Effect of Age-Specific Predation on Age Distribution and Survival of the Giant African Snail, *Achatina fulica*[1]

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The giant African snail, *Achatina fulica Bowdich,* one of the most destructive molluscan pests of many tropical areas of the world, became established in Hawaii November 30, 1936 (Pemberton, 1938). To control this pest predaceous snails, *Gonaxis quadrilateralis* (Preston), *G. kibweziensis* (E. A. Smith), and *Euglandina rosea* (Ferussac) were introduced (Davis and Butler, 1964; Davis and Krauss, 1964). According to Davis (personal communication, 1973) the population of *A. fulica* has declined markedly in recent years and numerous empty shells have been observed in many areas of Oahu. Using these shells a demographic analysis was made in this study to determine the role of introduced predators on the biological control of this mollusk.

METHOD OF STUDY

The life table approach was used in this study. To construct life tables it was necessary to obtain shell samples in the field and to estimate the age of each individual at the time of death.

Collection and Measurement of Shells. The shells were collected from two gulches, designated A and B, at Kailua, Oahu, March 18, 1973. The gulches, undisturbed by man, were covered with dense growth of guava (*Psidium guajava* L.), koa haole (*Leucaena glauca* L. Benth.) and monkey pod (*Samanea saman* (Jacq.) Merr.). All unbroken shells within an area of approximately 700 m^2 were collected by searching through the litter of decaying leaves and twigs. The number of shells collected from gulch A and B was 185 and 154, respectively. The length of each shell was measured to the nearest mm using a measuring rack built for this purpose.

Age Estimation. Since it was not possible to estimate age by appearance, shell length was used. Estimation of age was made by fitting the logistic growth curve to the shell length-age data of Kondo (1964):

$$Y = K / 1 + C e^{rt}$$

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where Y = age; t = shell length; e = base of natural logarithm; and K, C and r = constants. The method of curve fitting was the same as that described by Pearl (1944). The calculated curve shown in fig. 1 indicates that although small numbers were used the observed and calculated values agreed quite well.

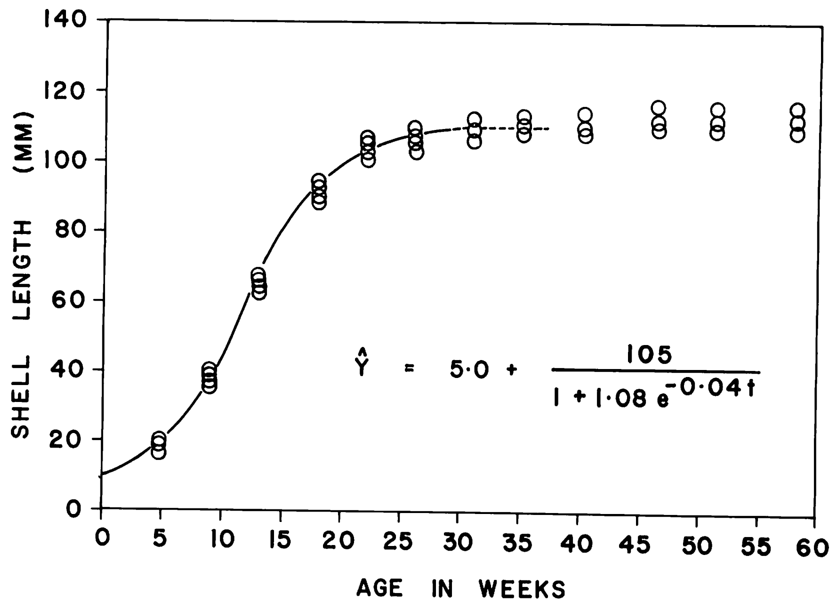

FIG. 1. The relationship between shell length and age of *Achatina fulica*. The calculated equation is based on data of Kondo (1964).

Construction of Life Table. The method of construction of life table was similar to that used for ungulates by Murie (1944), Deevy (1947) and Spinage (1972). Although complete life tables were constructed, data on only age distribution and survivorship, considered most pertinent to this study, are presented in this paper.

RESULTS

Age Distribution. The age-distribution pyramids shown in fig. 2 indicate that all age groups were not represented. In gulch A, individuals in age groups younger than 12 weeks were missing and in gulch B, individuals in age groups younger than 9 weeks. The data also indicate that the age range of shells in gulch A was higher than that of gulch B; 11-25 weeks for A and 8-20 weeks for B.

Field observations made during this study showed that predation by *Gonaxis* spp. and *E. rosea* on young *A. fulica* was the major cause of this anomolous age distribution. In gulch A there were numerous living *Gonaxis* spp. and in gulch B, *E. rosea*. Although small numbers of large living *A. fulica* were found, it was difficult to find small individuals. Similar observations were made by Davis (personal communication, 1973) and Davis and Butler (1964) who found that these molluscan predators are specific to the eggs and juvenile stages of *A. fulica*.

Survivorship. The survivorship curves, shown in fig. 3, were based partly on data from field collected shells and partly on estimates from Davis (personal communication, 1973) and Davis and Butler (1964). The estimates were made because it was not possible to obtain a complete array of individuals in all age groups.

