Snail Farming in Mature Rubber Plantation: 4. Studies on some Artificial Methods for Hatching of Snail Eggs and Protection of Young Snails during the Dry Season

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Summary

Three species of edible land snails of the moist forest belt of Nigeria, Archachatina marginata *(Swainson),* Archachatina papyracae *(Pfeiffer) and two phenotypes of* Limicolaria *species, sometimes named* Limicolaria flammae *(Muller) and* Limicolaria aurora *(Jay), were used in the study of three methods of artificial hatching of snail eggs and their young ones for the study of two methods of reduction of mortality during the dry season. The results of egg laying performance by the three species of snails showed a significantly (p< 0.01) higher population explosion in a given breeding season for* L. flammae/aurora *than for either* A. papyracae *or* A. marginata. *The results of artificial methods for hatching of snail eggs indicated that the use of plastic containers, plus either loose topsoil or cotton wool for the incubator mediums or the use of cellophane containers (bag) plus loose topsoil for the incubator medium, were in each case suitable for adoption in successful hatching of snail eggs artificially.*
Leaking coagulation pans or wooden boxes, half filled with heat sterilized loose topsoil and placed on the ground under shade of rubber tree canopy as dry season protection methods for the snails, were again in each case effective in the reduction of field mortality of the young snails. The survival rates were 100% ; 90.6% and 71.2% for youngs of A. marginata, A. papyracae *and* L. flammae/aurora respectively. *The results further indicated that the dry season protection method deemed optimum for the youngs of A. marginata may not necessarily be optimum for the youngs of either* A. papyracae *or* L. flammae/aurora.

Résumé

Elevage d'escargots dans une vieille plantation d'arbres à caouthouc: 4. Etudes de quelques méthodes artificielles d'incubation d'œufs d'escargots et protection des jeunes escargots pendant la saison sèche
Trois espèces d'escargots terrestres comestibles de la zone forestière humide du Nigeria Archachatina marginata, Archachatina papyracae *et deux phénotypes de l'espèce* Limicoloria *parfois nommés* L. flammae *et* L. aurora *ont été utilisées.*
Les résultats de ponte ont montré une beaucoup plus grande explosion démographique pendant la saison de reproduction chez Limicoloria *sp. Les résultats d'incubation indiquent que l'emploi de récipients en plastique avec soit de la terre meuble, soit de l'ouate comme substrat convient aussi bien pour réussir l'incubation artificielle que l'usage de sacs de cellophane avec la même terre meuble.*
La réduction de mortalité sur le terrain des jeunes escargots a été aussi effective en employant, en guise de protection des escargots pendant la saison sèche, des récipients à coagulation de récupération ou des caisses en bois, à moitié remplis de terre meuble stérilisée à la vapeur et installés sur le sol sous l'ombrage des arbres à caoutchouc. Les taux de survie ont été de 100% ; 90,6% et 71,2% pour les jeunes de A. marginata, A papyracae *et* Limicolaria *sp. respectivement. De plus, les résultats obtenus montrent que la méthode de protection qui paraît la meilleure en saison sèche pour les jeunes* A. marginata *n'est pas nécessairement la meilleure pour* A. papyracae *ni* Limicolaria *sp.*

Introduction

The three main species of edible land snails of the moist forest belt of Nigeria are *Archachatina marginata* (Swainson), *Archachatina papyracae* (Pfeiffer) and phenotypes of *Limicolaria species*, sometimes named *Limicolaria flammae* (Muller) and *Limicolaria aurora* (Jay). These species of snails vary widely in their respective liveweights to very mature liveweights of about 120 g to over 500 g for *A. marginata,* 18 g to over 30 g for *A. papyracae* and 8 to over 13 g for both phenotypes of *L. flammae/aurora.* Of these species, only *A. marginata* is available in the market throughout the year. Both *A. papyracae* and *L. flammae/aurora* are usually available in the market during the wetter period of the year, especially May to September, tending to become less available toward the end of the rains, with *L. flammae/aurora* disappearing faster than *A. papyracae.*

In spite of the value of snail meat in human nutrition (1, 5), no significant effort had been made in snail farming in Nigeria, compared to the farming of cattle, goats, sheep, pigs and poultry. Apart from its potentials for huge returns on investment with extremely low level of inputs, snail farming is also a convenient agricultural

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enterprise that can be accommodated within a family back yard (2). This makes it an attractive venture for house wives, retired civil servants and those without substantial capital or those seeking for farming ventures to augment their income capacity.

