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MASS-REARING OF PREDATORY EARWIG, *Euborellia annulata* (Fabricius), ON ARTIFICIAL DIET[1]

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ABSTRACT

Among the four diets tested, a 1:1 mixture of ground dog food and corn cob was the best. Based on biological parameters, the earwigs reared on this diet were the closest to those reared on Asian corn borer and red flour beetle preys. Earwigs reared on this diet had an average total nymphal period of 33 days and adult longevity of 72 days. A female adult laid an average of 4 egg batches with 54 eggs/batch. The percentage survival from egg to adult from four batches of eggs was 90%, with a sex ratio of 1 male to 6 females. Mass-rearing of earwigs using this artificial diet was less laborious compared to using preys and cheaper, with the 25,000 earwigs produced in two months costing about PhP 1,610.00 or only PhP 0.06 per earwig.

Key words : biological control, earwig, Asian corn borer, life cycle

Abbreviations: ACB - Asian corn borer, CES - Central Experimental Station, CCD - corn cob diet, DCD - mixture of dog food and corn cob diet, DD - dog food diet, GC - green corn, GSD - golden snail diet, , IPB - Institute of Plant Breeding, IRRI - International Rice Research Institute, OPV - open pollinated variety, RFB - red flour beetle, UPLB - University of the Philippines Los Baños

INTRODUCTION

The Asian corn borer (ACB), *Ostrinia furnacalis* Guenee, is one of the most destructive pests of corn from whorl stage to crop maturity. It is capable of reducing yield of green corn (GC) varieties Asukar and Lagkitan by 40-80% and of open pollinated variety (OPV) IPB VAR-1 by 20-70% (Morallo-Rejesus and Punzalan 2001). Medrano and Raros (1975) reported that the average yield loss of variety UPCA 2 due to borer infestation is estimated at 0.95% per borer tunnel which resulted in yield reduction of 0.70 cavan per hectare or an equivalent of 3.5 cavans per hectare for 5 borer tunnels per plant. On the other hand, farmers generally incur losses averaging 52% of the potential yield.

Field surveys by Situmorang et al. (1988 a & b) and Javier et al (1993 a & b) have indicated the presence of entomophagous arthropods feeding on ACB. One of them is the predatory earwig, *Euborellia annulata* (Fabr) (Dermaptera: Anisolabididae), feeding on eggs, larvae and pupae of ACB from tasseling stage to maturity of the corn plant. However, the occurrence and abundance of earwigs in the field is insufficient to control ACB especially when population of the latter is high. Likewise, establishment of earwig population is being hampered by the pre-planting cultural operations such as plowing and harrowing which disturb the earwig habitat and subsequently affect its generation cycle. Hence, augmentative releases of laboratory-reared insects every planting season are needed.

The life cycles of ACB predators, namely, *E. annulata*, *E. philippinensis* (Srivasta), *Nala lividipes* (Dofour) and *Proreus simulans* (Stal), were initially studied by Situmorang and Gabriel (1998b) by rearing them on four-day old larvae of ACB and then by Javier et al. (1993a) using larvae and pupae of red flour beetle (RFB), *Tribolium castaneum* (Herbst) (Coleoptera:Tenebrionidae), as preys. However, mass-rearing of *E. annulata* using the above mentioned preys was laborious because the preys have to be reared also. Thus, a mass-rearing technique in the laboratory using artificial diet was developed to mass-produce earwigs for augmentative releases in the field.

MATERIALS AND METHODS

Diets evaluated

Five artificial diets (golden snail, dog food, chicken manure, corn cob, 1:1 mixture of ground dog food and corn cob), were evaluated to determine the best among them. However, the use of dried chicken manure mixed with a little amount of water and sterilized in an open flame, was discontinued due to 100% mortality of earwigs a week after release on the medium.

