ON THE REPRODUCTIVE CAPACITY OF THE AFRICAN OR GIANT SNAIL, *ACHATINA FULICA* (FÉR.)

by

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Though already as early as 1910 GREEN published his notes on the bionomics of *Achatina fulica* (FÉR.) and, afterwards, there have appeared other articles on the same subject, yet it is regrettable that in none of these publications exact data on the reproductive capacity of the African snail are produced. Therefore, since conditions at Kampong Baru near Medan, East Coast of Sumatra, where the AVROS Experiment Station is situated, seemed favourable, breeding experiments were started which, in due course, would also have furnished data on the rate of growth and on the longevity of the African snail. However, these experiments came to an end when, in September 1943, the author was interned by the Japanese. At the time this preliminary report was put in typescript, the data obtained after April 1943 were not yet available. Since all original notes have been lost, it is now not possible to incorporate these supplementary data in the present paper. As far as I can remember these data merely confirmed the essentials already acquired before.

The breeding experiments commenced with a few couples of *Achatina fulica* found in copula, more couples being added in the course of time; in all, 13 couples have served for regular breeding purposes (cf. breeding protocol, table III). The animals were not picked up before it became quite evident that copulation was completely finished. Copulation is usually effected very early in the morning and takes a long time, an hour at least, but more often than not it lasts 1½-2 hours. The snails were then transferred to the laboratory, and put separately in boxes with glass cover and filled with a layer of vegetable débris which was always kept sufficiently moist. The temperature in the laboratory room varied from 24.4° C to 30.5° C. The boxes were daily cleaned and, if necessary, the food (slices of sweet potato, egg-plant, cucumber, *Opuntia* etc.) renewed. The question of the lime requirement of the snails has been duly considered, of course, but since it seemed desirable, in view of the special purpose of these experiments, that the nutrition of the snails under observation should be of almost the same kind as that which they are wont to find in their natural haunts, lime was supplied only in small quantities, viz. as little pieces of lime-cement bricks. Furthermore, care

has been taken to select couples of which the partners differed markedly in size as well as couples of which the partners were nearly equal in size. Individuals with a shell measuring less than 60 mm in length have never been found in copula thus far. This fact indicates that under conditions prevailing at Kampong Baru *Achatina fulica* reaches sexual maturity not before an age corresponding with a shell length of at least 60 mm, and this has been further substantiated by the dissection of numerous individuals with shells varying in length from 50-70 mm. In drawing conclusions from the data given in the tables it should be remembered that, up to the time a couple was picked up and isolated, it has remained utterly unknown whether anyone of the partners had already copulated once or twice (or perhaps more times) before; as regards the older (larger) individuals, this, indeed, will have happened.

Achatina fulica lays its eggs in batches, usually underground, in shallow holes, in crevices or under a stone, but if sufficient shelter and moisture are afforded by a dense low vegetation the eggs may also be deposited just upon the surface of the soil (for instance under the ground-cover in a rubber field or under a thick hedge of bamboo). The eggs are enclosed in a thin calcified shell (cf. also p. 5) and, at the time of their deposition, covered with a film of a clear slightly viscid substance which, apart from preventing the eggs to roll away one by one and thus being scattered, will protect in some degree the eggs against a too rapid desiccation. The chitinous shell which the young already possess at the time of egg-laying will, however thin it may be, also aid to the prevention of a too rapid desiccation. After deposition of the eggs, which act may take some hours, the animals do not care any longer about them. It has been observed on several occasions that, under cage conditions, the snail retires into its shell after oviposition and closes the aperture of the shell with a thin parchment-like cover (epiphragm), as it is wont to do in spells of very dry weather.