Farming edible land snails will command high acceptability in Nigeria, if their farming techniques are appropriately developed and disseminated. Two important areas in the development of snail farming technology that should be given proper attention are the development of appropriate methods of artificial hatching of snail eggs and the prevention of mortality, especially young snails and in particular during the dry harmattan period of the year. There is therefore increasing need for snail farmers to acquire efficient means of hatching their eggs artificially in order to keep pace with the scale of egg production under intensive system of management. Furthermore, since young animals in terms of smaller body size, have greater surface area per unit size, young snails with relatively greater surface exposure would be more vulnerable to a given prevailing adverse weather condition, especially during the harsh harmattan dry season. Very little attention had hitherto been given to the studies on the development of appropriate methods for artificial hatching of the eggs of edible African land snails and to the protection of young snails during dry season of the year.
This study was undertaken to identify ways in which snail farmers could increasingly hatch their eggs artificially and also ensure maximum survival of the young snails during the dry season. Meteorological data are provided in table 1.

Table 1
Meteorological data from July, 1999 to March 2000

Month/Year	Mean ambient temperature (°C)	Mean rainfall (mm)	Mean air relative humidity (%)
July, 1999	25.3	412.3	91
August, 1999	25.4	232.0	90
September, 1999	25.8	396.0	90
October, 1999	25.5	472.5	92
November, 1999	27.7	97.8	83
December, 1999	27.6	9.4	78
January, 2000	27.8	4.0	79
February, 2000	27.5	73	59
March, 2000	28.9	60.8	77

Materials and methods

Two experiments were carried out. The first of these was conducted in July to September, 1999 and the second, in November, 1999 to March, 2000.

In the first part of experiment, eggs laid by common species of edible land snails of the moist forest belt of Nigeria, namely, *Archachatina marginata, Archachatina papyracae* and a mixture of two phenotypes of *Limicolaria* species, *Limicolaria flammae* and *Limicolaria aurora* were used in the study of three methods of artificial hatching of snail eggs. Their mean liveweights were 143.5 ± 4.78; 24.6 ± 0.32 and 10.6 ± 0.34 g; for *A. marginata, A. papyracae* and *L. flammae/aurora* respectively. The snails were managed outdoors under mature rubber plantation by staff of the Farming Systems Research and Extension Division, Rubbers Research Institute of Nigeria, Benin.

Ten breeding snails each of the species *A. marginata, A. papyracae* and *L. flammae/aurora* were housed in raised wooden breeding boxes measuring 90 x 90 x 30 cm. The lids of the boxes were covered with plastic mosquito proof nettings to improve aeration and visibility of the contents. Smaller wooden boxes with the tops removed and each measuring 45 x 30 x 15 cm were filled with loose topsoil and placed in the centre of the breeding boxes for snails to enter and lay their eggs. Eggs laid by the snails were collected and incubated according to the artificial hatching method for snail eggs (3).

All snails were fed with green pawpaw fruits (*Carica papaya*) and cocoyam leaves (*Xanthosoma mafaffa*). These foods were offered fresh at 08:00 hours every day. Fresh drinking water was provided daily in a flat plastic container. About 40 g calcium carbonate was provided for the snails; twice a month for *A. marginata* and once a month for *A. papyracae* and *L. flammae/aurora*.

Clutches of eggs laid by each of the species of snails were incubated in the months of July, August and September, using three methods of artificial hatching cells described below :

- Plastic containers, using loose topsoil medium:
Plastic containers with covers, approximately 14 cm diameter, and 8 cm deep which had been perforated, top and bottom, were half filled with loose topsoil. Clutches of eggs laid were placed (according to species) in the hatching cells. The eggs were then covered with more of the soil, sealed, labeled and placed in boxes similar to the breeding boxes and designated as the hatching unit.

- Plastic containers using cotton wool medium:
The plastic containers were the same as those described above. Instead of loose topsoil, cotton wool was used as the hatching cell medium. The cotton wool was soaked in water, then gripped firmly with the hand and pressed to squeeze out most of the water for some 3 seconds. The cotton wool thus treated was used to incubate the eggs, imitating the method described for plastic containers, using loose topsoil medium.

- Cellophane bags, using loose topsoil medium:
Cellophane bags of the type and size used in wrapping (smaller) loaves of bread were obtained and prepared in similar way to the method of plastic containers, using loose topsoil medium to incubate the eggs.

All hatching mediums were moistened occasionally to prevent them from getting dry. They were examined for signs of hatching by carefully exposing the snail eggs in the hatching cells every alternate days, starting from the 22nd to the 44th days after incubation. Young snails that hatched out were collected, weighed and their dimensions were taken and then they were transferred to intensive rearing unit for young snails. The means of the data obtained for the months of July, August and September were used in subsequent calculations.