Live golden snails were collected from the International Rice Research Institute (IRRI) and University of the Philippines Los Baños (UPLB) experimental rice fields, washed three to four times with water and then allowed to stay for 24 hours in a container filled with non-chlorinated water to remove possible contaminants. The snails were again washed 3 to 4 times and then cooked in a casserole for 30 minutes. The meat was taken out from the shell, rinsed and cooked in an oven at 50°C for 24 hours. The toasted meat was then ground with the use of manual corn grinder.

Commercially available dog food (Pedigree) was purchased from the market while corn cobs were collected from the Institute of Plant Breeding (IPB) dumpsite and ground using a manual corn grinder.

Rearing the earwig stock culture

Seventy adult earwigs (20 males and 50 females, Fig. 1) collected from UPLB Central Experimental Station (CES) were pooled inside an acrylic pan with a diameter of 14.5 cm and 8.5 cm height and used as the founder population. They were then fed with a mixture of ground corn cob (CCD), ground toasted meat of golden snail (GSD), dog food (DFD) and *T. castaneum* and allowed to lay eggs till death. The emergent adults from the stock culture were used as initial parents (P_1) of the F_1 generation used for the succeeding studies.

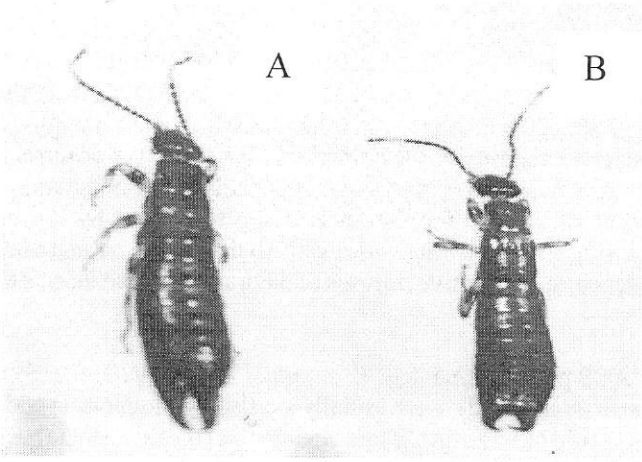

Figure 1. Female (A) and male (B) adults of *Euborellia annulata*.

Selecting the best diet

Ten grams of each diet and 250 gram soil (4 parts clay: 1 part sand) were placed inside the pan and water was added to the medium to have 27-30% moisture content. One male and three female adult earwigs were released per pan (Fig. 2), and then covered with cheesecloth to prevent their escape. Ten pans were provided per diet/replicate at room temperature of 27°C. The best diet was determined based on the following biological parameters: life cycle, oviposition period, number of eggs laid per batch, number of eggs that hatched based on the third instar nymphs present, and the percent adult survival. The results were compared with the published data on life cycle and fecundity of earwigs reared on the larvae and pupae of ACB and on RFB by Situmorang and Gabriel (1988b) and Javier (1993a), respectively. These two preys served as the standard diets for comparison. The test diet on which the biological parameters observed were closest to those reported for earwigs reared on ACB was considered the best, the ACB being an important target pest in the field.

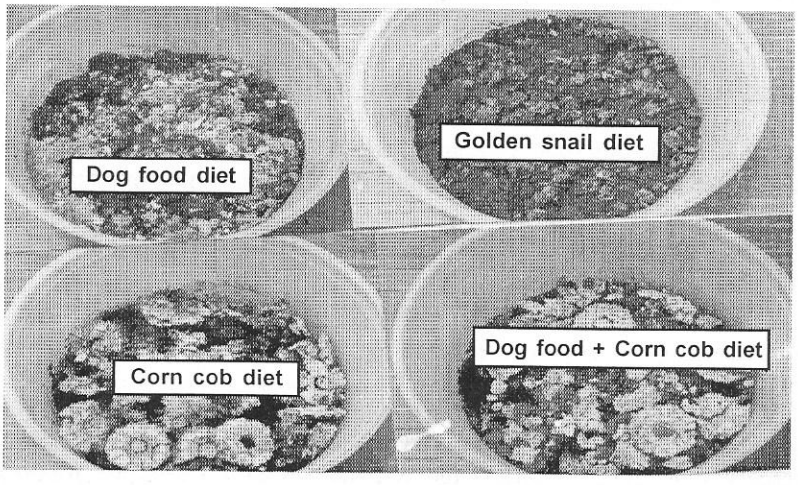

Figure 2. Acrylic pans containing the diets tested for mass-rearing earwigs.

