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IMPACT OF INDIVIDUAL'S SIZE ON THE DENSITY OF THE GIANT LAND SNAIL PEST *ACHATINA FULICA* BOWDICH (GASTROPODA: ACHATINIDAE)***

Summary

Population studies of the giant African land snail pest *Achatina fulica* BOWDICH occurring in Calcutta, India have been made in active period (July - October) in 1976, 1977 and 1978. Of the 10 different size groups, viz. 4-14, 14-24, 24-34, 34-44, 44-54, 54-64, 64-74, 74-84, 84-94 and 94-104 mm density of snail population was highest in the youngest size group and lowest in the oldest size group. The discrepancy in distribution of snail population has been noted between 24 to 64 mm size groups, while a degenerating pattern of distribution is well evidenced in the following size groups. The observed data were compared with the smoothed data. The fitting of the smoothed curves for different years is 90% satisfactory. On the whole, a gradual decline in percentage of snail individuals with the increase in size (shell length) has been recorded. The finding is justified from the correlation test ($r_{xy} = -0.909$) between two variables i.e. the size and the density of the snails sampled.

Riassunto

Negli anni 1976, 1977 e 1978, durante il periodo di maggiore attività, sono stati condotti studi su popolazioni della dannosa chiocciola gigante africana *Achatina fulica* BOWDICH, che è presente a Calcutta, India. Gli individui furono suddivisi, in base alle dimensioni, in 10 gruppi, cioè 4-14, 14-24, 24-34, 34-44, 44-54, 54-64, 64-74, 74-84, 84-94 e 94-104 mm: la densità di popolazione risultò massima per i gruppi più giovani e minima per i più vecchi. Si è notata una divergenza nella distribuzione dei gruppi fra 24 e 64 mm ed un evidente impoverimento di densità nei gruppi di maggior dimensione. La perequazione effettuata in base ai dati rilevati nei vari anni è soddisfacente per il 90%. Nel complesso è stata osservata una graduale diminuizione percentuale con l'incremento delle dimensioni (lunghezza della conchiglia): ciò concorda con il coefficiente di correlazione ($r_{xy} = -0,909$) fra le due variabili: dimensione e densità di popolazione delle chiocciole in esame.

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Introduction

The giant African land snail *Achatina fulica* BOWDICH is a serious agri-horticultural pest in all the countries where it has been introduced (REES, 1951; MEAD, 1961, 1979; GODAN, 1983; RAUT & GHOSE, 1984). It is a prolific breeder. Reports on its rate of egg laying and hatching are also available (MEER MOHR, 1949; REES, 1951; WEEL, 1949; GHOSE, 1959; MEAD, 1961; KEKAUOHA, 1966; RAUT & GHOSE, 1984). In nature, breeding is monsoon dependent. The breeding period extends from 4 months to 8 months in a year in different parts of the globe depending upon the length of monsoon (MEER MOHR, 1949; KEKAUOHA, 1966; MEAD, 1961; RAUT & GHOSE, 1984). The recruitment of individuals almost throughout the monsoon is a common phenomenon in this snail species. Of course, at the same time, the population is used to face the usual mortality (RAUT & GHOSE, 1977, 1984). As a result, in a given area, at a given time, occurrence of individuals with different sizes is a must. Since the snail (*A. fulica*) starts breeding with the attainment of 60.3 mm (average) in shell length; the deposition of eggs in clutches, at certain intervals, continues for the remaining part of the snail's life and, the juvenile snails are more susceptible to death during aestivation (RAUT & GHOSE, 1979, 1984), nature of distribution of individuals in different size groups would throw some light on the population build-up of *A. fulica*. This sort of study would also prove helpful in proper evaluation of the damage caused by *A. fulica* to any agri-horticultural plant species. Because, different size groups of snails (*A. fulica*) have different food preference (JASKI, 1953; RAUT, 1982). It is to be mentioned here that in Calcutta, the newly hatched *A. fulica* usually bears a shell 4 mm in length and the shell length of the largest individual recorded so far was never more than 104 mm (RAUT & GHOSE, 1984). Since a gradual decline in the percentage of snail individuals with the increase in shell size (length) is a common occurrence in the present study, an attempt has been made to establish the impact of shell size on the population density of *A. fulica*.

