103 Leaves with alar cells inflated at the basal angles 104
103 Leaves with alar cells not or slightly differentiated 105
104 Upper cells rhomboidal, peristome single .....568. MEIOTHECIUM
104 Upper cells elongate, peristome double ..... 568. SEMATOPHYLLUM
105 Plants unbranched or nearly so, robust with ovate leaves 4—5 mm long, cells 40—60 × 100—150 μ ..... 535. HOOKERIA
105 Plants branched pinnately to abundantly so, sometimes from a prostrate rhizome-like stem, leaves less than 4 mm long, leaf cells usually narrow 106
106 Leaf base oval, deeply concave, abruptly prolonged into a long flexuose awn ..... 549. STENODICTYON
106 Leave base various, gradually narrowed to the tip or blunt 107
107 Plants regularly pinnately branched, leaves grass green, falcate-secund ..... 581. VESICULARIA
107 Plants irregularly branched or forming an expanded frond, leaves complanate or erect-spreading, often yellowish 108
108 Leaves oblong with a nearly truncate tip bearing coarse teeth ..... 525. HOMALIA
108 Leaves ovate or broader toward the base, often attenuate at the tip 109
109 Leaves lanceolate, tapering to a long acuminate, coarsely serrate tip, branches hooked at tips ..... 550. RHYNCHOSTEGIOPSIS
109 Leaves broader with tip from a broader base, margin entire to serrate, branches not hooked at tips 110
110 Leaf margin entire, unbordered, ecostate, leaf cells 150—200 μ ..... 553. LEUCOMIUM
110 Leaf margin usually serrulate to serrate above, costa extending nearly to mid-leaf, leaf cells smaller 111
111 Leaf cells elongate-rhomboidal above, leaves 2—2.5 mm long, brood filaments often borne in leaf axils ..... 544. LEPIDOPILIDIUM
111 Leaf cells narrowly hexagonal to linear, leaves usually longer than 2.5 mm, brood filaments absent ..... 544. LEPIDOPILUM
112 Alar cells inflated, oblong, often yellowish, in a single basal row, sharply defined 113
112 Alar cells none or a weakly defined group of quadrate cells, not inflated or slightly so 115
113 Leaves 2.5—3.0 mm long with a long, flattened serrate acumen ..... 572. RHAPHIDOSTICHUM

113 Leaves 1.0—2.0 mm long, or when longer with a tubulose tip and nearly entire margins 114
114 Leaves homomallous or secund ..... 568. SEMATOPHYLLUM
114 Leaves erect-spreading to wide-spreading ..... 572. ACROPORIUM
115 Leaves strongly curved at the tips and very asymmetric, strongly complanate and plane ..... 529. ISODREPANIUM
115 Leaves straight and symmetric, or somewhat curved and asymmetric, if curved then falcate-secund and not strongly complanate 116
116 Leaves with axillary cylindrical propagula 117
116 Leaves lacking axillary propagula, uniformly distributed paraphyllia or other accessory structures sometimes present on stems 119
117 Leaf margins entire or serrulate 118
117 Leaf margins serrate to the base ..... 560. LEPYRODONTOPSIS
118 Leaf margins entire, costa lacking ..... 513. ORTHOSTICHIDIUM
118 Leaf margins serrulate to base, costa variable on same plants ..... 513. JAEGERINA
119 Large pendent mosses 10—30 cm long with deeply concave, broadly ovate to obovate leaves with a cuspidate-acuminate tip ..... 518. PILOTRICHELLA
119 Prostrate forms, mostly much smaller with narrower leaves 120
120 Leaf margins entire 121
120 Leaf margins serrulate to serrate 122
121 Branches strongly complanate, appearing 2-ranked ..... 566. PLAGIOTHECIUM
121 Branches weakly complanate, dorsal and ventral leaves erect-spreading ..... 578. ISOPTERYGIUM
122 Minute plants to 10 mm long with narrowly lanceolate leaves less than 1 mm long, 8—10 small quadrate alar cells ..... 567. PTEROGONIDIUM
122 Plants larger, leaves more than 1 mm long, alar cells none or different from *Pterogonidium* 123
123 Alar cells numerous, quadrate and hyaline, extending from mid-leaf base to the basal angle and up the margin ..... 563. ENTODON
123 Alar cells absent or slightly differentiated at the basal angles 124
124 Branches strongly complanate, leaves broad with each marginal tooth bifid ..... 546. CROSSOMITRIUM
124 Branch somewhat complanate with dorsal and ventral leaves erect-spreading, sometimes falcate-secund 125
125 Leaf cells papillose on back by projecting ends of the cells ..... 582. MITTENOTHAMNIUM
125 Leaf cells smooth on back or nearly so 126
126 Leaves symmetric, complanate and widely spreading ..... 580. TAXIPHYLLUM
126 Leaves asymmetric, falcate-secund, slightly complanate ..... 577. ECTROPOTHECIUM

