INTERPRETATION OF VARICES AND GROWTH RIDGES ON SHELLS OF *EUPLEURA CAUDATA*[1]

In some bivalve mollusks, growth ridges are formed annually and can be used to determine age. For example, the Pismo clam (Weymouth 1923), the Pacific razor clam (Weymouth, McMillin and Holmes 1925), and the Pacific cockle (Weymouth and Thompson 1931) can be aged accurately by counting shell ridges. To my knowledge, only Magalhaes (1948), who found that from none to 3 growth ridges a year are formed on shells of *Busycon canaliculatum* and *B. carica* with no apparent relationship to age, and Clarke (1956), who states without experimental evidence that ridges on shells of *Nassarius trivittatus* probably have no relationship to age, have treated this subject with regard to snails. Cole (1942) attempted to assign ages to smooth oyster drills, *Urosalpinx cinerea*, by counting ridges on the siphonal canal, but he did not determine beforehand whether they were correlated with age. Andrews (1956) questioned Cole's conclusions on this account.

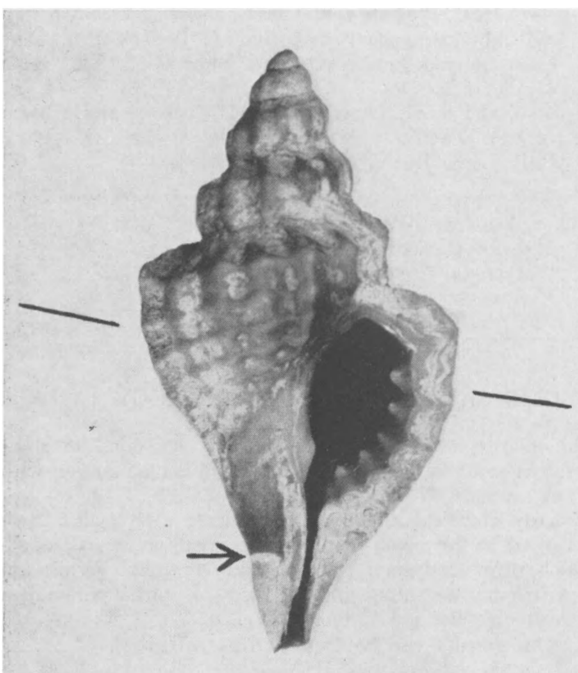

FIG. 1. Shell of *Eupleura caudata*. Arrow points to siphonal canal growth ridge. Lines at left and right show where shell was cut for Figure 2. Shell measures 22.0 mm in height.

It might be suspected that growth ridges on certain snails do not represent yearly markings because the distance between successive growth ridges is usually considerably smaller than yearly increments in growth. For example, recent observations at the Virginia Fisheries Laboratory of the rough oyster drill, *Eupleura caudata,* show that, whereas the distance from the siphonal growth ridge to the tip of a fully grown siphonal canal where the next growth ridge would appear may measure 2 to 6 mm, shell growth may exceed 10 mm a year (Figure 1).

Records of individual *E. caudata* actually showed that these snails do not deposit a consistent number of varices and siphonal canal ridges per growing season (Figures 1 and 2). Growth of this drill in Virginia waters extends from about the beginning of May to the end of October. In contrast to *U. cinera* which may have several or many small and usually poorly-defined growth ridges on its siphonal canal, *E. caudata* usually has one prominent ridge. When the first varix has been laid down, when the drill is 10 to 15 mm high, there is no ridge on the siphonal canal. After this, shell growth usually occurs as half-whorl increments. A thin layer of new shell material is deposited through an arc of 180° and then it flares out to form another varix. While this layer is being reinforced from the inside with successive layers of new shell, there is growth neither laterally at the varix margin nor longitudinally at the siphonal canal tip. It takes approximately 7 weeks to form and reinforce a half whorl. With its formation, a new growth ridge which consists of a line of demarcation between the tip of the old siphonal canal and the new shell appears on the new siphonal canal. Varices and growth ridges are formed with each successive half whorl of growth and old ridges are grown over.

