BIO-ELECTRONIC TECHNIQUES FOR THE STUDY OF MOLLUSCAN ACTIVITY. – Bio-electronics offers effective techniques for obtaining information on movement and physiology of animals, and its use has grown significantly in recent years. Although electronic components are now small enough to be used on at least the larger mollusk species, none of the more than 1700 references of biotelemetric studies in the recent review of Ysenbrandt et al. (1976) concerns mollusks.

I recently conducted a study in the Philippines on the activity patterns of *Ryssota uranus* (Pfeiffer). This study was made in conjunction with research on the activity of *Varanus grayi* Boulenger, a large arboreal lizard. The snail's activity, home range, etc., were of particular interest to the *Varanus* study because the snails constitute a rather large portion of the lizard's diet. A discussion of the data obtained in the *Ryssota* study is being prepared for publication.

Techniques and discussion. During this study two techniques new to malacological research were employed. Both proved successful within the limitations discussed below. With modification, these limitations can be minimized and both techniques made highly valuable to future studies of molluscan behavior.

1. Biotelemetric transmitters. The transmitter used in this study was a simple blocking oscillator (see Shields, 1979) designed to operate in the FM entertainment band (Fig. 1). Battery size determined unit weight (5.5 g for transmitter and 7.5 g for battery in this study) and life expectancy. Maximum reception range was estimated at 100 m when used with a J. C. Penney Co., Inc., Model 1960 AM/FM receiver, but, within the limestone karst of the study area, reception distance was reduced to approximately 30 m.

I constructed the transmitters so that the components conformed in size and shape to the apex of the shell and so that the loop antenna laid in the suture (Fig. 1B). The completed transmitters were dipped in PDS Air Dry Plastic Coating (made by Plastic Dip International, St. Paul, Minnesota, U.S.A.) for waterproofing. The transmitters and battery pack were mounted on the shell with epoxy cement and sprayed with an acrylic paint for final waterproofing. It was found that snails cannot be kept in airtight containers (plastic bags, etc.) after transmitter mounting and prior to release due to the noxious fumes of many waterproofing agents.

Although data were obtained on activity patterns of *Ryssota uranus*, the technique had one major limitation: signal strength was so great that at close distances some directionality was lost, and only after a great deal of time and receiver detuning were the snails' exact positions located. As most snails do not move far during any one activity period, a signal transmitted over a wide area becomes a hindrance in determining the exact location of the snail. With modification of transmitter components, a weaker signal can be achieved whereby directionality is maintained at a maximum.

Precise location at close distances required detuning of the receiver. Detuning is accomplished by shortening the telescopic antenna usually provided on small FM receivers and/or tuning the receiver to pick up only the weakest signal possible when near the snail. Thus, the signal will be lost when the receiver is moved away from the transmitting snail. With practice, the snail can be found easily.

2. Light-emitting diodes (LED). The Radio Shack Model FRL-4403 flasher LED (made by Archer Electronic Parts; US$1.29 each) incorporates an electronic microchip in its base that causes the diode to switch on and off. The LED leads are attached to two 1.5V batteries connected in series (Fig. 2B). Battery size determines life of the unit (Duracell mercury button type No. TR 126 lasts approximately five days; silver oxide, and especially lithium types, would last much longer; smaller batteries, such as those used in hearing aids, last a proportionately shorter length of time). Assembly requires only the soldering of the leads (exhibiting polarity) to the appropriate battery terminals. While convenient to use, the flash rate is quite fast, thus shortening battery life.

