

Island Ecology in Bermuda

Barry L. Wulff
Michael F. Gable
Robert E. DeGoursey

FIELD COURSES ARE A logical extension of a well-founded undergraduate program in biology. They may involve only one afternoon a week during a semester or perhaps several long weekends in a minicourse. Extended field courses, however, are a rarity. Given the proper setting and a well-planned program, field courses lasting a week or more can provide many educational rewards not attainable in the classroom.

Twelve hundred and fifty kilometers southeast of New York City and 950 kilometers due east of Cape Hatteras, North Carolina, in the Sargasso Sea, lies a group of islands superbly situated to provide a unique set of educational experiences. The Somers Islands, better known as Bermuda, are the setting for an island ecology course offered at the end of each spring semester by Eastern Connecticut State College (ECSC).

Since the course was initiated ten years ago by Professor Emeritus William Jahoda, more than 200 students from Connecticut State Colleges and the University of Connecticut have participated in a nine-day, two-credit field course. Course participants use the subtropical oceanic islands and the facilities of the Bermuda Biological Station for Research—one of the finest marine research institutes in the world.

The primary goal of the course is to provide participants with an opportunity to study the ecology and natural history of the organisms found in a variety of subtropical habitats. By comparing and contrasting the characteristics of this variety of unfamiliar habitats, participants achieve an awareness and understanding of the diversity of organisms and community patterns they have not previously encountered. That the environments are

Barry L. Wulff is associate professor of biology at Eastern Connecticut State College, Willimantic, Connecticut 06226. He received his B.S. degree in biology from The State University of New York at Cortland, and in 1968, he was awarded his M.A. degree in marine science by the College of William and Mary in Virginia. Wulff received a Ph.D. degree from Oregon State University at Corvallis in 1970. Since receiving his doctorate, he has been studying the characteristics of wetland communities and the natural history of nonvascular plants, particularly fungi. Wulff presently chairs the research committee for the North American Mycological Association and is president of the Natural Resources Council of Connecticut Inc., reflecting his strong interest in maintaining the quality of the global environment. He has traveled extensively throughout the United States and Panama, Newfoundland, Bermuda, Mexico, and northern Quebec. He is an avid backpacker and



nature photographer. Michael Gable is associate professor of biology at Eastern Connecticut State College. He teaches introductory biology,

taxonomy of plants and animals, invertebrate zoology, and limnology. Gable received his B.S. degree in zoology from the University of Florida, and was awarded his M.S. and Ph.D. degrees in zoology by the University of New Hampshire in 1969 and 1972 respectively. He spent two years as a National Science Foundation research assistant working on the infaunal and epifaunal ecology of marine and estuarine waters while he was doing graduate work. He holds memberships in AAAS, the American Association of University Professors, AIBS, the Crustacean Society, and the Ecological Society of America. He has written a laboratory manual, *Taxonomy of Plants and Animals*, and wrote a chapter on crustaceans for an invertebrate biology text. Gable's present research is focused on long- and short-term successional plate studies of estuarine amphipods, and student projects that investigate the biology and ecology of Connecticut amphipods. Robert DeGoursey received his B.A. degree in biology from the University of Connecticut in 1971. He is presently a University Research Assistant at the University of Connecticut Marine Sciences Institute's Laboratory in Noank, Connecticut 06340. DeGoursey is presently at work on a project investigating the environmental impact of ocean dredge disposal on benthic communities in the New England area. He has taught courses in marine ichthyology and tropical marine ecology at various schools and colleges in Connecticut. DeGoursey has an avid interest in underwater photography and is compiling a photographic library of the conspicuous marine flora and fauna of southern New England.

“foreign” is, in itself, a strong stimulus for inquisitive minds.

There are about 130 islands in Bermuda; all lie on a seamount, an extinct volcanic peak rising more than 4,000 m from the sea floor. The bulk of the land mass is Pleistocene and recent limestones that form a cap about 30 m thick on the volcanic pedestal. The physiography of the entire Bermuda platform suggests an atoll because carbonate islands, shoals, and reefs surround a central shallow-water lagoon. Many of Bermuda’s shoals, instead of being reefs, are actually eroded and submerged wind-blown limestone deposits thinly veneered with encrusting organisms. Bermuda is, therefore, not considered a true atoll.