In the second part of this experiment, two types of materials, metal and wooden structures were used in the study of their effectiveness for dry season protection of young snails.
The metal equipment consisted of 6 leaking coagulation pans for natural rubber latex each measuring 45 x 30 x 15 cm. They were half filled with heat sterilized loose topsoil, cooled and moistened with water. Eighty young snails each of the species *A. marginata, A. papyracae* and *L. flammae/aurora,* about 2 weeks to 2 months old, were sorted out into 2 sizes per species and placed in these pans (40 young snails per pan). A second coagulation pan was then inverted over the first to form as cover.
The wooden equipment consisted of 6 boxes with the tops removed and they were constructed to the same dimension as those of the coagulation pans decribed above. They were given the same treatments as the contents of the coagulation pans and contained 40 young snails per wooden box. A second wooden box was inverted over the first to form as a cover.
Fresh cocoyam leaves (*Xanthosoma mafaffa*) and sliced green pawpaw fruits (*Carica papaya*) were provided for each group of snails *ad libitum.* Each of the three species of snails were assorted into 2 sizes and were replicated in the metal and wooden box equipment. These were placed on the ground under good shade formed by rubber tree canopy on the 25th November 1999. Inspection was done every morning to remove stale foods and to provide fresh ones. The soil in these equipment were occasionally moistened slightly to prevent them from being excessively dry. To avoid further accidental crushing of young snails with top covers of both dry season protection methods, daily inspection times were handled with utmost caution. Thereafter, no further accidental deaths by crushing was recorded throughout the duration of this study.

On the 31st day of March, 2000 after rainfall had resumed, the surviving young snails were estimated and compared with the results of earlier experiments (4) to evaluate methods of reducing field mortality of snails (*A. marginata*) during the dry season.

Results

The mean liveweights of the three species of snails, including their egg laying performance plus the weights of the eggs are presented table 2. The mean liveweights of the snails used in this study indicated that the relative liveweight of one *A. marginata* was equivalent to 5.8 individual numbers of *A. papyracae* or to 13.5 individual snails in the *Limicolaria* phenotype mixture of *L. flammae/aurora.* Also, the relative liveweight of one *A. papyracae* was equivalent to 2.3 individual snails in the *L. flammae/aurora.*
The average number of clutches of eggs laid by the ten snails in each of the three species of snails in the months of July, August and September were 5; 8.3 and 13.7 clutches of eggs per month for *A. marginata, A. papyracae* and *L. flammae/aurora* respectively. The number of clutches of eggs laid per month for *A. papyracae* was slightly higher than for *A. marginata*, but the difference was not significant ($P > 0.05$). Both were however, significantly ($P < 0.05$) less than the clutches of eggs per month laid by *L. flammae/aurora.* Average number of eggs laid per month were approximately 42.3; 68.3 and 1339.7 eggs and which were equivalent to 8.5; 8.2 and 98 eggs per clutch for *A. marginata, A. papyracae* and *L. flammae/aurora* respectively. The average number of eggs per clutch for *A. marginata* and *A. papyracae* were similar ($P > 0.05$), but both were highly significantly ($P < 0.01$) less than the average number of eggs per clutch for *L. flammae/aurora.*

The relative weight of an egg of *A. marginata* was 6.9 times heavier than an egg of A. papyracae or 96.7 times heavier than an egg of *L. flammae/aurora.* Likewise, an egg of *A. papyracae* was about 14 times heavier than an egg of *L. flammae/aurora.*
The hatching response of eggs of the three species of edible land snails to three methods of artificial incubation are presented in table 3. All snail species that hatched out from the plastic containers plus cotton wool incubation medium had consistently light (opaque) shell colour while those that hatched out from containers plus loose topsoil incubation medium had dark shell pigmentation.
The mean hatchability percentage, using plastic containers plus loose topsoil medium for artificial incubator across snail eggs species was 90.2 ± 1.48%. The use of plastic containers plus cotton wool medium for artificial incubator across snail eggs species was 88.7 ± 0.72%, while the use of cellophane containers plus

Table 2
Comparative egg laying performance of three species of edible land snails from July to September, 1999