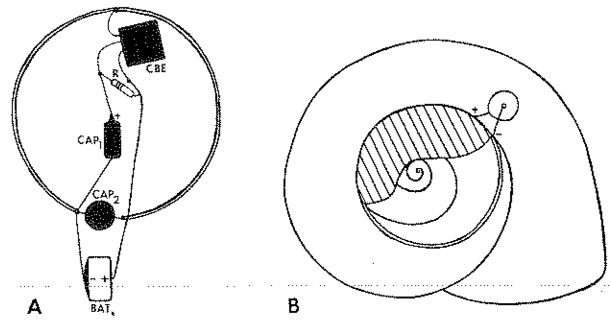
A much longer-lived miniature flasher is shown in Fig. 2A. A detailed description of this flasher can be found in Wolcott (1977) and Kephart (1980). This flasher is slightly less convenient, because more components are used in its construction, making it larger. However, the size increase is offset by the fact that only one 1.5V battery is required (life expectancy is one month or more), so total weight increase is not great. These LEDs are available in several colors, sizes and shapes. Different capacitor values will provide a variety of flash rates (the flasher illustrated provides a flash rate of about 1/sec). Individual snails then can be identified from a distance by a combination of color and flash rates (the latter may be determined by recording the elapsed time for five or more flashes).

In both LED units, the polarity indicated (Fig. 2) for components must be maintained. Maximum light emission normally occurs at the distal tip of the LED, and this should be considered in mounting the unit to facilitate recognition from a distance. Maximum visual discrimination for the strongest LEDs is about 75 m.

In the present study, the unit shown in Fig. 2B was used. The LED unit was secured to the posterior portion of the upper surface of the body whorl with black electrician's tape (Fig. 2C), maximizing visibility from all angles while the snail was active. The tape was trimmed about the umbilicus and apertural lip to facilitate body movements. Reflective tape also was used in several places on the shell to increase the possibility of recapture in case of unit failure. The weight of the unit was 18 g, but this could be reduced substantially by the use of smaller batteries (with loss of unit life expectancy).

Because of the species' nocturnal habits, this technique proved highly successful in recording its activity. The snails were found easily and observed while active every night for the duration of the study. The snails became inactive when under a lighted headlamp, but were not distracted by the flashing LED.

FIG. 1. Biotelemetric transmitters. **A**, Collector, base and emitter (CBE); resistor (R); electrolytic capacitor (CAP_1); ceramic disc capacitor (CAP_2); battery (BAT), one Duracell mercury button type. **B**, Mounting position on snail.



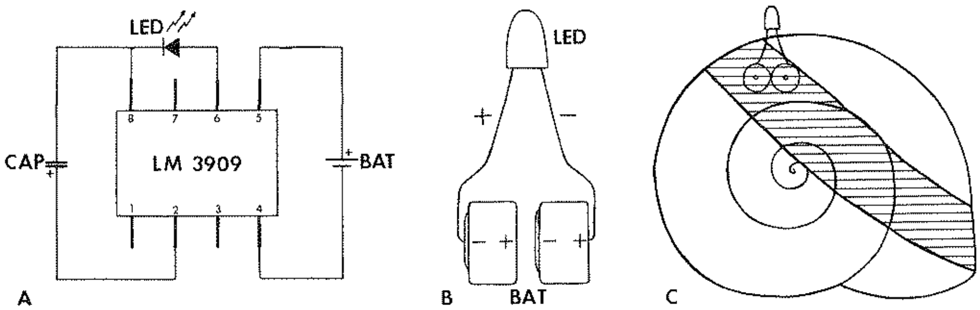


FIG. 2. Light-emitting diodes. **A**, Electrolytic capacitor (CAP); battery (BAT), Duracell 1.5V mercury button type; light-emitting diode (LED); integrated circuit (LM3909) (after Kephart, 1980). **B**, Light-emitting diode (LED), Radio Shack FRL-4403; batteries (BAT), two Duracell 1.5V mercury button type in series. **C**, Suggested mounting position on snail.

Although LEDs can be effective in the study of large nocturnal or arboreal snails, highly secretive species and juveniles of some species could impose limitations on their use. For example, a juvenile *Ryssota* with an attached LED promptly disappeared into deep cracks in the limestone, not usually inhabited by adults, rendering the LED useless. A radio transmitter would be more appropriate in such situations.

Another possible disadvantage is that the LED may attract predators, although this was not the case in the present study.

The transmitters and LEDs proved effective in determining home range, home site range, and daily activity patterns. Continued use and modification of these techniques are urged, for they are effective, easily constructed and operated, and inexpensive.

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KURT AUFFENBERG, *Malacology Division, Florida State Museum, University of Florida, Gainesville, Florida 32611, U.S.A.*

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