LITERATURE CITED

CROSBY, M. R. 1968. *Micromitrium* Aust., an earlier name for *Nanomitrium* Lindb. Bryologist 71:114-117.

CRUM, H. A., AND W. C. STEERE. 1957. The mosses of Porto Rico and the Virgin Islands. Sci. Surv. Porto Rico & Virgin Islands 7:395-599.

HOWARD, R. A. 1968. The ecology of an elfin forest in Puerto Rico, 1. Introduction and composition studies. J. Arnold Arboretum 49:381-418.

Florida Sci. 38(3):175-182. 1975.

INVASION OF A RENOVATED POND BY WALKING CATFISH, *CLARIAS BATRACHUS* (LINNAEUS), AND OTHER SPECIES

Lothian A. Ager

Florida Game and Fresh Water Fish Commission, Lake Okeechobee Biological Station, Okeechobee, Florida 33472

Abstract: *Renovation of a borrow pit twelve months after initial renovation revealed pond invasion by at least seven and possibly eleven species of fish including the potentially noxious walking catfish,* Clarias batrachus *(Linnaeus), via a shallow drainage ditch connecting with a small stream.*

Establishment of the walking catfish, *Clarias batrachus* (Linnaeus), in the fresh waters of south Florida was recorded as early as 1968 by Lachner, et al. (1970). This exotic fish and others in south Florida have recently received considerable attention by investigators (Courtenay, 1970; Courtenay and Ogilivie, 1971; Courtenay and Robins, 1973; and Courtenay, et al., 1974) as to occurrence, distribution and environmental impact on native organisms. The spread of the walking catfish in south Florida has been confined only by the ocean on the east. From the presumed area of escape the fish now resides in the fresh waters of at least seven counties in southeastern Florida. The species was first recorded from Lake Okeechobee in 1970. This paper describes the invasion by the walking catfish of a small freshwater borrow pit after renovation. The borrow pit is located in section 25 of Township 37 South, Range 36 East in Okeechobee County and is in the upper reaches of the Nubbin Slough watershed.

Materials and Methods—The borrow pit of about one surface acre and a maximum depth of nearly 13 ft, with typically soft, acid, tannin stained water was renovated in April 1973 with rotenone at a concentration of 2 ppm. No walking catfish were observed. The pit contained an assortment of native species. Within 2 wk after renovation, 200 lbs. of dolomite and 8 bales of hay were scattered along the pond edge for enhancement of invertebrate and zooplankton production. Thirty days after renovation the borrow pit was stocked with approximately 50 pairs of adult mosquitofish and 14 bluegill, 5 males and 9 females, to establish a forage fish base.

Nine snook were stocked in the pond in October for an over-winter survival study. It was during October and November that rainfall filled the pond to overflowing via a shallow ditch which connected to Nubbin Slough drainage between 0.25 and 0.5 miles from the pit.

Results and Discussion—In April 1974 (12 months after initial renovation) the pond was again renovated with rotenone at a concentration of 2 ppm to determine the over-winter survival of the introduced snook. Table 1 provides a list of species and weight of fishes recovered upon renovation. Without a spillway, invasion of the pond during overflow in this area of little topographic relief was accomplished by no less than 7 species of fishes, possibly 11. A total of 48 adult walking catfish had invaded the pond. Adult warmouth, lake chubsucker, Flor-

ida gar, bowfin and brown and yellow bullheads were recovered upon renovation indicating pond invasion.