	Archachatina marginata	*Archachatina papyracae*	*Limicolaria flammae/aurora*
Number of breeding snails Mean liveweight :	10	10	10
Start of Experiment (g)	143.5 ± 4.78	24.6 ± 00.32	10.6 ± 0.34
Range of liveweight (g)	127.01-156.16	20.03 - 29.26	8.89 - 12.40
Mean shell lenght (mm)	96.0 ± 3.03	60.2 ± 5.84	50.3 ± 0.47
Mean shell breadth (mm)	54.6 ± 0.96	27.8 ± 0.49	18.7 ± 0.42
Number of clutches of eggs laid	15	25	41
Total number of eggs laid	127	205	4.019
Range of eggs/clutch	7 - 10	6 - 10	36 -115
Average number of eggs/clutch	8.5	8.2	98
Mean weight of egg (g)	2.9 ± 0.14	0.42± 0.01	0.03 ± 0.01
Mean lenght of egg (mm)	21.8 ± 0.26	10.5 ± 0.46	4.6 ± 0.22
Mean breadth of egg (mm)	16.0 ± 0.24	8.13 ± 0.29	3.5 ± 0.11
Mean liveweight at hatch (g)	2.7 ± 0.30	0.34 ± 0.01	0.02 ± 0.01
Mean lenght at hatch (mm)	9.1 ± 0.18	7.7 ± 0.21	3.9 ± 0.04
Mean breadth at hatch (mm)	8 ± 0.16	5.9 ± 1.52	2.5 ± 0.05

Table 3
Hatching response of eggs of three species of edible land snails under different incubation methods during the months of July to September, 1999

Incubation method	*Archachatina marginata*	*Archachatina papyracae*	*Limicolaria flammae/aurora*
Plastic container plus soil medium:			
Incubation period (day)	31.6 - 1.29	31.1 ± 1.12	28.9 ± 0.63
Range (day)	26 - 41	26 - 36	24 - 32
Mean hatchability (%)	89.8 ± 4.68	92.9 ± 4.07	87.8 ± 5.01
Range (%)	66 - 100	87.5 - 100	64.1 - 100
Plastic container plus cotton wool:			
Incubation period (day)	29.8 ± 3.68	28.8 ± 1.20	28.3 ± 3.33
Range (day)	27 - 38	26 - 36	24 - 30
Mean hatchability (%)	88.9 ± 11.15	89.9 ± 6.83	87.4 ± 6.43
Range (%)	70.8 - 100	74.9 - 100	80.3 - 100
Cellophane container plus soil medium:			
Incubation period (day)	32.9 ± 9.38	30.2 ± 4.83	29.1 ± 3.26
Range (day)	26 - 40	26 - 38	25 - 34
Mean hatchability (%)	86 .6 ± 10.21	89.9 ± 11.11	89.1 ± 9.76
Range (%)	71.6 - 100	80.7 - 100	78 - 100

Table 4
Mortality of three species of young snails under two outdoor methods of dry season management, from November, 25th, 1999 to March, 31st, 2000

	Coagulation pan method					Wooden box method				
Size 1: Larger snail	Number at 25.11.99	Accidental loses	Natural death	Number at 31.3.00	% Survival	Number at 25.11.99	Accidental loses	Natural death	Number 31.3.00	% Survival
A. marginata	40	-	-	40	100	40	-	-	40	100
A. papyracae	40	1	3	36	90	40	-	2	38	95
L. flammae/aurora	40	2	11	27	67.5	40	3	6	31	77.5
Size 2: Smaller snails										
A. marginata	40	2	-	38	95	40	1	-	39	97.5
A. papyracae	40	1	6	33	82.5	40	-	4	36	90
L. flammae/aaurora	40	3	16	21	52.5	40	5	13	22	55

loose topsoil medium across snail eggs species was 88.2 ± 0.8%. Furthermore, the mean hatching response of eggs of the three species of snails across the artificial incubation methods studied was 89 ± 0.61% and the variation between snail eggs species across the artificial incubation methods were 88.4 ± 0.9%; 90.6 ± 1.2% and 88.1 ± 0.51% for *A. marginata, A. papyracae* and *L. flammae/aurora* respectively.

The mortality rate (table 4) among snail species were 1.9 ± 1.2%; 10.6 ±.2.58% and 36.9 ± 5.81% for *A. marginata, A. papyracae* and *L. flammae/aurora* respectively. When death by accidental crushing of young snails were accounted for, the adjusted mortality rates were 0.0%; 9.4 ± 2.13% and 28.8 ± 5.25% or 100%, 90.6% and 71.2% survival rates for *A. marginata, A. papyracae* and *L. flammae/aurora* respectively. The ratio of efficiency between the two methods for dry season protection, using either the coagulation pan (metal) or wooden box method was 1: 1.

The data were *A. marginata* 100 : 100%; *A. papyracae* 88.8 : 92.5% and *L. flammae/aurora* 66.3 : 72.3% for coagulation pan and wooden box methods respectively. When the efficiences of the two methods were compared across the snail species, their ratio was again 1 : 1; or 85 ± 9.91% for the coagulation pan method and 88.3 ± 8.27% for the wooden box method.