Materials and Methods

Random sampling of *A. fulica* population was made almost fortnightly from five different sites of the garden of the Institute of Jute Technology, Ballygunge, Calcutta during the period 5 July 1976 to 30 October 1978. In each site an area of 1 m² was selected irrespective of density of snail population. The sampling was made between 18.00 and 19.00 hours, the peak period of activity of the snails (RAUT, 1979). *A. fulica* of different size groups occurring in these sites were collected manually. They were counted and the length of each individual was recorded.

To study the impact of individual's body size on the population density the snails were grouped, based on their shell length, into any of the 10 size groups viz. 4-14, 14-24, 24-34, 34-44, 44-54, 54-64, 64-74, 74-84, 84-94 and 94-104 mm. The density of snail population was finally tabulated in terms of percentage for statistical analysis of the data. PIELOU (1977) was consulted for statistical analysis.

302

Results

The per cent of *A. fulica* occurring in a m² area in the garden of the Institute of Jute Technology, Ballygunge, Calcutta has been figured under 10 different size groups during the period of 4 months July to October in 1976, 1977 and 1978 in Tables 1-3. It is to be mentioned here that the snails were found active in the garden during the said period. In other months of the year they were in their aestivating homes. The observed data were smoothed, and both observed and estimated percentages of *A. fulica* population under 8 different size groups have been presented in Table 4. If x be the size of the snails and y be the density of snail population the smoothed curves for different years are as follows:

For 1976, $\hat{y} = 14.913416_e - \dfrac{1}{2 \times 2347.4178} (x - 6.1408)^2$

For 1977, $\hat{y} = 75.859356_e - \dfrac{1}{2 \times 13438.44} (x - 189.25489)^2$

For 1978, $\hat{y} = 2.30819 \times 10^9{}_e - \dfrac{1}{2 \times 118708.73} (x + 2096.7286)^2$

The fitting is quite good. The goodness of fit test, χ^2 (Chi square) values are 12.047, 1.3891 and 8.5625 respectively compared to $\chi^2\alpha$, k-1 = $\chi^2\alpha$, q = 14.689 at 10% level of significance which implies the fittings are 90% satisfactory.

The smoothed snail density for the three different years can be compared with their coefficient of variation (C.V.) measure. The C.V. for three different years are 45.7%, 47.75% and 51.83%. With this regard, the smoothed snail density for the three different years are also comparable because they are very close to each other.

Now, other than the estimation of density for different size of snails, we have expressed their functional relationship. But, the size x and the density y of the snails are very much correlated. Actually, the size and the density of snail in nature are inversely proportional i.e. the two variables proceed in different directions. This is vivid by their correlation coefficient $r_{xy} = -0.909$.

Table 1. Occurrence of *A. fulica* (in percentage) of different size groups in the garden of the Institute of Jute Technology, Ballygunge, Calcutta during the sampling dates of July to October in 1976.

Size groups of *A. fulica*	Sampling dates							
	July		August		September		October	
	5	20	5	20	5	20	5	20
4-14 mm	19	27	26	19	23	28	26	18
14-24 mm	15	18	19	20	23	24	10	22
24-34 mm	16	6	7.5	3	9	6	14	10
34-44 mm	5	4	6	9	8	10	14	14
44-54 mm	5	9	4.5	10	4	6	8	8
54-64 mm	10	8	14	12	10	14	14	5
64-74 mm	12	12	9	14	8	2	9	6
74-84 mm	6	8	5	7	8	6	2	9
84-94 mm	7	5	2	3	4	2	1.5	4
94-104 mm	5	3	7	3	3	2	1.5	4

303

Table 2. Occurrence of *A. fulica* (in percentage) of different size groups in the garden of the Institute of Jute Technology, Ballygunge, Calcutta during the sampling dates of July to October in 1977.