Goldspotted topminnow, golden shiner, flagfish and dollar sunfish may have survived the initial rotenone treatment. Though less likely, they may have been carried to the pond by vectors such as wading birds or water spouts as explanation of their presence. However, the presence of these species are of little consequence in fish pond management.

TABLE 1. Fishes recovered from a borrow pit renovated with rotenone, April 1974.

Species	Number	Weight (lbs.)	Percent Weight
Snook	9	12.9	9.5
Largemouth Bass	7	5.4	4.0
Bluegill (adults)	NR[1]	18.6	13.7
Warmouth (adults)	NR	9.0	6.6
Lake Chubsucker (adults)	NR	25.2	18.6
Florida gar	3	1.0	0.7
Bowfin	4	11.0	8.1
Brown and yellow bullheads	NR	35.5	25.7
Walking catfish	48	14.1	10.4
Other (Forage)	NR	5.0	3.7
Goldspotted topminnow			
Dollar sunfish			
Mosquitofish			
Golden shiner			
Flagfish			
Bluegill (juveniles)			
Warmouth (juveniles)			
Lake chubsucker (juveniles)			
Totals	71	137.7	100.0

[1]NR = Not Recorded.

It is evident from these findings that workers renovating ponds for restocking purposes should take into account the effects of temporary water drainage into and out of ponds. Invasion of adult fishes resulting in potential establishment of populations such as the one described could easily occur resulting in immediate unbalance. Where ponds exist with surroundings subject to flooding or overflow connection to permanent water bodies where exotics are suspected to be present within the watershed, workers should exercise some precautionary measures in pond management and experimentation to insure exclusion of these invaders.

LITERATURE CITED

COURTENAY, W. R., JR. 1970. Florida's walking catfish. Ward's Nat. Sci. Bull. 10(69):1-6.

———, AND V. E. OGILIVIE. 1971. Species pollution; introduced animals and the balance of nature. Animal King. 74:22-28.

———, AND C. R. ROBINS. 1973. Exotic aquatic organisms in Florida with emphasis on fishes: a review and recommendations. Trans. Am. Fish Soc. 102:1-12.

———, H. F. SAHLMAN, W. MILEY, II, AND D. J. HERREMA. 1974. Exotic fishes in fresh and brackish waters of Florida. Biol. Cons. 6(4):292-302.

LACHNER, E. A., C. R. ROBINS, AND W. R. COURTENAY, JR. 1970. Exotic fishes and other aquatic organisms introduced into North America. Smithsonian Contrib. Zool. 59:1-29.

Florida Sci. 38(3):183-184. 1975.

FLORIDA JUNIOR ACADEMY OF SCIENCES

PROCEEDINGS, 1975 ANNUAL MEETING

Cooperation by Mr. Johns Virgil Mixson, State Director of the Junior Academy for 1975, has allowed us once again to present abstracts for the top three presentations in each category recognized by the Junior Academy. We can take pride in the accomplishments of our students in the Junior Academy as they prepare for careers in the sciences.—*Editor.*

SENIOR HIGH EXPERIMENTAL PAPERS

1. *Electric Potential and Embryonic Induction: Biochemical Interrelationships,* In Vitro *Effects, and Regenerative Aspects.* Margaret Ann West, Rockledge High School. Sponsor, Robert Collier.—Regeneration is dependent upon induction, resulting in differentiative growth. According to McMahon, induction is at least partially dependent on concentrations of neurotransmitters. They in turn cause production of cyclic AMP and GMP, coupled to production of inorganic ions. The intra– and extra–cellular concentrations of ions determine the membrane potential. Thus, the cellular content of cyclic AMP, cyclic GMP, inorganic ions, and electric potential may control differentiation. One example of inductive growth is that of the developing embryo. Application of embryo extracts, known to cause induction, from the roof of the archenteron *in vitro* combined with the electric potentials of Becker may produce regeneration. Protein synthesis should serve as an indication of growth which could be applied *in vivo* to produce regeneration. Protein synthesis should serve as an indication of growth, while treatment of the cells with trypsin should disrupt the normal ion flow, providing a method of testing the proposed theory of induction.