Oceanic islands, such as the Hawaiian Islands, Seychelles, Galapagos, and Bermuda, are considered distinct ecological systems because of their isolation from continental land masses. Their endemic populations of plants and animals usually have evolved in isolation from mainland populations. Although Bermuda has been considerably influenced by humans, it still boasts a variety of endemic species. Notable examples are the Bermuda palmetto, a blue-eyed grass (*bermudiana*), a maidenhair fern, a skink, and a colony of cahow birds—previously thought extinct.

Though it has an area of less than 50 square kilometers, Bermuda offers easy access to a variety of terrestrial and marine habitats, including subtropical forests, xeric limestone communities, coral reefs, and mangrove swamps. Many native plants and animals have a subtropical origin and are closely related to species found in the West Indies or southeastern United States. In addition, the public and private gardens contain a large number of showy plants imported from around the world. Students from northern climates are usually unfamiliar with these groups of organisms.

Another noteworthy feature of geographically isolated islands is that the relationship between socioeconomic patterns and the environment is clearly defined. Islands that are economically developed demonstrate a strong dependence on other countries for resources. Bermuda, therefore, provides students with a grasp of the world in a nutshell—a microcosm with identifiable inputs and outputs.

Student Selection and Trip Preparation

Each year, twenty-two students are selected to participate in the course. The selection process is accomplished through an information request form that, in addition to requiring information on educational background, asks students to state their goal for participating in the course. Normally, students must have completed a minimum of two biology courses.

Students are selected so that the group will have individuals with diverse backgrounds. Thus, student interaction supplements the knowledge gained from course



FIGURE 1. Examining the flower of the Bottlebrush plant.

instructors. Senior science students often find this experience an eye-opening synthesis of their many undergraduate courses, and they can share their knowledge with beginning science students who, in turn, are being introduced to many new experiences. Students not majoring in science obviously benefit from the knowledge of science students; yet, nonmajors contribute their share by providing perspectives that frequently shed a different light on “science” for the major. The participation of freshmen and sophomore students is also an excellent means of publicizing the course to other students during the following school year.

The course is offered at the end of the spring semester immediately following final examinations, usually during the last week in May. This scheduling minimizes disruption of the student’s normal load of spring courses, and students are eager to be involved in totally different experiences. Also, by including the course as part of the normal spring semester load, no special tuition is charged; students only pay a fee for expenses incurred during the trip.

Before they depart for Bermuda, students attend three illustrated seminars spread over nine hours, which provide an overview of the course and introduce the geological evolution of oceanic islands and the subtropical animal diversity with emphasis on marine invertebrates and fishes. Readings are assigned to be completed prior to the trip so the students may benefit fully from the learn-

ing experiences they encounter. Participants receive a mimeographed field guide to the conspicuous fauna and flora. They are expected to become familiar with the scientific names of the commonly encountered species and to use these names in discussions and writings.

All students must be able to swim; they bring a mask, snorkel, and fins with them to Bermuda. Instruction in snorkeling for the novice is available at ECSC before the course begins. During the years that the course has been offered, more than half the students have prepared themselves by becoming certified SCUBA divers, and some have taken special instruction in underwater photography.

Before their departure, students receive a detailed list of what to bring. We inform them of the customs and laws of Bermuda that may affect them. We emphasize that no drugs will be tolerated. No difficulties with misconduct have ever been encountered.

Everyone is informed of the ground rules of the grading policy, too. Basically, to pass the course with a "C" or better, the student must actively participate in the field and complete a substantial written report on the ecology of Bermuda within one month after returning home. The

grade is based primarily on the content and quality of the paper, which should reflect in a coherent statement how much the student was able to learn and synthesize during the trip. Most papers contain between twenty and fifty pages of text with additional figures and tables.

Many students receive a partial scholarship (\$50 to \$150) for the course from the ECSC College Alumni Foundation and the ECSC President's Institutional Welfare Fund. Should they fail to prepare a satisfactory term paper, students must return the scholarship money. Participants agree to this condition in writing when they accept the scholarship money.

On to Bermuda

The group flies to Bermuda from Bradley Airport, which serves the Hartford/Springfield area. Students pick up their tickets at the airport, where group seating has been arranged. Arrival time in Bermuda is shortly after midday, and two things are on students' minds—eating and swimming in the magnificent turquoise water. These activities are accomplished posthaste. Everyone has a chance to relax, cool off, and test his/her snorkeling skills.



FIGURE 2. Student examining cuttlefish.