Discussion

There was highly significant ($p< 0.01$) difference between the average number of eggs laid per clutch by the three species of snails, which tended to imply higher population explosion in a given breeding season for the *Limicolaria* phenotypes, *L. flammae/aurora* than for either *A. marginata* or *A. papyracae.* Further studies would be necessary to probe the economic importance of the differences between the egg laying performance of the three species of snails in terms of ultimate edible biomass production per breeding season or per life cycle vis-à-vis the disparity in their respective liveweights.

There was no significant ($P> 0.05$) difference between the mean incubation period of the snail eggs across snail species and incubation methods. Thus, the efficiencies of the artificial incubation methods studied were similar. All snail species that hatched out from the plastic containers plus cotton wool for incubation medium had peculiar shell colour, whish were consistently very light (opaque) shell colour. Those that hatched out from containers plus loose topsoil for the incubation medium had dark shell colour or pigmentation, thus suggesting that, loose topsoil as a matter for an incubation medium was highly correlated to dark pigmentation of the shell colour of snails. Dark shell pigmentation generally adds to the aesthetic value of live snails due to mostly to its 'fresh forest colour'.

The mean hatchability percentages across the snail eggs species were 90.2 ± 1.48%; 88.7 ± 0.72% and 88.2 ± 80% for plastic containers plus topsoil medium, plastic containers plus cotton wool medium and cellophane containers (bags) plus loose topsoil medium for artificial incubators respectively. Furthermore, when the hatching response of eggs of the three species of snails were estimated across the three artificial incubation methods studied, the mean hatchability of 89 ± 0.61% was obtained. Their variations from the estimated mean were 88.4 ± 0.95%; 90.6 ± 1.2% and 88.1 ± 51% for *A. marginata, A. papyracae* and *L. flammae/aurora* respectively. The results demonstrated that each of the three methods employed in the study of artificial hatching of snail eggs could be recommended for adoption in snail farming technology aimed at keeping pace with induced scale of egg production under intensive system of management. However, the choice of which method a farmer prefers to practice in his farm is therefore an option based on convenience.

The results of the second part of this study showed that mortality rates between snail species and across the dry season protection methods were species dependent. Thus the young ones of *A. marginata* survived best, followed by *A. papyracae* and then *L. flammae/aurora*. When loses through accidental crushing of young snails with the top covers of both dry season protection methods were accounted for, the adjusted mortality rates were 0.0%; 9.4 ± 2.13% and 28.8 ± 5.25% or 100%; 90.6% and 71.2% survival rates for *A. marginata, A. papyracae* and *L. flammae/aurora* respectively. Thus, there were no other causes of death for *A. marginata* except through accidental crushing of the young ones with top covers of the dry season protection equipment, while *A. papyracae* and *L. flammae/aurora* species in addition suffered loses from other causes. This observation tends to indicate that a dry season protection method which offers optimum protection for the youngs of *A. marginata* may not necessarily be optimum for youngs of either *A. papyracae* or for *L. flammae/aurora*. In earlier work on dry season protection methods for snails out-doors (4), using three age grades of *A. marginata*: baby snails, 1-2 months old (4.6 - 9.5 g liveweight), growing snails, 4 - 6 months old (22.3 - 70.8 g liveweight) and mature snails, over 2 years old (387 - 468 g liveweight), the mature snails all survived, 100% each in all the three methods studied. The first of these dry season protection methods consisted of dry season paddock with broken corrugated asbetos roofing sheets placed on the ground as shelter for the snails, and all the three age grades of snails scored each 100% survival. The second and third methods were, dry season paddock with thick grass litter and dry season paddock with bare ground respectively. The baby snails had 100% mortality each in these two later treatments. The growing snails had 64% and 58% mortality rates for the grass litter and the bare ground treatments respectively. Hence, as in the corrugated asbestos roofing sheet experiments cited above, the results obtained for the young ones of *A. marginata* in the present study showed consistent 100% survival except loses due to accidental crushing of snails during routine management exercise. Therefore the dry season protection methods reported in this study, whether constructed with metal or with wood is recommended for adoption in outdoor integration of snail farming in tropical tree crop plantations. Obviously, wooden equipment by virtue of its being more susceptible to weathering due to exposure in the field would require frequent rehabilitation than metal equipment. However, the wooden equipment is within easy affordability of the resource poor farmers. Further studies are necessary to discover more suitable outdoor dry season protection methods to increase the survival rates of *A. papyracae* and *L. flammae/aurora* to hundred percent.

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