Results using this experimental plan have shown an overall positive synthesis of DNA, RNA, and protein in explant cultures stimulated with 3-6nA DC current and mesodermal grafts. Further experimentation with explants using embryo extracts have shown the same overall results, with some minor deviations. Trypsinized explants showed some change in synthesis, although the results were not conclusive. Muscle monolayers had the only positive synthesis in cultures stimulated with 14.46 pA per mm^2 DC current and archenteron extract. Results from trypsinized muscle monolayers were not conclusive. L1210 leukemia cells showed positive synthesis in cultures stimulated with both electricity and extract.

The technique used has been found successful *in vitro*, showing the need for *in vivo* studies to ascertain the effectiveness of applying the method to regeneration.

---

2. *A Spectroscopic Study of 9-Hydrazinoacridine and its Interactions with DNA.* Clare Yu, Gainesville High School. Sponsor, Mary Ann Sullivan.—The aromatic molecule 9-hydrazinoacridine was studied as a neutral molecule, a monocation, and a dication in aqueous solutions at various degrees of acidity and basicity through the use of absorption and fluorescence spectroscopy. An

absorption spectrum is a graph of the amount of light that a molecule absorbs at various wavelengths, and a fluorescence spectrum is a graph of the amount of light that a molecule emits at various wavelengths. A solvent study of 9-hydrazinoacridine was performed to investigate the effect that the polarities and the hydrogen bonding capabilities of different solvents had on the absorption and fluorescence spectra. The interactions between 9-hydrazinoacridine and DNA were also studied to determine whether or not 9-hydrazinoacridine intercalates with DNA. Intercalation refers to the insertion of an acridinium cation between successive base pairs of nucleic acid or between adjacent bases on a polynucleotide chain.

The absorption and fluorescence spectra indicated that positive charge exists in the hydrazine group and at the heterocyclic nitrogen in both the monocation and dication species. From the solvent study it was determined that the neutral molecule is more polar in the excited state than in the ground state, while the monocation is less polar in the excited state than in the ground state. The results also indicated that 9-hydrazinoacridine may intercalate with DNA.

---

3. *The Effects of Hemicholinium-3 on Synaptic Transmission in the Vertebrate Retina.* Roz Rafanelli, Rockledge High School. Sponsor, Robert B. Collier.—Chemical synapses exist within the inner plexiform layer of the retina. It is necessary to determine the neurotransmitters of these junctions for a complete understanding of the retinal pathway—a bridge between man's brain and his environment. Data exist indicating the presence of cholinergic transmitters at these synapses. The purpose of this investigation was to determine whether or not acetylcholine is a transmitter of the retina. Hemicholinium-3, a synthetic neurotoxin specific to blocking the production of acetylcholine, was injected into the vitreous body of two rabbit's eyes for each experiment. It was hypothesized that if acetylcholine is a transmitter within the retina, the animal would go blind after injection. To be sure that blindness was a result of acetylcholine production blockage, the animals were placed in separate light environments.

The avg rate of blindness in the flashing light environment was 10 hr and 36 min, while it took 12 hr and 48 min for the onset of blindness in the dark environment. The substructure of the inner plexiform layer allows for the synthesis, storage, and destruction of acetylcholine. It is therefore concluded that acetylcholine is a neurotransmitter of the vertebrate retina.

Other State Finalists Were: Scott Bradley, Merritt Island High; John Dekker, Science Center; George Ellis, Science Center; Michael Halem, Cocoa High; Ronald Herbanck, Sandalwood High; Jerry Jackson, Rockledge High; Michael Maier, Satellite High; Gregory Miller, Rockledge High; Mary Pelzer, Merritt Island High.

JUNIOR HIGH EXPERIMENTAL PAPERS

1. *Effects of Antioxidants on Aging in* Drosophila melanogaster. Jeffrey C. Webster, Cocoa High School. Sponsor, E. H. Steel III.—One of the most im-

portant biological problems today is how an organism ages and dies. Although the changes that occur in aging cells are not yet understood, there is evidence that some changes are due to oxidation of cellular lipids. Therefore, antioxidants might prevent these changes and lengthen life-span. Evidence for this was reported by Harman, who found that feeding 1% 2-mercaptoethylamine increased the life-span of mice by 29%, while 0.5% butylated hydroxytoluene increased life-span by 45%. The effect was confined to certain strains of mice, but Packer found that alphatocopherol doubled the life-span of cultured human cells.

