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BRIEF COMMUNICATIONS

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TEST OF TELEMETRY TECHNIQUES ON FRESHWATER MUSSELS. - Richard J. Neves, Fred Servello and Rebecca Wajda - Biotelemetry has become an important research tool in aquatic environments, especially for studying the movements of fishes in large lakes and rivers (Winter, 1983). The technique has been used far less frequently on invertebrates -- primarily on marine crustaceans (Lund & Lockwood, 1970; Clifton *et al.*, 1970; Monan & Thorne, 1973; Kanciruk & Herrnkind, 1978; Jernakoff, 1987) and large land snails (Auffenberg, 1982). The application of bio-electronic technology to freshwater bivalves has not been reported, but now the availability of miniature transmitters makes such studies possible on mollusks.

We attempted to evaluate the suitability of magnetometry and radiotelemetry to relocate freshwater mussels (Unionidae) in anticipation of the translocation of endangered mussels, as specified in recovery plans, to historic habitat (Neves *et al.*, 1987). Of the two techniques tested, one proved potentially effective for the remote monitoring of bivalves.

Methods. Magnetometry. A model DM22 portable magnetometer (Dowty RFL Industries, Boonton, NJ[1]) was used to locate specimens of the mucket, *Actinonaias ligamentina* (Lamarck 1819) that had been placed at marked locations in the New River, western Virginia. The magnetometer, consisting of a control box and hand-held ring-core fluxgate sensor (probe), measures magnetic field intensity or differential, indicated by a bipolar meter and audible tone. Magnetic fields ranging from ± 10 Gamma to ± 100,000 Gamma can be measured by using one of seven full-scale ranges of sensitivity.

Disk magnets of three strengths (3.5, 18, 27 million GaussOersted) and two diameters (8.4 and 12.7 mm) per strength were attached, one to each mussel. The magnets were secured externally, dorsad to the posterior ridge, with waterproof epoxy. Tagged specimens of *A. ligamentina*, 80-120 mm long, were pushed into the river bottom at known locations. We then conducted a systematic search for these attached magnets (mussels) by sweeping motions of parallel arcs within 5 cm of the substratum as we waded in the river. The deflection of the gamma meter needle indicated proximity to a magnet. As the probe passed over or near the magnet, needle deflection changed from one end of the scale to the other, reflecting the opposite poles of the magnet. Preliminary field tests were conducted to assess background magnetism and the appropriate sensitivity level to set the magnetometer. To prevent false readings, we used a sensitivity scale that would ensure that background levels of magnetism did not exceed one-half scale deviation.

Radiotelemetry. Radio transmitters purchased from two companies (Advanced Telemetry Systems, Bethel, Minnesota; L.L. Electronics, Mahomet, Illinois) were tested on specimens of the ennessee pigtoe, *Fusconaia barnesiana* (Lea 1838), a species in size (50-80 mm long) and shape that is similar to federally listed congenerics (Fig. 1). Transmitters weighed either 3.5 or 5.5 g (in air), including the

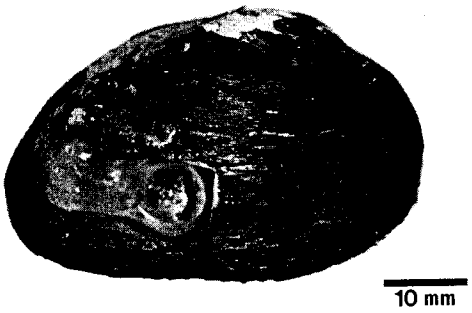

FIG. 1. Radio transmitter with internal coil antenna attached to a specimen of the Tennessee pigtoe.

[1] Reference to trade names or manufacturers does not imply Government endorsement of commercial products.

mercury battery that reportedly provided a tag life of 30 days. Both whip and coiled antennas were tested for range and suitability.