The eggs are broadly ovoid, their dimensions averaging 5.40 mm $\times$ 4.28 mm; their volume is 0.055 cc on an average and their average weight 61 mgr. Besides slight differences in the average size of the eggs from batches laid by different individuals, one can find in almost every batch a few eggs of conspicuously small size; nevertheless, from such eggs eventually hatch young snails of quite normal appearance, though accordingly smaller in size. The colour of the eggs may also show slight variations; in some batches the eggs have a very pale yellow or almost white coloured shell, whereas in other batches the colour is dark lemon-

eggs.

yellow. The majority of the batches, however, has lemon-yellow coloured

There is a wide variation in the number of eggs of the batches of individuals of approximately the same size, and this too is often demonstrated in the number of eggs of subsequent batches of one and the

same animal (cf. table III). The highest number of eggs in a batch, obtained under cage conditions at Kampong Baru, has been 315, the lowest 82 [1]). The total number of eggs of 48 batches, obtained under similar conditions, amounted to 8312 or 177.3 per batch.

In table I all batches, obtained in the rearing experiments at Kampong Baru, have been arranged in 4 groups, according to the size of the mother snail at the date of the deposition of the eggs. These groups comprise snails with shells ranging from 60-70 mm in length (group A), from 71-80 mm (group B), from 81-90 mm (group C), and from 91-100 mm (group D). For each of these groups the average number of eggs per batch is given in the 4th column of the table, and from those figures we see at once that the difference between the averages of group A and group B on the one hand and between group C and group D on the other hand are very slight. There is, however, a very marked difference between the averages of the second and the third group, a difference of no less than 51.7 eggs. The reason for this sudden increase is not very obvious, but, perhaps, this increase is an indication that there are two distinct periods of reproduction, and that full sexual maturity is reached not until in the second reproductive period. Moreover, it would seem that full sexual maturity corresponds with a shell measuring 80 mm at least (cf. also the accompanying graph, fig. 1).

One may object that the arrangement of the batches in 4 groups has been done irrespective of the question whether the batches are virtually a first deposition of the mother snail or a second or a third, etc. It is almost certain, however, that the batches which in table I are marked with an asterisk truly represent the first depositions of each of the snails I A, VI A, VIII A, IX A, IX B, X A, XI B and XIII A (cf. table III), all belonging to the two groups, i.e. bearing shells from 60-80 mm in length. From the snails I A, VI A, VIII A, IX A, X A and XI B (cf. table III) there have been 6 controlled second depositions (in table I marked with two asterisks). The majority of the batches registered in the groups C and D most likely represent third and fourth (or even later) depositions. The average number of eggs per batch of the category of snails

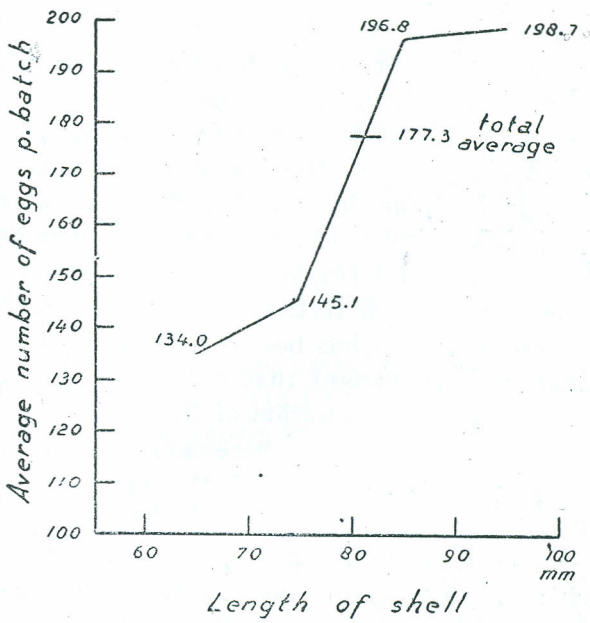

Fig. 1.

[1]) In a batch, obtained earlier in breeding experiments with the giant snail at the Deli Tobacco Experiment Station, we counted not less than 394 eggs!

with shells ranging from 60-80 mm in length is 146.8 (all controlled first and second depositions taken together); the average per batch of the category with shells from 81-100 mm in length is 198.0 (all "third" and later depositions taken together). The difference between both these averages is 51.2 eggs or nearly the same figure as found for the difference between the averages of group B and group C.