In contrast to work on mice, little is known of the effects of antioxidants on other organisms. I studied the effects of ascorbic acid and butylated hydroxytoluene on the life-span of *Drosophila melanogaster.* Each culture contained 10-20 flies, and each experiment employed 50-200 flies. Daily counts were recorded of survivors. The avg life-span of the control flies was 18.8 days. The maximum life-span was 36 days. The avg life-span was 17.3 days with 1.0% ascorbic acid, and 15.4 days with 0.1%. Maximum life-span was 40 days with 1% ascorbic acid, and 43 days with 0.1%. The avg life span was 1.6 days with 2.0% butylated hydroxytoluene. The maximum life-span was 5 days. With 0.5% butylated hydroxytoluene, the avg life-span was 3.2 days, and the maximum life-span was 7 days. Thus, ascorbic acid had little effect on the life-span of *Drosophila,* while butylated hydroxytoluene was very toxic.

---

2. *Measuring the Calcium Content and the Thickness of the Egg Shell of the* Pelecanus occidentalis *Using the Standard Ethylenediaminitetra Acetic Acid Titration Method.* ALICE SENNE, Stone Middle School. Sponsor, CARL WILKINSON.—The *Pelecanus occidentalis* (Eastern Brown Pelican) which ranges along the coast of the Southern United States is an endangered species. One of the reasons that it is endangered is the effect of DDT (Dichloro-Diphenyl-Trichiorethane). DDT affects the pelican by causing both a softening and thinning of the egg shell. This is due to the induction of liver enzymes that lower the estrogen levels in the female birds.

There are some twenty-one designated nesting grounds in the State of Florida. This study will be conducted on Pelican Island, located in the Indian River about one-eighth of a mile south of the Inlet Marina in Sebastian, Florida. All observations and egg collections will be made under the direct supervision of Mr. Lawrence Wineland, the National Wildlife Conservation Officer in charge of Pelican Island. Two series of tests will be run in order to determine egg shell thickness and calcium content. The thickness will be measured with a micrometer caliper. The calcium content will be measured using the EDTA Titration Methods. The results of those tests will be compared with test results taken from a 10 yr period beginning 1964. Those results were determined by the U. S. Fish and Wildlife Service Research Center, Laurel, Maryland.

---

3. *Ionizing Radiation and Chemical Pollutants.* L. MAURICE HOLLAMAN, Southwest Junior High.—No abstract submitted.

Other State Finalists Were: WILLIAM ARNOLD, Central Junior High; PAUL BOWMAN, Stone Middle School; STEPHEN BOSCOVICH, Southwest Junior High; SCOTT BOYER, Southwest Junior High; KENT DAY, Stone Middle School; ANNA GRIESHABEN, Southwest Junior High; LEONARD MCMILLIAN, Southwest Junior High; PATTIE MIKES, Southwest Junior High; PAUL PERONARD, Stone Middle School.

SENIOR HIGH LITERARY PAPERS

1. *The Temperature Dependency of Interferon Production in Chicken Cells* in Vitro. KEITH COLLINS, Merritt Island High School. Sponsor, PAT DENNINGHOFF.—In 1957, Dr. Alick Isaacs and his associate Dr. Jean Lindenmann discovered a substance called interferon which was found to have anti-viral properties. Specifically, interferon is a protein of low molecular weight and is relatively non-antigenic. It is also active on viruses both *in vitro* and *in vivo*. Interferon is a broad term which describes a system of virus inhibition and by itself does not actually possess anti-viral properties.

The most practical means of inducing interferon production is by means of a virus. This is due to the fact that almost every major group of virus has been found to induce its production. As would be expected of a metabolic process, the production of interferon occurs within definite temperature ranges. It is generally inhibited at low temperatures. Researchers have found the temperature for interferon production to be higher than that of virus replication. It was also found that this temperature range varied with different inducers. There are several theories to explain the reason for this, but there are no conclusive data to back them.