The nutrient composition of the different diets (Table 1) was also considered in the screening, particularly the protein content which is the primary requirement for optimum growth of the earwig.

Table 1. Approximate nutrient composition of the four diets compared in mass-rearing earwigs.

Nutrient Composition (%)	Screened Diets			
	Dog food (DFD)	Golden snail (GSD)	Corn cob (CCD)	Dog food + corn cob DCD)
Dry matter	-	53.43	90.4	90.4
Crude protein	21	4.09	2.5	23.5
Ether extract	-	-	-	-
Crude fat	8	0.55	0.5	8.5
Crude fiber	4	0.40	32.4	36.5
Ash	-	38.85	1.5	1.5
NFE (Carbohydrates)	-	9.55	65.2	65.2
Moisture	12	-	-	12
Calcium	*	17.19	0.06	0.06
Phosporous	-	0.07	0.020	0.02
Arginine	-	2.20	-	-
Threonine	-	1.52	-	-
Leucine	-	2.29	-	-
Isoleucine	-	2.89	-	-
Valine	-	2.22	-	-
Tryptophan	-	0.18	-	-
Lysine	-	0.11	-	-
Histidine	-	0.75	-	-
Phenylalanine	-	1.63	-	-
Potassium	*	-	-	*
Magnesium	-	-	-	-
Sterols	-	-	-	-
Vitamins	*	-	-	*
Minerals	*	-	-	*

NFE = Nitrogen free-extracts
* additional nutrients that can be found in the diet.
- no data
Sources: Gerpacio, AL and Castillo, LS 1979; Escobin, RP Jr. 1987; Sebastian, A. 1984

Mass-rearing

Soil (3 parts clay: 1 part sand) 7.5 cm deep was placed at the bottom of the mass-rearing box made of galvanized iron sheet measuring 37.5 cm wide, 73.0 cm long and 28 cm high, with a detachable cover made of two layers of fine organza cloth (Fig. 3). Fifty male and 150 female adult earwigs were released inside the box and fed with a mixture of 1:1 ground dog food and corn cob (DCD) on acrylic pan which gave the best result in the diet screening test. The initial amount of diet provided was 400 grams per box, then 200 grams was added every 10 days. A total of 1 kilogram of the diet was consumed per month /box.

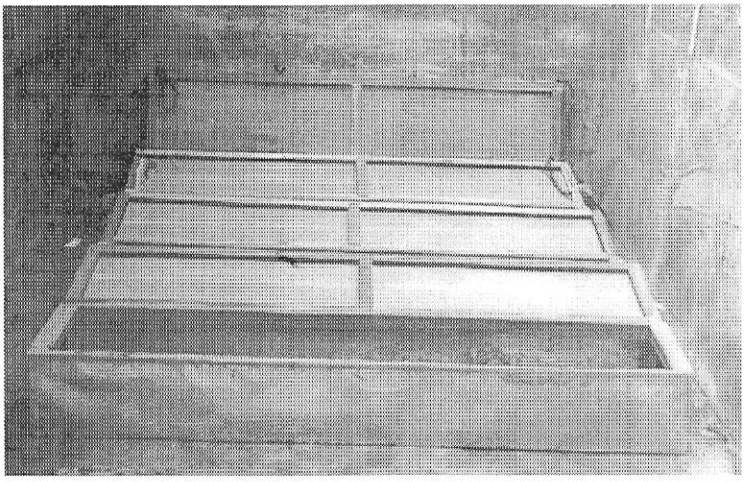

Figure 3. Earwig mass-rearing boxes, each one measuring 37.5 cm wide, 73.0 cm long and 28 cm deep

RESULTS AND DISCUSSION

Performance of *E. annulata* on four test diets

The life cycle of the earwig reared on each of four diets (GSD, DFD, CCD, DCD) was compared to the life cycle of those reared on the larvae and pupae of RFB and ACB preys reported by Javier et al. (1993a) and Situmorang et al. (1988b) as shown in Table 2.