As to how many eggs a giant snail can produce during its life, the breeding experiments do not furnish definite information, though judging from the figures in table III, and assuming that the giant snail will outlive two reproductive periods, reproduction probably being limited to the rainy seasons, in which at least 6 batches will be laid, the total number of eggs that a giant snail can produce during its whole life may amount to about one thousand (1.000).

From the figures in table III it appears that in 3 cases the shortest period between copulation and egg-laying has been 14 days; in 3 other cases the periods were 16, 17 and 18 days respectively. Most likely cross-fertilization has occurred in all these 6 cases. If, however, we grant that eggs, actually originating as a result from cross-fertilization, may be laid even 4-5 weeks after copulation took place, then in 5 more cases cross-fertilization can have occurred. Of those partners which, according to the length of their shell, had not yet reached full sexual maturity at the time of isolation, 5 may be considered as true protandric hermaphrodites (viz. Nos. 1 A, VI A, IX B, XI A, XIII A) and 3 as protogynic hermaphrodites (viz. Nos. VIII A, IX A, X A).

It goes without saying that the afore-mentioned period of 4-5 weeks is a mere supposition which may prove to be true or not, but it does not seem warranted to connect those batches, produced 2 or more months after copulation, with that same act. In such cases the production of eggs should be considered rather as the result from self-fertilization. Of course, without microscopical examination nothing positive can be decided as to whether a single sexual act may or may not suffice to produce 2 or more batches of fertile eggs, but as regards the cases that the first batch or the second has been produced not until 2 or more months after copulation, it is thought that self-fertilization gives, for the time being, a more plausible explanation of those facts. Accepting this view, copulation does not at all seem necessary for the production of fertile eggs, since approximately 80% of the eggs hatched quite normally (*vide infra*).

There is, however, no reason to doubt that under normal natural conditions cross-fertilization is the usual mode of multiplication in *Achatina fulica*. The question may be raised whether parthenogenesis has occurred instead of self-fertilization, but, for the present, this possibility is left out of consideration here.

This faculty of self-fertilization is a very significant feature, because it enables the giant snail to establish a new colony by means of

a single individual, if only that individual can hold out for a fairly long time on its new station. The ability of *Achatina fulica* to overcome periods of drought by "estivation", and also to endure total immersion for 10-12 hours without being much impaired, greatly enhances, of course, the chances of holding out.

Incubation lasted from 1-10 days, with an average of 5.37 days (cf. table II). For the time being no reliable correlation can be detected either between the duration of the incubation period and the number of eggs per batch, or between the duration of the incubation period and the time elapsed between copulation and egg-laying (between each of two subsequent depositions, respectively). In several cases the incubation period did not last longer than 2 days at most, and it is worthy of note that in these cases a large percentage of the eggs had their shells insufficiently calcified. This insufficient calcification can be looked upon as a symptom of lime deficiency in the snail's diet, but then, we may ask, why in the other cases the snails, living on just the same diet, did produce eggs with normal shells. With equal right we may look upon it as symptomatic of a tendency in some individuals towards internal incubation, resp. ovoviviparity.

Though the majority of the eggs of a batch hatched almost simultaneously, it took, in most instances, 2 days before all fertile eggs of a batch had hatched; in 5 instances it has lasted 3 days.

The fertility of the eggs proved fairly great. In 20 batches under special control the fertility ranged from 55.2% to 93.3%, with an average of 81.79% (table IV). The percentage of fertility was determined 2-4 days after the eggs had commenced to hatch. From the figures in table IV it does not seem likely that in younger snails fertility of the eggs should be less than in older ones. Moreover, the figures with reference to the cases that the fertility has been determined in 2 subsequent batches do not bear evidence that, as a rule, fertility should diminish with each subsequent batch.

Out of the 26 giant snails which have been under close observation during a period of 5-7 months 4 individuals (15.4%) failed to produce eggs; the reason for this sterility is not known at present.

Summary.

From the records of breeding experiments it is tentatively concluded that *Achatina fulica* (FÉR.) has two distinct periods of reproduction, and that full sexual maturity is reached not until in the second reproductive period, this period being characterized by a shell measuring at least 80 mm in length.