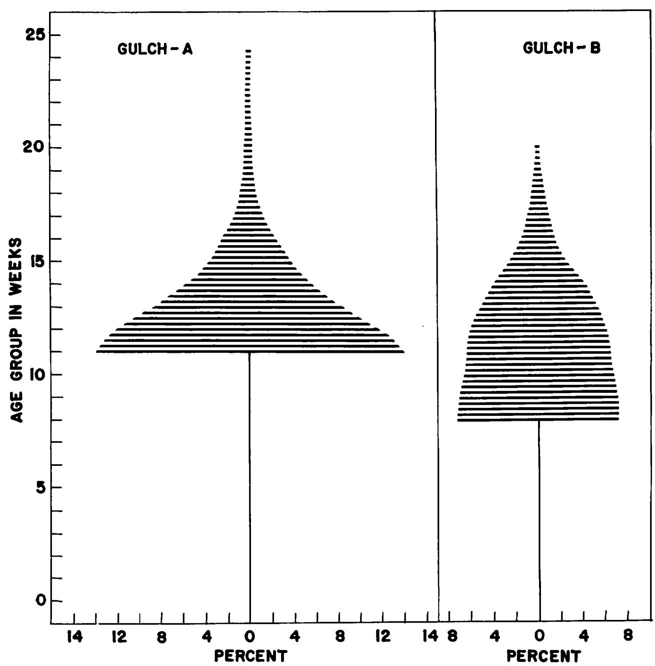

FIG. 2. Age-distribution pyramids based on age estimated from length of dead field collected shells of *Achatina fulica*.

Fig. 3 indicates that in gulches A and B there was a marked decrease in survival at two points; one in young age groups and the other in the old age groups. In both cases the survival rate was lowest among young age groups. It is also evident from fig. 3 that the overall survival rate was lower in gulch B than in A. There appears to be no explanation for this difference, except that in the former gulch the predominant predator was *Gonaxis* spp. while in the latter it was *E. rosea*.

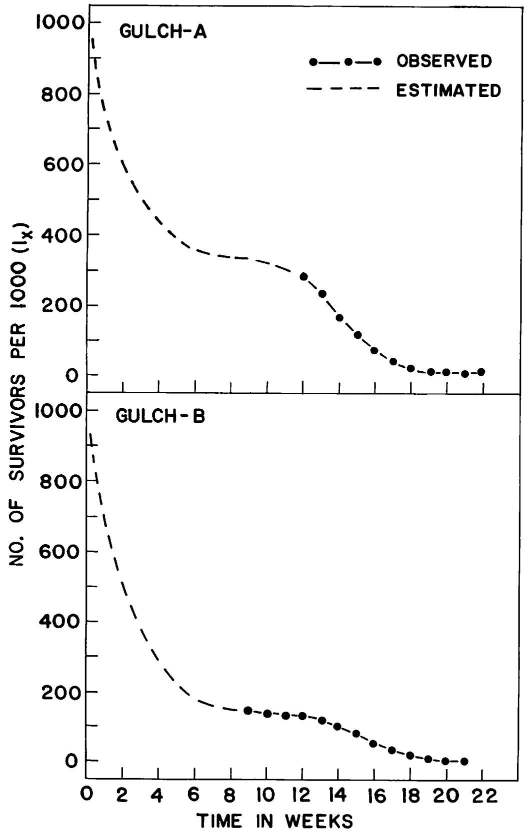

FIG. 3. Survival curves of *Achatina fulica* based partially on data calculated from field samples and partially from Davis (personal communication, 1973) and from Davis and Butler (1964). The standard life table notation was used in this study; l_x refers to the number of individuals surviving in each age class.

Discussion

In this study shell length was used in estimating the age of *A. fulica.* It should be pointed out that in using shell dimensions we disregarded aestivation, which appears to be a common phenomenon. Presumably shell growth ceased during aestivation and therefore the predicted ages corresponded to physiological rather than chronological ages. Unless characters aside from shell dimensions are used, it would be difficult to estimate the true chronological age.

Among *A. fulica* populations throughout the world there is a great variation in the size of the shells (Mead, 1961). This variation may be due to genetic, nutritional and environmental factors. The variation in size and growth rate that might be caused by these factors would affect age prediction. To improve prediction further studies are needed.

One of the problems in a study of this kind is the differential perishability between shells of old and young snails. Shells of young snails being thin and fragile do not withstand weathering and predation. Frequent sampling of the shells would partially eliminate this problem.

The absence of individuals in young age groups in field samples was, however, not due entirely to perishability. Davis (personal communication, 1973) and Davis and Butler (1964) stated that *Gonaxis* spp. and *E. rosea* feed on eggs and young individuals of *A. fulica*. Therefore, these predators, acting as age-specific mortality factors, are capable of causing the type of age distribution observed in this study. Furthermore, Davis and Butler found that in a living population of *A. fulica* there were 197 individuals less than half inch in length, out of a total of 424, in the absence of predators. After the introduction of predators they were not able to find any individual less than 2 inches long among a total of 250 live snails collected. Such data also support the viewpoint that *Gonaxis* spp. and *E. rosea* are effective age specific mortality factors that can alter age distribution as well as reduce the survival of *A. fulica*.

SUMMARY

Age distribution and survival rate of the giant African snail, *Achatina fulica* Bowdich, were studied by means of life tables which were constructed by estimating the age of field collected shells of dead *A. fulica* by shell length. The lack of individuals in young age groups was the characteristic feature of the age-distribution pyramids. This feature was attributed to age specific predation by *Gonaxis* spp. and *Euglandina rosea*. The low survival rate among young individuals was also attributed to predation.

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