Size groups of *A. fulica*	Sampling dates							
	July		August		September		October	
	5	20	5	20	5	20	7	22
4-14 mm	0	15	24	27	28	30	26	17
14-24 mm	21	16	12	19	17	16	19	21
24-34 mm	14	10	12	11	13	10	12	13
34-44 mm	12	10	9	9	10	10	10	11
44-54 mm	12	8	11	8	7	8	7	8
54-64 mm	9	9	7	8	9	10	9	8
64-74 mm	8	10	7	7	8	7	8	6
74-84 mm	9	7	6	5	4	5	4	5
84-94 mm	9	8	6	4	3	2	3	6
94-104 mm	6	7	6	2	1	2	2	4

Table 3. Occurrence of *A. fulica* (in percentage) of different size groups in the garden of the Institute of Jute Technology, Ballygunge, Calcutta during the sampling dates of July to October in 1978.

Size groups of *A. fulica*	Sampling dates							
	July		August		September		October	
	2	19	5	20	17	30	15	30
4-14 mm	9	36	31	31	30	34	24	16
14-24 mm	12	18	17	18	13	14	16	19
24-34 mm	13	8	10	12	12	9	12	11
34-44 mm	12	7	10	9	10	9	9	10
44-54 mm	9	7	8	9	10	8	10	10
54-64 mm	10	5	6	8	8	6	7	8
64-74 mm	10	5	4	5	7	7	6	8
74-84 mm	7	4	6	4	6	5	5	5
84-94 mm	8	5	4	3	3	5	6	5
94-104 mm	10	5	4	1	2	3	5	6

Table 4. Observed and estimate (smoothed) average density (in percentage) of *A. fulica* during active period in 1976, 1977 and 1978.

Size groups of *A. fulica*	Year					
	1976		1977		1978	
	Observed	Estimated	Observed	Estimated	Observed	Estimated
4-14 mm	23	20	21	19	26	24
14-24 mm	19	15	18	16	16	16
24-34 mm	9	14	12	14	11	13
34-44 mm	8	12	10	12	10	11
44-54 mm	7	11	9	9	9	9
54-64 mm	11	9	8	8	7	8
64-74 mm	9	7	8	7	6	6
74-84 mm	6	5	5	6	6	5
84-94 mm	4	4	5	5	5	4
94-104 mm	4	3	4	4	4	4

304

Discussion

Though, in the present study, the observed and expected densities of *A. fulica* population are very close to each other a clear discrepancy in distribution of snail population under different size groups is well marked. It is clear that in all the years density in lowest size groups was highest. The percentage of snails in 14-24 mm size group was next in order. But, thereafter, marked variations in population density in snails belonged to 24-34, 34-44, 44-54 and 54-64 mm size groups have been noted. In the remaining 4 size groups a degenerating pattern of distribution is well evidenced. The discrepancy in distribution of snail individuals under different size groups is most probably associated with the growth rate of individual snail as well as the mortality rate experienced by the snail population in the study period concerned.

In Calcutta, in their natural habitat, *A. fulica* reproduce in monsoon months (July - October), almost at an equal tempo (RAUT, 1978; RAUT & GHOSE, 1984). The growth of the snail is also dependent on a number of factors (MEAD, 1961; GHOSE, 1963; KONDO, 1964; RAUT & GHOSE, 1978, 1984). It is obvious that with the increase in number the snails had to face the competition both for food and shelter. As a result the fittest individual would grow faster. Besides, as per natural cycle (RAUT & GHOSE, 1977, 1984), they had to over come the aestivating hazards for a period of 8 months every year. Other than usual mortality, mass mortality during aestivation due to desiccation has also been noted by RAUT & GHOSE (1979). And, it is statistically proved that the juvenile snails are more susceptible to death during aestivation (RAUT & GHOSE, 1979). In the present study the anomaly in distribution of *A. fulica* in the juvenile size groups viz 24-64 mm is, most probably, the effects of both the factors, the growth and mortality. Since aged snails are better adapted at least in searching food and to fight against unfavourable environment they are less prone to unusual death. Under such conditions, usual growth in snails would also be maintained. This would undoubtedly show a degenerating pattern of population structure as is evidenced from the data collected on the last 4 size groups of the giant snail pest *A. fulica*.