Later in the afternoon, the group is welcomed to the Biostation by the Director, Wolfgang Sterrer, and is then taken on a thorough tour of the physical plant and grounds.

Students get acquainted not only with the station itself at this point, but also with the wide variety of vegetation that has been planted in the area. The names, characteristics, and natural history of the commonly encountered plants are described. Many of these plants are seen over and over again in Bermuda, so the information is continually reinforced.

The Bermuda Biological Station

The Bermuda Biological Station was founded in 1903 by Professor Mark of Harvard University; in 1926, it was incorporated in New York as an international non-profit organization. The Biostation is located on Ferry Reach, a narrow waterway separating St. George's Parish from the remainder of the Bermuda Islands to the south. The main facilities can accommodate forty investigators and students; an additional twenty cottages are available for families. All meals are prepared in a modern central dining hall. Food has always been delicious and plentiful—two basic elements for a successful field course.

Students may use the newly constructed George T. Scott Laboratory, which is equipped with microscopes, dissecting tools, glassware, preservatives, chemicals, and running sea water. Precision instruments are available, too. Beneath the laboratory are many large salt water holding tanks and a diving locker that houses tanks, weights, backpacks, and an air compressor.

An assortment of boats is available for on- and off-shore investigations. The "Panulirus II," a 20 m twin diesel powerboat, is equipped with winches, cranes, bathythermographs, plankton nets, dredges, and bottom samplers for work in the nearby ocean environment. Two smaller vessels, the "Mic Mac" and "Velella," are used for student groups to travel to the outer islands up to 11 km offshore.

The Mark Library contains about 13,000 volumes and subscribes to nearly 250 publications in the marine sciences. The composition of this collection makes the Biostation's library one of the finest sources of references in the world for subtropical island biology and marine ecology. The Biostation has issued over 800 research reports and 17 special publications. It also maintains a reference collection of preserved specimens that students are permitted to use to validate taxonomic determinations.

The first evening in Bermuda includes a "get-together" party, which initiates students into the Biostation community. We like the students in the group to get to know one another early in the week and become a functional unit. Camaraderie is encouraged. Other visiting student groups and visiting researchers are also invited to the party.

The Daily Program

Early on the second day in Bermuda, everyone rents a moped. A moped is the most convenient form of transportation around the island; with a moped, the students have a sense of freedom because they can explore independently during their free time.

Safety is one of our greatest concerns because it is easy for a cyclist to get hurt. If we are overbearing on any rule, it is our insistence that the mopeds be operated safely. We show slides of accident victims during each seminar before coming to Bermuda, and we give our own special introduction to the cycles, reiterating the rules of the road, good driving tips, and simple maintenance procedures. Our safety program includes the motto "never look back" and tells students what to do if they find themselves driving rapidly off the road and down the shoulder. Absolutely no riding barefoot or with sandals is permitted. A bad case of "road rash" (abrasions) can spoil the week for someone. We take the time to watch the students' driving and caution them about their errors.

Each evening at dinner an itinerary for the next day's activities is posted. This informs everyone about where we are going, the time for activities, the distance (in case they need gas for their mopeds), and the types of activities scheduled for each stop. Such preplanning saves a lot of time and headaches.

Although we bike in groups, students have road maps and should be able to find a field site on their own. An instructor always rides at the end of the group to ensure that no one is left stranded because of a breakdown or accident.

Each day, we try to schedule half-day sessions—one in the water and one in a terrestrial habitat. Each half-day finds us at a new location and a different habitat. To avoid sunburns, we schedule the more exposed, non-shady environments for near the end of our stay.

Much of our activity involves snorkeling or SCUBA diving. Special precautions are necessary, especially when there are twenty to twenty-five participants. All three of us are SCUBA certified; but never do we all SCUBA dive in the same field operation, and never are we all in the water at the same time. One of us keeps a watchful eye by continually scanning the water. A buddy system operates even for the snorkelers. We attempt to pair less-experienced swimmers and divers with more-experienced ones. Before any dives are made, one of us personally checks the competency of each of the certified divers.