The highest number of eggs in a batch, obtained under cage conditions at Kampong Baru, was 315, the lowest 82. The total number of

eggs of 47 batches, obtained under similar conditions, amounted to 8330 or 177.2 per batch. The total number of eggs that a giant snail may produce during its life is estimated at approximately 1.000.

Self-fertilization has repeatedly been observed. This faculty of self-fertilization is considered an important factor in the establishment of *Achatina fulica* in newly invaded territories.

The incubation period lasted from 1-10 days, those instances of a very short incubation period, attended with insufficient calcification of the egg shell, perhaps indicating a tendency towards ovoviviparity.

Fertility of the eggs is fairly great, about 80% of the eggs hatched quite normally.

Copulation does not seem a *sine qua non* for the production of fertile eggs.

TABLE I. AVERAGE NUMBER OF EGGS PER BATCH IN RELATION TO SIZE OF SNAIL.

Length of shell in mm	Number of eggs per batch	Total of eggs	Average per batch	Average per batch for A+B and C+D
60 — 70 (group A)	114* — 137** — 120* — 135* — 144* — 163** — 125	938	134.0	140.5
71 — 80 (group B)	177* — 139* — 157** — 130* — 122** — 145** — 168* — 155 — 93 — 205**	1451	145.1	
81 — 90 (group C)	249 — 140 — 192 — 82 — 159 — 207 — 201 — 230 — 222 — 206 — 192 — 185 — 215 — 304 — 185 — 146 — 181 — 254 — 205 — 182 —	3937	196.8	197.5
91 — 100 (group D)	92 — 266 — 151 — 275 — 188 — 315 — 168 — 114 — 197 — 190 — 230 —	2186	198.7	

Total number of eggs: 8512. Average per batch: 177.3. For signs after the numbers of second column cf p. 3.

TABLE II. INCUBATION PERIOD IN DAYS.
NUMBER OF EGGS IN BRACKETS.

No. of snail	1 batch	2 batch	3 batch	No. of snail	1 batch	2 batch	3 batch
I A	4 — 6 (177)	6 (145)	—	VIII A	3 (135)	5 — 6 (163)	6 (115)
I B	7 — 9 (92)	7 — 8 (266)	6 (151)	VIII B	—	—	—
II A	—	—	—	IX A	5 — 6 (114)	8 — 10 (137)	8 — 9 (125)
II B	7 — 8 (230)	7 — 8 (222)	—	XI B	6 (130)	—	—
III A	8 — 9 (249)	10 (140)	8 — 9 (192)	X A	4 (144)	10 (157)	10 — 11 (93)
III B	3 (206)	3 — 4 (304)	—	X B	4 — 5 (185)	4 — 5 (230)	—
IV A	2 — 3 (146)	—	—	XI A	—	—	—
IV B	7 — 8 (192)	3 — 5 (185)	5 — 6 (197)	XI B	8 — 9 (139)	1 — 2 (205)	—
V A	—	—	—	XII A	5 — 6 (275)	10 (188)	7 — 8 (168)
V B	5 — 6 (215)	1 — 2 (182)	—	XII B	3 — 4 (315)	1 — 2 (190)	—
VI A	4 (120)	1 — 2 (122)	—	XIII A	2 — 3 (168)	—	—
VI B	5 — 7 (82)	3 — 4 (159)	—	XIII B	3 — 4 (207)	2 — 3 (254)	—
VII A	1 — 2 (181)	—	—	N.B. The incubation period of the 114 eggs of the 4th batch of snails No. I B lasted 2 - 3 days.			
VII B	1 — 2 (201)	2 (205)	—				

TABLE III. BREEDING PROTOCOL.