In conclusion, further experimentation is definitely needed on the relationship between temperature and interferon production. The purpose might be to find the temperature optimum in which interferon production best occurred and determine this accurately. Interferon is indeed a prospect for the future.

---

2. *Production, Utilization and Characteristics of Orange Peel Oil.* CHRISTOPHER M. LOHSE, Cocoa High School. Sponsor, EDMUND H. STEEL III.—There are two general methods used in the manufacture of essential orange oils. In the primary method, oil sacs in the flavedo are punctured, the oil is rinsed away and separated from the water emulsion by centrifugation. The second method involves the distillation of small amounts of peel oil that have become interfused during the processing of citrus products. These are referred to as distilled oils. This paper concerns the different methods of production, current industrial utilization, and physiochemical characteristics of the various orange peel oils.

---

3. *Organic Molecules on Mars.* MARK E. MINIE, Science Center. Sponsor, MAX ULM.—The possible existence of organic molecules on Mars has long been a source of interest to scientists, since the presence of such molecules on that planet would have many important implications in the fields of astronomy and

biology. Many attempts have been made to detect their presence on Mars, with none of the attempts so far meeting with any success. Yet, the Mariner space probes have shown that the Martian atmosphere contains mostly CO_2 and water vapor, and that the surface of the planet is exposed to intense ultraviolet radiations; conditions that should lead to the spontaneous photochemical production of simple organic molecules, such as formaldehyde. These simple molecules can later be synthesized into more complex molecules of biological interest; amino acids, for instance. Laboratory experiments performed by JPL scientists and the author have shown that aldehydes are formed in significant quantities under simulated Martian conditions. Therefore, there must be a natural mechanism in the Martian environment by which such molecules are removed from the atmosphere. Several possible mechanisms are discussed, including photodisassociation of the molecules by ultraviolet light and possible reactions on the Martian surface leading to more complex molecules.

Other State Finalists Were: Ginger Bruner, Marianna High; Charles Cooper, Marianna High; Kurt Denninghoff, Merritt Island High; Denise Hall, Lely High; Gino Mayo, Marianna High; Karen Saunders, Lely High; Carolyn Vipperman, Marianna High; Rose Wynn, Marianna High.

JUNIOR HIGH LITERARY PAPERS

1. *The Effect of 50 PPM (parts per million) Nitric Oxide on the Bronchi and Alveoli in the Respiratory Tract of* Mus musculus. Mark Oler, Kennedy Middle School. Sponsor, David E. Murray.—Nitric oxide is a suspected cause of adverse effects on the bronchi and alveoli in *Mus musculus* (mice) due to its chemical interactions that lead up to the formation of nitric acid. The chemical reactions occur in this sequence:

Nitric oxide is exposed to an atmosphere. There it is oxidized to nitrogen dioxide. This will have occurred by the time it reaches the lungs. Next, nitrogen dioxide is inhaled by the exposed organisms. While in the lungs it reacts with the fluids and tissues forming a nitric acid solution—for when nitrogen dioxide and water are brought into contact with each other they form a nitric acid solution. This reaction is theorized from the stand-point of occurring in the lungs.

The effects suspected to be caused by this pollutant are hypertrophic and inflamed bronchi and alveoli possibly causing impairment of function. Also, the tissue surrounding the bronchi may develop necrosis. The effects correlate to the experiments done by Dr. S. Koshmider and A. Misiewicz, Dr. A. Propst, Dr. W. H. Blair and Dr. Peter K. Mueller, a leading authority in the field of nitrogen oxides. He stated that of the oxides of nitrogen, nitric oxide and nitrogen dioxide were the most important because of their toxic effects and their chemical reactions.

In conclusion, the experiment which will be performed by the researcher will show what effects nitric oxide has on lung tissue. By determining what is done to test organisms, the results should be considered as comparable to the effects this pollutant could have in man.