Some activity is planned for almost every evening. We give seminars on subjects such as the subtropical vegetation or reef fishes; visiting researchers or staff members of the Biostation give seminars on a variety of topics such as oceanic oil pollution, commensalism in crustaceans, marine fungi, and the international Mid-Ocean Dynamic Experiment (MODE) program. Bermuda's conservation director, David Wingate, and the Director

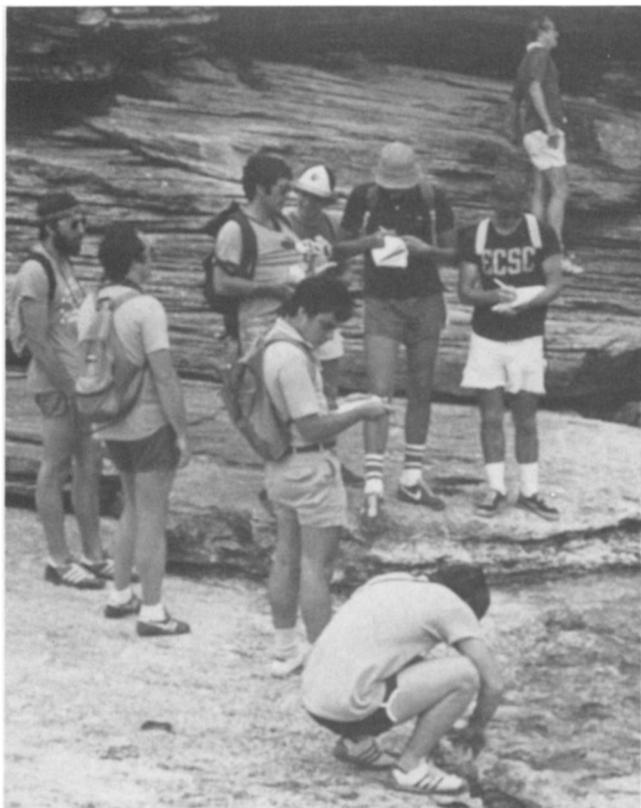


FIGURE 3. Students studying intertidal communities at Spanish Rock.

of Agriculture and Fisheries in Bermuda, Walwyn Hughes, are also frequent lecturers. On an evening when no seminar is scheduled, we may all pile into a boat for a plankton tow or for snorkeling on a shallow reef with dive lights. Students will often find time at night to snare a whistling frog, *Eleutherodactylus*, for observation.

Habitats on the Trip

During our stay, we try to visit as many natural habitats as possible. A description of each of the habitats we have regularly used for field work is given below.

Paget Marsh Nature Preserve is a 10-hectare freshwater marsh and swamp area in the center of the main island, forested with a dense growth of Bermuda palmettos, Bermuda cedar, giant ferns (*Acrostichum*), and a number of other endemic species. The entrance way is densely vegetated with the allspice tree, and lacy vines of *Asparagus plumosa* wind up the tree trunks into the canopy. In the preserve one is likely to encounter the giant toad *Bufo marinus*. This area of the island is probably the least disturbed by humans.

Walsingham Trust Forest is the largest uninhabited tract of land on the island (12 hectares), and geologically one of the finest examples of Bermuda's oldest exposed rock formations, the "Walsingham aeolianite," which is older than 300,000 years. Here one encounters many underground caves and sinkholes having connections to

the sea. Here are found profuse growths of naturalized plants, especially the sweet-smelling jasmine vine (*Jasminum simplicifolium*) and the fiddlewood tree (*Citharexylum spinosum*). Many rare endemics are also found here.

The Bermuda Botanical Gardens, the formal gardens of Bermuda since 1898, display numerous exotic species capable of surviving in a frost-free climate. This is an excellent place for study of the diversity of cultivated plants and the variety of morphological patterns exhibited by plants from throughout the world. Here we examine special collections of orchids, euphorbs, conifers, palms, species of *Ficus*, among the many other exotics.

Nonsuch Island is an outer island of more than 5.9 hectares currently being established by David Wingate as Bermuda's living museum with the restoration of its original native plant and animal life. Truly a spectacular environment with numerous habitats, this is a "must" for any natural history tour. The island has several important features; it is the site of a research project begun in 1968 by the Agriculture and Fisheries Department to re-establish a breeding population of the green turtle. This is also the only place that one will encounter examples of the endemic skink, *Eumeces longirostris*. It was on Nonsuch that the famous naturalist-writer Dr. William Beebe along with Dr. John Tee Van operated a marine laboratory from 1928 to 1931, and it was from here that their famous bathysphere descent was organized.

The Dune Communities are beach dunes composed of calcium carbonate grains derived from the break-up of coralline red and green algae, foraminifera, and mollusks. The plant and animal species found on the upper slopes of the dunes are uniquely adapted to surviving in this water-deficient and saline environment. The commonly encountered species include the sea lavender (*Mallo-tonia gnaphalodes*), beach lobelia (*Scaevola plumieri*), and sea grape (*Coccolobis uvifera*).