In May 1956, 60 drills, having at least one varix and measuring in height from 12.8 to 26.2 mm, were caged and examined once a month until fall 1957, *i.e.* through 2 summers and a winter. The cages consisted of wooden frames with plastic screen sides and top (4 holes to a linear inch) and plastic screen bottoms (8 holes to a linear inch). The cages were 37 inches long, 16 inches wide and

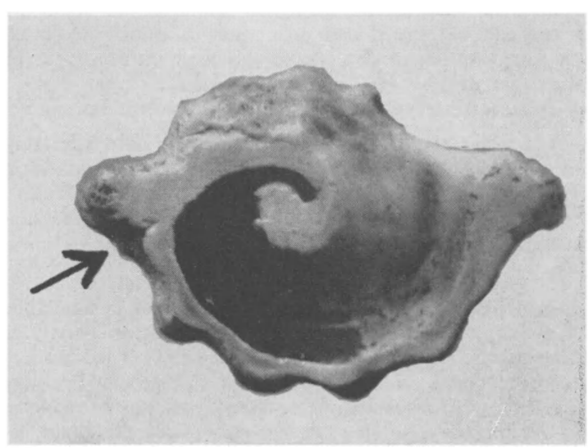

FIG. 2. Shell cut approximately perpendicular to longitudinal axis. Prominent ridges at left and right are varices. Four smaller ridges at bottom are axial ribs. Arrow points to place where growth of last half whorl of shell began. Shell grew in counterclockwise direction from here and stopped at varix on right.

[1] Varices are prominent ridges parallel to the margin of the aperture on shells of certain snails. This research was conducted under a contract at the Virginia Fisheries Laboratory with the U. S. Fish and Wildlife Service, No. 14-19-008-2372, Study of Oyster Drills in Chesapeake Bay.

6 inches deep, and included 8 compartments 9 x 8 x 6 inches. For support and stability they were tied into seasoned, tarred sea-rac oyster trays (Hewatt and Andrews 1954) and suspended in the York River along the laboratory pier one foot from the bottom with from one to 3 feet of water covering them. A male and female drill were kept in each compartment with several one- and 2-year old oysters for food. Although ages of the drills were unknown, it is probable that both young and old drills were included in the experiment because their heights matched almost the full range of heights of hundreds of drills collected randomly from nature.

Most mature drills in cages did not grow either summer because growth of *E. caudata* usually ceases with the onset of sexual maturity (unpublished data). Mature females were considered as those which deposited embryo cases during the experiment. Immature females did not deposit cases. Mature males had a full-size penis. Growing drills did not form a consistent number of half whorls and coincident varices and siphonal growth ridges per growing season. Eight individuals each formed 2 in one summer, apparently a normal number because many wild drills collected in late summer near the cages also showed 2 half whorls which appeared to be newly formed. Seventeen caged drills deposited just one half whorl a summer, but only 2 of these grew during both summers. A single caged drill deposited 3 half whorls. Several drills died or were lost during the experimental period.

It is clear that varices and siphonal growth ridges on shells of *E. caudata* cannot be regarded as yearly formations and probably have little value in determining age of drills.

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THE AVAILABILITY OF A MINIATURE BOMB CALORIMETER FOR ECOLOGY

A miniature bomb calorimeter, described by McEwan and Anderson (1955), is now being tested with reference to biological material at the University of Michigan. Individual samples of biological material as small as 6 mg can be burned and estimation of calories released on complete combustion can be provided with an error of the order of 5% (1% on larger samples).

Data of this type may be of value for two reasons:

1. Studies of population and community energetics rely heavily on caloric determinations (discussed in Slobodkin 1960).
2. There is intrinsic evolutionary interest in the distribution of calories per gram among animals.

It seems advisable to burn as wide a variety of microfauna samples as possible, while the bomb is available. We will, therefore, attempt to provide caloric analyses in exchange for appropriately prepared and labeled samples of microfauna (*i.e.* animals of less than 50 mg dry weight). No more than 3 or 4 analyses can be made in a working day, so that we can not guarantee rapid results, but we will try to keep up with the demand.

Samples should be accompanied by complete taxonomic and collecting data.

Frozen dried material is best. Alternatively, samples may be dried for 24 hours at 60° C in a vacuum oven and mailed in screw topped vials or weighing bottles. Low drying temperatures are advisable to prevent loss of volatile, energy rich, compounds. A period of starvation prior to drying will help avoid contamination with gut contents.

Any chemical analyses of duplicate samples to those burned in the bomb would be of great value. Combustion train analysis for C, H and N would permit approximate weighting for the protein, carbohydrate, fat ratio (Spoehr and Milner 1949).

Our results will be expressed as cal/gm.

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