Number of couple [1])		Date of copulation, resp. isolation	Date of deposition and number of eggs per batch.			Period (in days) between date of copulation and date of deposition		
			1st batch.	2nd batch.	3rd batch.	1st batch.	2nd batch.	3rd batch.
I	A (70 mm)	22 — IX — 1942	18 — I — 1943 177	1 — III — 1943 145	—	118	160	—
	B [2]) (91 mm)		6 — X — 1942 92	12 — XI — 1942 266	28 — XII — 1942 151	14	51	97
II	A (82 mm)	26 — IX — 1942	—	--	—	—	—	—
	B (89 mm)		31 — X — 1942 230	16 — I — 1943 220	—	35	112	—
III	A (83 mm)	26 — IX — 1942	10 — X — 1942 249	11 — XI — 1942 140	6 — I — 1943 192	14	46	102
	B (86 mm)		23 — XI — 1942 206	6 — II — 1943 304	—	58	133	—
IV	A (85 mm)	2 — X — 1942	25 — II — 1943 146	—	—	146	—	—
	B (90 mm)		4 — XI — 1942 192	21 — I — 1943 185	9 — III — 1943 197	33	111	158
V	A (62 mm)	2 — X — 1942	—	—	—	—	—	—
	B (78 mm)		21 — I — 1943 215	30 — IV — 1943 182	—	111	210	—
VI	A (67 mm)	5 — X — 1942	28 — XI — 1942 120	24 — II — 1943 122	—	54	142	—
	B		2 — XI — 1942	24 — I — 1943				

	B (81 mm)		19 — I — 1943 201	12 — III — 1943 205	—	100	152	—
VIII	A (67 mm)	13 — X — 1942	11 — XI — 1942 135	31 — I — 1943 163	12 — III — 1943 115	29	110	150
	B (89 mm)		—	—	—	—	—	—
IX	A (65 mm)	20 — X — 1942	5 — XI — 1942 114	6 — I — 1943 137	20 — II — 1943 125	16	78	123
	B (71 mm)		31 — I — 1943 130	—	—	103	—	—
X	A (66 mm)	21 — X — 1942	23 — XI — 1942 144	28 — I — 1943 157	27 — III — 1943 93	33	99	157
	B (83 mm)		6 — II — 1943 185	7 — IV — 1943 230	—	108	168	—
XI	A (72 mm)	29 — X — 1942	—	—	—	—	—	
	B (74 mm)		12 — XI — 1942 139	6 — IV — 1943 205	—	14	159	—
XII	A (91 mm)	29 — X — 1942	16 — XI — 1942 275	27 — I — 1943 188	2 — III — 1943 168	18	90	124
	B (91 mm)		6 — II — 1943 315	26 — III — 1943 190	—	100	148	—
XIII	A (66 mm)	20 — XI — 1942	2 — III — 1943 168	—	—	102	—	—
	B (82 mm)		7 — XII — 1942 207	8 — III — 1943 254	—	17	108	—

[1]) For each of the snails the length of its shell at the date of isolation is given in brackets. The shell was measured again after the deposition of each batch, though these measurements are omitted here.

[2]) The 4th batch of No. I B was deposited 6.III.1943 (i.e. 165 days after copulation) and comprised 114 eggs.

TABLE IV. FERTILITY OF EGGS OF *ACHATINA FULICA*.

No. of snail	Length of shell in mm	Number of eggs per batch	Number of eggs hatched	Fertility %
I A	74	177	159	98.8
I A	76	145	131	90.3
V B	83	215	181	84.2
V B	84	182	139	76.3
VIII A	70	163	140	85.9
VIII A	71	115	101	87.8
X A	70	157	126	80.2
X A	72	93	66	70.9
XII A	93	188	153	81.4
XII A	94	168	143	85.1
XII B	94	315	248	78.7
XII B	97	190	169	88.9
VI B	85	159	130	81.1
IX B	75	130	103	79.2
X B	92	230	127	55.2
XI B	76	205	179	87.3
XIII B	85	254	200	78.6
A.P.A. [1])	—	139	102	73.3
A.P.A. [1])	—	194	181	93.3
A.P.A. [1])	—	267	237	88.4
	Totals	3686	3015	Average: 81.79

[1]) A.P.A. means: eggs of batches found in the experimental garden at Kampong Baru.