Headland Communities are solid, but very porous, limestone-based communities near the shore having water deficit problems similar to that of the dunes, and subjected to nearly continuous winds. In these cliffs above the sea, one regularly sees nesting colonies of the longtail tropic bird (*Phaeton lepturus*). Xeric vegetation is common, such as the prickly pear (*Opuntia dillenii*), seaside purslane (*Sesuvium portulacastrum*), coast spurge (*Cam-aesyce buxifolia*), and Tamarisk (*Tamarix gallica*).

Thalassia Beds are beds of sea grasses (*Thalassia* and *Cymodocea*) similar to the eel grass (*Zostera*) beds in New England estuaries. They harbor many burrowing fishes, sea cucumbers, and pen shells. Present-day algal stromatolites similar to those found in Precambrian fossil beds are constantly being formed and are easily found between the clumps of grass.

Walsingham Pond is a very steep-sided and deep brackish water pond connected to the sea through underground tunnels. Here we snorkel around the fringes,

finding many invertebrates and algae including fan worms, colonial ascidians (*Clavellina*), the upside down jellyfish (*Cassiopeia*), and the green algae *Acetabularia*, *Halimeda*, and a variety of *Caulerpa* species.

Shelly Bay is a small shallow bay on the north shore rich in mollusk shells, where students occasionally discover living specimens rarely found in other areas, such as the octopus.

Pot Boilers are actively growing small-rimmed intertidal reefs of about 10 m in diameter and located about 100 m off the south beaches. The framework of the reef, unlike all other reef types, is a combination of red coral-line algae and vermetid gastropods rather than coral.

The Bermuda Aquarium is an aquarium-museum-zoo complex that displays many native and exotic fishes as well as other animals capable of surviving in Bermuda's climate. We visit behind the scenes to see the operation and management plan. Together we can look at and discuss the features of the species in the tanks.

Shark Hole is a sheltered portion of Harrington Sound whose steep walls abound with algae and beautifully colored sponges, and whose depths abound with spiny lobsters (*Panulirus*) and sea cucumbers (*Isostichopus*). It is also the site of a number of intertidal caves that are accessible to the snorkeler.

Natural Arches is a majestic coral reef just off the south shore where students see the hermatypic corals and study some of the inter-relationships typical of the coral reef system. Origins of the reef structure and the distribution and classification of the invertebrates and fishes are stressed. Beautiful examples of the black sea urchins (*Diadema*) and a variety of parrot fishes are seen here.

Night Plankton Tow is an after-dark plankton tow a kilometer out of the St. George's Harbor off the south shore, where several bioluminescent species are collected along with many species not characteristic of New England waters. After the tow, we spend several hours studying the collection under the microscope, finding arrow worms, copepods, hydromedusae, mantis shrimp larvae, and chains of diatoms.

Whalebone Bay is located about four kilometers from the Biostation. Here we search for algae and invertebrates that live in the zone alternately covered and uncovered by the ocean's tides. The porous nature of Bermuda's limestone rocks provides innumerable tiny crevices and tunnels, almost every one inhabited by living organisms.

North Rock is the northernmost point of the Bermuda platform, an area eleven kilometers offshore, marked by a lighted tower. The large lagoon between North Rock and the major land mass is partly occupied by the coral preserve. Extremely clear water and a tremendously diversified complement of invertebrates and fish fauna characterize this area. At low tide the water depth is 2 m in some places, affording unparalleled vistas to the snorkeler. One can often see a distance of 30 m underwater. This reef provides a startling contrast to the more

turbid, silty inshore areas. Many horny corals (sea fans, sea whips, sea rods, and sea feathers), and true stony corals (rose, brain, star, tree, and hat corals), giant anemones (*Condylactis*), algae, and fishes (both reef and pelagic species) are found in great abundance here.

The Flatts is an area adjacent to the Bermuda Aquarium, forming the inlet into Harrington Sound. Here the students see the effects of humans and their discarded non-organic wastes on marine communities. Part of the area is subjected to very strong currents that allow only selected species of plants and animals to exist. The area where we snorkel, however, is characterized by heavy siltation, relatively small water exchange, and little wave action. The bottom in this area is rapidly becoming covered with a dense cover of *Cladophora prolifera*, presumably due to a significant increase in nutrients seeping from the septic systems of the houses surrounding Harrington Sound.