Table 2. Comparative life cycles of *E. annulata*[a] reared on different diets .

Stages Period	Average Number of Days					
	Golden snail (GSD)	Dog food (DFD)	Corn cob (CCD)	Dog food + corn cob (DCD)	Red Flour Beetle (RFB)	Asian corn borer[c] ACB)
Eggs						
Incubation	9	7	9	8	7	6.5
Nymhal Stage						
First instar	6	4	7	5	4.5	6.5
Second instar	7	6	8	7	6	5.5
Third instar	9	8	12	8	10	7.5
Fourth instar	11	8	11	8	9.5	9.5
Total	33	26	38	28	30	29
Adult emergence to first egg laying	14	10	18	10	12.5	10
Adult longevity	41	50	21	72	101.5	88

[a] Based on 90 females.
[b] Based on Javier et al., 1993a.
[c] Based on Situmorang and Gabriel ,1988b.

The average incubation periods of the eggs of earwigs reared on DFD and DCD were the closest to that of eggs reared on ACB. The same thing was true for total nymphal period. Moreover, the average pre-oviposition period (10 days) of the female earwigs reared on DFD and DCD was exactly the same as that of females reared on ACB. But adult earwigs reared on each of the four test diets lived for a much shorter period (21-72 days) than those reared on ACB (88 days) or RFB (101.5 days). Nonetheless, those reared on DCD still lived the longest among earwigs reared on test diets. This parameter is very important because the longer the predator lives the more pest preys it would consume and, consequently, the greater the control potential in the field.

Regarding fecundity and survival, it can be noted in Table 3 that the closest again were those of earwigs reared on DFD and DCD, although not as good as those reared on RFB and ACB. However, the 1:6 male to female sex ratio was a plus factor in the mass production of earwigs.

Summing up, the biological data in Tables 2 and 3 show that the dog food + corn cob diet or DCD was the best while corn cob alone or CCD was the poorest among the four diets tested. On corn cob diet, the incubation, nymphal, and pre-oviposition periods were the longest while adult life was the shortest. This may be attributed to the much lower protein content of CCD. The more favorable sex ratio of 1:9, on this diet was offset by the much lower fecundity and survival rate.

Cost of earwig production

The five rearing boxes produced 25,000 earwigs in two months. This number of earwigs would be sufficient for release in one hectare of cornfield. At current prices of materials, investment of PhP 8,400.00 would be needed to start a colony. The cost of producing earwigs was estimated at PhP 1,610.00 or PhP 0.06 per earwig as shown in Table 4.

Table 3. Fecundity and survival of *E. annulata*[a] reared on different diets (P_1 to F_1 generation).

Parameters	Screened Diets		Standard Diets			
	Golden Snail (GSD)	Dog Food (DFD)	Corn Cob (CCD)	Dog food + corn cob (DCD)	Red flour Beetle[b] (RFB)	Asian corn borer[c] (ACB)
Number of egg batches per female	2	4	2	4	6	8
% survival from egg to adult	75	90	70	90	-	92
Sex ratio (Male:Female)	1:5	1:6	1:9	1:6	1:3	1:1

[a] Based on 90 females.
[b] Based on Javier et al. 1993a.
[c] Based on Situmorang and Gabriel,1988b.
- no data

Table 4. Partial economic analysis of mass-producing earwigs in the laboratory using a 1:1 mixture of dog food and corn cob diet (DCD).