---

2. *Myasthenia Gravis.* LINDA BATTIN, Edgewood Junior High. Sponsor, PHILIP W. ROSE.—Myasthenia Gravis (MG) is a neuromuscular disease that affects the muscles of the extremeties, eyes, face, respiratory organs, throat, and tongue. MG is the result of very poor transmission of impulses at the neuromuscular junction. The thymus, the organ my project is based on, plays a very important part in MG. In the normal person, the thymus has shrunk or disappeared by adulthood. But, when a person has MG, the thymus is frequently enlarged or tumorous. In very few, though, do these tumors become malignant. In many myasthenics, antibodies against the voluntary muscles and certain cells in the thymus are demonstrable in the blood serum. In these cases, the myasthenic has developed antibodies against his own tissues—autoantibodies. This process may constitute an autoimmune disorder. The cells do not seem to be the exact cause of MG and their role in the disease is not clear. The thymus does produce a hormone, thymin, which may produce, or cause to be produced elsewhere, a circulating substance that interferes with neuromuscular transmission.

The purpose of this researcher's project is to successfully induce MG into experimental animals. Other researchers have claimed to induce MG, but they have only induced a myasthenic-like condition. To start with, the researcher will use a method that medical student Daniel Conlin, working under Dr. Robert Schimpff at the University of Florida, developed. This method involves taking the thymus glands of hamsters and processing the tissues. The resulting extract will be injected into other hamsters. This procedure produces a myasthenic-like condition. From this point, the researcher will perform other experimentation, mainly observatory, with various control experimentation to compare with future data. From these data, the researcher hopes that a method to induce experimental MG will be clearer.

In conclusion, researchers know that the thymus plays at least a minor role in MG, but they still must find the link between the thymus and the other factors involved. For now, though, researchers need to find a way to successfully induce MG into experimental animals so they may do better, in depth, experimentation.

---

3. *The Effects of Black Holes on the Future Life on Earth.* ROBERT BERRY, Kennedy Middle School. Sponsor, D. E. MURRAY.—On June 30, 1908, a huge fireball exploded in the remote Tunguska region of Siberia, destroying trees and land for almost 100 km. Many people have attributed this to a meteorite, or possibly a comet that exploded just before hitting the earth. But the latest theory about the cause of this is that it was a black hole. A black hole is a region of space in which a star or any other particle of matter has collapsed into a state so dense that no matter can escape its great gravitational pull. One theory about the use of black holes to our advantage is shooting hydrogen at it. As it enters it will be compressed, heated, and ignited. From this, fusion begins and electricity is produced. This electricity could be directed at huge ground antennas and converted into a regular household current.

The first thing that would happen if a black hole were to come into the vicin-

ity of the earth is that it would probably affect the tides. Second, after passing through the atmosphere and hitting the earth it could cause a massive shock wave. And third, if cosmic radiation were to be trapped inside it could be released during the explosion.

Black holes can help us, or they can also destroy us.

Other State Finalists Were: CHARLES LINDSEY, Edgewood Junior High; JAMES MCDONALD, Edgewood Junior High; MIKE MILLER, Kennedy Middle School; DEBRA MINICUS, Kennedy Middle School; CRAIG REED, Edgewood Junior High; KELLY SCHOFIELD, Kennedy Middle School; GREG SMITH, Edgewood Junior High; JOHN WHITED, Kennedy Middle School.

Florida Sci. 38(3):185-191. 1975.

THE ACADEMY'S FIRST HOME

As announced by President Taft in the F.A.S. Newsletter, the Florida Academy of Sciences has established a permanent headquarters for the first time in its history. The situation is particularly favorable for the Academy because we are housed in the only institution in Florida which is a member of the international Association of Centers of Sciences and Technology and because the John Young Museum and Planetarium in Orlando is independent of any governmental agencies or a single academic institution. Thus, it is, indeed, a site on "neutral ground", as President Taft phrased it, and one where the Academy may eventually realize a permanent secretariat and archives. Certainly the existence of a single Academy mailing address enhances the ability of the Academy to achieve its mission in the scientific community and in the State at large. We can look forward to a new vigor and greater involvement of the Academy in activities appropriate to our Charter as we are able to take full advantage of our new situation.

Why does the Florida Academy of Sciences need an office and related facilities at this time?