Radio transmitters were attached and covered with commercial epoxy (Tru Bond, Devcon Corp., Chicago, Illinois) and air-dried for 45 min before the animal was submerged (Fig. 1). Tagged specimens were transported to the New River and placed in the substratum at various locations. We used a 10-channel receiver (ATS) with loop antenna (48 mHz range) to locate specimens at least twice weekly for the life of the tags, using the standard triangulation method (Tyus, 1982). After triangulation, we detached the loop antenna and used the receiver directly to pinpoint the location of the tag. Ranges of transmitters with whip and coiled antennas were determined by walking upstream from a transmitter until the signal became inaudible.

We later placed tagged mussels in an artificial circular stream with substratum and observed the movement and orientation of tagged and untagged *Fusconaia barnesiana*, to compare behavior.

Results and Discussion. As judged by field trials with the magnetometer, we concluded that the use of magnets and a portable magnetometer for relocating tagged freshwater mussels is a time- and labor-intensive project, due primarily to the relatively small magnetic field around each magnet and the occurrence of background electromagnetic fields. Naturally occurring magnetized materials such as iron ferrite or magnetite and many types of igneous rock produce fields that essentially render the magnetometer ineffective at its higher scales of sensitivity. Because of natural and anthropogenic sources of electromagnetism in streams and rivers, the detection of small magnets is ineffective except at close range. Magnetometry posed several disadvantages: short range of detection (< 30 cm), background levels of magnetism (noise), restricted water depth of < 0.5 m (length of probe), and the need to use both the instrument meter and audio signal to locate specimens – which is difficult while one is sweeping the probe.

Testing of the various radio transmitters in the river revealed no audible differences in signal strength at water depth < 1.0 m and within 50 m of the transmitter. Ranges of the two types of antennas (0.5 m water depth) were roughly 400 m for the whip antenna and 250 m for the coil antenna, when there were no obstructions between transmitter and receiver. Specimens of *Fusconaia barnesiana* with all tested radio tags were easily relocated by triangulation. Once the intersect location was determined, often within 2-5 m of the radio-tagged mussel, the antenna was removed and the receiver was held above the water surface. At a water depth of roughly 0.6 m at most locations, the transmitter signal was strong enough to locate specimens to within 1 m.

Battery life for the LLE and ATS radio-tags was 3 or 4 weeks. After the batteries died, we returned tagged specimens to the laboratory for observations of behavior in a circular stream with low water velocity (< 20 cm/s). The attached transmitters did not inhibit burrowing of mussels into the substratum, where they remained for about 2 weeks before we released them. However, field observations in the New River indicated that the whip antenna occasionally collected detritus, which probably disturbed the burrowed mussel. Although the length of the whip antenna could be reduced, the range of transmission would also be reduced.

Table 1. Transmitters tested on freshwater mussels in the New River, Virginia.

Source	Weight in air (g)	Antenna type	Dimensions (mm) L W D	Frequency (mHz)
LLE*	3.5	Whip	20 x 12 x 7	48-123
LLE	3.5	Whip	30 x 14 x 6	48-165
LLE	3.5	Coil	30 x 10 x 8	48-142
ATS*	5.5	Coil	20 x 13 x 6	48-190
ATS	3.5	Coil	17 x 9 x 5	48-140

* LLE - L.L. Electronics: ATS - Advanced Telemetry Systems

We concluded that the smaller coil antenna radio tags provide an effective means of relocating mussels to within 1 m. Two key issues on the practicality of radiotelemetry for freshwater mussels are battery life of the transmitter and size of the tags, particularly for use on small endangered species. The tag must be small enough to produce little or no drag and not alter the stability of the mussel when it is burrowed. Commercially produced tags are available for small species, but battery size ultimately determines overall tag size and weight. Batteries (mercury and lithium) now used with small transmitters have relatively short lives because current drains are continuous (Tyus, 1982); consequently, only short-term monitoring of translocated mussels is possible. Transponders are available for radio tags, but they add significantly to tag size. Development of a microchip-controlled tag that would turn itself on and off (e.g., 1 hr each day), at a time selected by the user, would greatly extend battery life and overcome the major liability of the tags available for mollusk telemetry.

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