Particulars	# of units	Unit Cost (PhP)	Cost (PhP)
Initial Cost			
Acrylic pan	10 pcs	190.00	1,900.00
Mass rearing box	5 pcs	700.00	3,500.00
Corn grinder	1 unit	3,000.00	3,000.00
			8,400.00
Production Cost			
Dog food	5 kg	65.00	325.00
Corn cob	5 kg	2.00	10.00
Labor			
1st month	.5/day x 3 days/week x 4 weeks	170.00	1,020.00
2nd month	.125/day x 3 days/week x 4 weeks	170.00	255.00
			1,610.00
Cost per earwig			**0.06**

CONCLUSION AND RECOMMENDATION

The most promising among the four diets tested was the dog food-corn cob mixture. It is less expensive than the pure dog food diet because corn cob is a farm waste and grinding of the material is easily done. Moreover, adult life of earwigs is longer on the mixed diet than that of insects reared on pure dog food. Considering therefore, the much greater labor requirement in mass-producing earwigs using the natural preys (red flour beetle or Asian corn borer) which have to be mass-produced also, the use of 1:1 mixture of dog food and corn cob diet would be more practical and hereby recommended for the mass production of earwigs for field release. The initial population of 50 males and 150 females per box produced 2,000 earwigs of different stages in a month's time. To have sufficient earwigs for the needed releases in one hectare corn field, the farmer should maintain at least 5 boxes for rearing and should be set up one month ahead of corn planting.

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REFERENCES

ESCOBIN RP JR. 1987. Fresh Azolla (*Azolla microphylla* Kaulfuss) as partial Replacement to Palay-Snail-Shrimp based ration for egg laying mallard and growth fattening Muscovy Ducks. [M.S. Thesis]. College Laguna, Philippines: University of the Philippines Los Baños. 71 p. (Available at College of Veterinary Medicine-Institute of Animal Science Library, UPLB).

GERPACIO AL, CASTILLO LS. 1979. Nutrient composition of some Philippine feedstuff. 4th Edition. Extension Division, Dept. of Animal Science, College of Agriculture, UPLB. Technical Bulletin 21 No. 117 p. (Available at College of Veterinary Medicine-Institute of Animal Science Library, UPLB).

JAVIER PA, DAYAOEN-ABELLON C, MORALLO-REJESUS B. 1993a. Studies on the life history of earwigs predatory to the Asian corn borer, *Ostrinia furnacalis* (Guenee). Philipp. J. Sci. 122(4):357-376.

JAVIER PA, DAYAOEN-ABELLON C & MORALLO-REJESUS B. 1993b. Seasonal abundance of the natural enemies of the Asian corn borer, *Ostrinia furnacalis* (Guenee). Philipp Agric Scientist. 76(3):299-312.

MEDRANO FG, RAROS RS. 1975. Yield losses due to the corn borer: estimation and the responses of different corn varieties. Philipp. Ent.. 2(6): 385-398.

MORALLO-REJESUS B, PUNZALAN EG. 2001. Mass rearing and augmentative releases of predatory earwigs, *Euborellia annulata*. pp. 5-75. In Terminal report of DA-BAR project (88-294-21) "Development of Biological Control Based-IPM for Asian Corn Borer, *Ostrinia furnacalis* Guenee". 211p.

SEBASTIAN A. 1984. The use of larval assay (*Tribolium castaneum*) in determining starch quality of cassava rootmeal in correlation with broiler trials. [B. S. Thesis] College, Laguna. 43 p. (Available at College of Veterinary Medicine-Institute of Animal Science Library, UPLB).

SITUMORANG J, GABRIEL BP. 1988a. Biology of *Labidura riparia* (Pallas) and its predatory capacity on the Asian corn borer. Philipp. Ent. 7(3):195-214.

SITUMORANG J, GABRIEL BP. 1988b. Biology of the two species of predatory earwigs, *Nala lividipes* (Dufour), (Dermaptera:Labiduria), and *Euborellia annulata* (Fabricius) (Dermaptera:Carcinophoridae). Philipp. Ent. 7(3):215-238.