One very practical answer is that we own many full sets of back numbers of the journal which were graciously well-housed, gratis, at the University of Florida until last Spring when our 200 square feet of space was required for other purposes by the University. Nearly 8 tons of back numbers requiring over 300 running shelf feet of storage were moved by volunteers to Orlando. They are now housed on shelving in air conditioned, vermin-controlled storage at the John Young Museum. The Museum purchased materials and Academy volunteers constructed the shelving designed especially to achieve maximum storage efficiency. Soon full runs and broken sets of our journal will be announced as available so that the Academy may recover needed capital.

Although housing back numbers is an important consideration, it is secondary to the importance of having a central point to receive correspondence from our subscribers and institutional members. Some mail is presently received after being forwarded several times before it reaches the editorial office where we can process claims and address changes. But, most importantly, a headquarters is an important step toward realization of a fully functional academy offering a variety of services to its membership and to the public at large. We have reached the point where it is no longer reasonable to ask a few dedicated scientists to carry the increasing burdens of Academy management entirely on their own time and with inadequate support systems. Already the headquarters office has undertaken mailing of the F.A.S. Newsletter, for instance, as well as functioning primarily as an editorial office for the journal. Soon we anticipate that the addressing equipment available to us in the Museum will be used for most Academy mailings with a great increase in efficiency.

The value of the benefits accruing to the Academy exceeds greatly our annual rent of one dollar. We are properly expected to cooperate with the museum by assisting in identifying expertise sometimes needed in museum programs, by entering jointly in cooperative ventures of common concern, and by acknowledging our cooperative relationship with the Museum.

We now have the means to become the strongest academy in the southeast and to assume a leadership role among state academies of science. Let us rise to that challenge by extending our membership, by personal participation in Academy affairs, and by taking pride in being part of the most forward-looking and dynamic, totally independent, state academy in America today.—*Editor.*

Florida Sci. 38(3):191-192. 1975.

ERRATUM: Figures 2 and 3 were reversed as published (FLORIDA SCIENTIST 38(2):117 and 119) in Cowell and Resico, "Life History Patterns in the Coastal Shiner, *Notropis petersoni*, Fowler."

INSTRUCTIONS TO AUTHORS

Rapid, efficient, and economical transmission of knowledge by means of the printed word requires full cooperation between author and editor. Revise copy before submission to insure logical order, conciseness, and clarity.

MANUSCRIPTS should be typed double-space throughout, on one side of numbered sheets 8½ by 11 inch, smooth, bond paper.

A CARBON COPY will facilitate review by referees.

MARGINS should be 1½ inches all around.

FOOTNOTES should be avoided. Give ACKNOWLEDGMENTS in the text.

ADDRESS should be given following the author's name.

ABSTRACTS should be typed double-spaced immediately following the address.

LITERATURE CITED follows the text. Double-space every line and follow the form in the current volume.

TABLES are charged to authors at $25.00 per page or fraction. Titles must be short, but explanatory matter may be given. Type each table on a separate sheet, double-space, unruled, to fit normal width of page, and place after Literature Cited.

LEGENDS for illustrations should be grouped on a sheet, double-spaced, in the form used in the current volume, and placed after Tables. Titles must be short but may be followed by explanatory matter.

ILLUSTRATIONS are charged to authors ($20.00 per page or fraction). Drawings should be in India ink, on good board or drafting paper, and lettered by lettering guide or equivalent. Plan linework and lettering for reduction, so that final width is 4 5/8 inches, and final length does not exceed 7 inches. Do not submit illustrations needing reduction by more than one-half. Photographs should be of good contrast, on glossy paper. Do not write heavily on the backs of photographs.

PROOF must be returned promptly. Leave a forwarding address in case of extended absence.

REPRINTS may be ordered when the author returns corrected proof.

FLORIDA ACADEMY OF SCIENCES

INSTITUTIONAL MEMBERS FOR 1975

Archbold Expeditions
Barry College
Eckerd College
Edison Community College
Florida Atlantic University
Florida Institute of Technology
Florida Southern College
Florida State University
Florida Technological University
Gulf Breeze Laboratory
Jacksonville University
John Young Museum and Planetarium
Manatee Junior College
Miami-Dade Community College
Mound Park Hospital Foundation
Ormond Beach Hospital
Rollins College
St. Leo College
Stetson University
University of Florida
University of Miami
University of South Florida
University of Tampa
University of West Florida

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