There are a number of mangrove communities that are easily accessible around the island. Both the red mangrove (*Rhizophora mangle*) and the black mangrove (*Avicennia nitida*) are found in Bermuda. The shallow water sediments around the mangrove roots harbor a diversity of invertebrates, in addition to fine examples of coralline green algae such as *Penicillus*, *Halimeda*, and *Udotea*. Examination of the roots of *Rhizophora* themselves will turn up an additional array of species.

If we are fortunate enough to have scheduled our visit to coincide with a full moon, we are likely to witness a



FIGURE 4. Photographing corals at North Rock.

brilliant display of fireworms (*Odontosyllis enopla*). For above five days following the full moon, the fireworms give a spectacular bioluminescent display commencing within a few minutes of 55 minutes past sunset. A single female can be observed from a distance of more than 1,000 m!

Some Finishing Touches

Near the end of the nine-day experience, after they have become familiar with the plants and animals, the participants are given an opportunity to conduct a small field or laboratory research project on their own. They select from a list of suggested projects, or they may have an idea of their own approved by one of the instructors. We do this to prevent students from selecting projects they will not be able to complete. Also, because they will be scattered all over the islands, we like to know where they will be working. By dividing the supervision of projects among the three of us, we are able to monitor each student's progress. All projects involving a boat or swimming require that each student go with a buddy. The report of their research investigations is presented as an addendum to their final written report.

We stress academics heavily during the Bermuda program, but we also give students a little free time for exploring on their own. A noon-to-noon break scheduled during the middle of our stay provides an opportunity for them to see the sights of Hamilton and St. George's and to renew their energy for more work. We try hard to make the experience a memorable one and to provide opportunities to do things they cannot do at home. Our last morning in Bermuda is spent taking the group picture and frolicking in the surf on a secluded south beach.

After returning to Connecticut, students have one month to prepare and submit a term paper. A date is set for a cookout-reunion where we gather to show slides, swap stories, and generally relive the memorable moments.

What does the course cost each participant? The total fee for 1980 was \$525, which did not include moped

rental. This includes room, board, airfare, laboratory and facility fees—the works. The mopeds run about \$66 for the eight days, including gasoline. All fees must be paid before the group leaves for Bermuda. A penalty fee is assessed if a student withdraws from the course within a month of our departure.

Some Reflections on Leadership

Running an extended field course is not easy. More than academics must be on the minds of the leaders. Not only must a high-quality educational program be offered, but the health and welfare of the participants must also be considered. We keep a watchful eye on the progress and activities of each of the students. Though we are not trying to control their private lives or their personal behavior, we feel obliged to see that they take full advantage of the benefits of the program. Most of our students have never before been so far from home. The change in surroundings can be stimulating to some, intimidating to others. We observe, but do not over-control, the group dynamics as the field portion of the course progresses. Interpersonal relationships develop by themselves. We speak to students about their behavior only if it interferes with someone else's safety or with the smooth functioning of the program. Having a variety of activities helps to prevent the formation of cliques. The goal, if any, of controlling the social part of the program should simply be the bonding of everyone into a cohesive functioning unit.

It would be practically impossible for one—or even two—instructors to run such an active program. The demands are great. We often find ourselves spelling each other; generally, students are on the go from 7:00 a.m. to after midnight. During mealtimes, or in hours scheduled for relaxation, we socialize with our students, yet retain their respect. We are visible and available for consultation. Finally, a course such as this should be fun and rewarding for everyone, including the leaders.

NOTE—This paper is contribution 852 from Bermuda Biological Station.

Zoology Course

. . . from p. 356

students who work slowly or who wish to go beyond the assignments. The variety of presentation modes used in this course may stimulate students' interest by allowing them to immediately use knowledge gained in one format to enhance the understanding of material in other formats.

Acknowledgment—This study was supported by a grant to Furman University by the Lilly Endowment. The learning resource center was constructed and equipped

through funds provided as a CAUSE grant from the National Science Foundation.

References

- GILBERT, S. G. 1965. *Atlas of general zoology*. Minneapolis: Burgess Publishing Company.
- POSTLETHWAIT, S.N., NOVAK, J.D., and MURRAY, H.T. 1972. *The audio-tutorial approach to learning*. 3rd ed. Minneapolis: Burgess Publishing Company.