A fulica, though a native of East Africa has been introduced in many countries (MEAD, 1961, 1979; GODAN, 1983; RAUT & GHOSE, 1984). Following introduction, the initial explosive build-up of population in a new area has also been recorded. Also, in the first few years, after introduction, the snail specimens are reported to be large, vigorous and healthy looking (MEAD, 1979). In the following years, the average size of the individuals is noticeably reduced, even moderately large specimens are scarce or entirely absent. In some areas unusual deaths following diseases have resulted in drastic reduction in snail density (MEAD, 1961; RAUT, 1983). It seems that there exists a selection pressure that inhibits the growth of individual specimen under the functions of environment in which it is exposed. The snails, under such conditions, also try to adjust themselves by reducing the rate of growth of their body to a permissible lower range. This may have resulted in appearance of large number of aged individuals with the shell size appreciably below the expected range. In other words the density of *A.*

305

fulica will be low if size becomes large. It is justified from the correlation coefficient value obtained in the present study.

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BIBLIOGRAPHY

GHOSE K.C., 1959 - Observations on the mating and oviposition of two land pulmonares, *Achatina fulica* Bowdich and *Macrochlamys indica* Godwin-Austen. *J. Bombay nat. Hist. Soc.*, **56**: 183-187.

GHOSE K.C., 1963 - The early stages of development in *Achatina fulica* Bowdich (Mollusca: Gastropoda). *J. Bombay nat. Hist. Soc.*, **60**: 228-232.

GODAN D., 1983 - Pest slugs and snails, biology and control. Springer-Verlag, Berlin, pp. X + 445.

JASKI C.J., 1953 - *Achatina fulica. Tropische Natuur*, **33**: 91-98.

KEKAUOHA W., 1966 - Life history and population studies of *Achatina fulica. Nautilus*, **80**: 3-10.

KONDO Y., 1964 - Growth rates in *Achatina fulica. Nautilus*, **78**: 6-15.

MEAD A.R., 1961 - The giant African snail; a problem in economic malacology. University of Chicago Press, Chicago, pp. XVII + 257.

MEAD A.R., 1979 - Economic malacology with particular reference to *Achatina fulica*. In: Fretter, V. & Peake, J. (Eds.), *Pulmonates*. Academic Press, London, Vol. 2B, pp. X + 150.

MEER MOHR J.C. VAN DER, 1949 - On the reproductive capacity of the African or giant snail, *Achatina fulica* (Fér). *Treubia*, **20**: 1-10.

PIELOU E.C., 1977 - Mathematical ecology. John Wiley & Sons, New York, pp. XII + 386.

RAUT S.K., 1978 - The giant African land snail *Achatina fulica* Bowdich. *Zoologiana*, **1**: 29-31.

RAUT S.K., 1979 - Distribution and population of the land snails *Achatina fulica* Bowdich and *Macrochlamys indica* Godwin-Austen. *Bull. zool. Surv. India*, **2**: 7-16.

RAUT S.K., 1982 - The extent of damage inflicted by *Achatina fulica* Bowdich to agrihorticulture economic plants. *J. zool. Soc. India*, **34**: 7-12.

RAUT S.K., 1983 - Epizootic disease of the giant African land snail *Achatina fulica. Proc. Symp. Host. Environ., Zool. Surv. India, Calcutta*, 29-37.

RAUT S.K. & GHOSE K.C., 1977 - Effect of upwardly directed shell aperture on the aestivating land snail *Achatina fulica. Nautilus*, **91**: 31-33.

RAUT S.K. & GHOSE K.C., 1978 - Influence of aestivation on the growth rate of *Achatina fulica* and *Macrochlamys indica. J. zool. Soc. India*, **30**: 7-11.

RAUT S.K. & GHOSE K.C., 1979 - Factors influencing mortality in land snails *Achatina fulica* and *Macrochlamys indica. Proc. zool. Soc. Calcutta*, **32**: 107-120.

RAUT S.K. & GHOSE K.C., 1984 - Pestiferous land snails of India. Tech. Monograph, No. 11, Zoological Survey of India, Calcutta, 151 pp.

REES W.J., 1951 - The giant African snail. *Proc. zool. Soc. London*, **120**: 577-598.

WEEL P.B. VAN, 1949 - Some notes on the African giant snail, *Achatina fulica* Fér. III. Observations on its biology. *Chronica Naturae*, **104**: 335-336.