EVALUATION OF FEED FOR REARING *CORCYRA CEPHALONICA* AND OPTIMISATION OF HOST AND PARASITOID AGES FOR MASS-PRODUCTION OF TRICHOGRAMMATID PARASITOIDS

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ABSTRACT

Trichogramma parasitoids are widely used as biological control agents against lepidopteran pests. *Corcyra cephalonica* (Stainton) (rice moth) is one the commonly used factitious hosts in their mass rearing. In an effort to reduce the mass-producing costs, the present study was carried out in order to identify cheaper and locally available feeds that would be used for rearing the larval stages of *C. cephalonica*. A total of 17 types of feed components were compared and it was found that the type of feed component used for rearing the rice moths affected the developmental time, with the shortest developmental periods recorded in maize + wheat bran, rice + wheat bran, and wheat + wheat bran. Also affected were the number of parasiotoids emerged, with wheat giving the highest number. In addition, the quantity of eggs produced was highest in maize feed. In all, maize was the cheapest feed for rice moth production, a welcome finding given that maize is plenty in Kenya.

Key words: Egg parasitoids, *Trichogramma, Trichogrammatoidea, Helicoverpa armigera*

1.0 INTRODUCTION

The African bollworm, *Helicoverpa armigera* Hübner is a key pest on several vegetable crops, especially tomato, capsicum and French beans. Farmers resort to use of chemical pesticides for its management. However, these chemical pesticides have adverse effects to the environment and beneficial fauna in the agroecosystem. Moreover, consumer concerns for securing fresh produce free from pesticide residues necessitates a shift to safer alternatives.

Trichogramma species are among the most widely used parasitoids for augmentative biological control ,mostly because they are easy to mass-rear. In addition, they attack many important pests (King *et al*., 1985). Prior to rearing *Trichogramma*, another insect is raised to produce eggs in which the *Trichogramma* wasps develop (Morrison *et al.,* 1976). Currently, the majority of *Trichogramma* used in biological control programmes are produced *in vivo*, using factitious hosts such as the eggs of *Sitotroga cerealella* Olivier or *Ephestia kuehniella* Zeller (Hassan, 1998). The rice moth, *Corcyra cephalonica* Stainton is one of the factitious hosts used in mass rearing trichogrammatid species (Awang and Lee, 1998). The major constraints in rice moth production are high cost of feed and labour (Awang and Lee, 1998).

The age of host eggs has been shown to be an important factor affecting host acceptance of several *Trichogramma* species (Pak, 1986; Somchoudhury and Dult, 1988; Hints and Andow, 1990; Zhang *et al*., 1995). Navarajan (1979) showed that differences among *Trichogramma* species in their preference for host eggs of different ages existed. The preference of some species for host eggs of a certain age was shown to be very pronounced (Zhang *et al*., 1995). Parasitoid effectiveness is likely to be diminished if certain ages of the host are preferred over others because non-preferred stages or species have an increased probability of remaining unparasitised (Ehler and Van den Bosch, 1974). It is important to select a parasitoid species that accepts a broad range of host ages, because preference for younger host eggs would increase the possibility of rejection of eggs, resulting in lower efficacy (Pak *et al*., 1986).

The effects of factors such as temperature and food on reproductive capacity of *Trichogramma* and *Trichogrammatoidea* have been investigated (Ashley and Gonzalez, 1974; Stinner *et al*., 1974; Calvin *et al*., 1984). In addition, the roles of other factors such as host availability and its timing also needs to be investigated. Two native parasitoids, *Trichogramma* sp. nr. *mwanzai* and *Trichogrammatoidea* sp. nr *lutea* show promising results for the control of *H. armigera* in tomato in Kenya.

The objectives of this study were two-fold: to evaluate locally available feeds for rice moth production and to evaluate host-age and parasitoid-age preference of the two native parasitoids for purposes of improving productivity in mass-rearing systems.

2.0 MATERIALS AND METHODS

2.1 Evaluation of Feeds

Eggs of *C. cephalonica* were obtained from Animal Rearing and Quarantine Unit (ARQU) at the International Centre of Insect Physiology and Ecology (ICIPE), Nairobi, Kenya. Seventeen treatments comprising various feeds and feed combinations were evaluated. The feeds and their combinations were sorghum, rice, millet, maize, wheat, wheat bran, rice bran; sorghum + wheat bran, sorghum + rice bran, rice + wheat bran, rice + rice bran, millet + wheat bran, millet + rice bran, maize + wheat bran, maize + rice bran, wheat + wheat bran and wheat + rice in a ratio of 3:7 bran to feed. All feeds were finely. The feeds were oven-heated at 100°C for 6 hours, to get rid of any contamination. Rearing of *C. cephalonica* was carried out in 3-litre plastic troughs whose top surface had been cut open, and the open surface fitted with muslin cloth to ensure proper ventilation. Approximately 2550 (0.17cc) of *C. cephalonica* eggs were introduced into each of the diets in the containers. The experiment was maintained at 28±2°C, 70-80%R.H., LD 12:12.

Adult parasitoids, after emergence, were daily collected from the troughs and their sex recorded. They were then separately transferred into egg-laying chambers (28 cm height and 29 cm diameter), through a hole (3 cm diameter) in one end of the chamber (28 cm height and 29 cm diameter), while the bottom end had an iron mesh. The hole was then sealed with a stopper. It is from the hole that parasitoid food (cotton wool wicks soaked in a 20% honey solution) was hang. A plastic basin (16 cm height and 40 cm diameter) was placed at the bottom of the oviposition chamber so as to collect eggs passing through the mesh. Eggs were collected daily, sieved to remove rubbish and their quantity recorded.

2.2 Host and parasitoid Age Optimization

Trichogramma sp. nr. *mwanzai* and *Trichogrammatoidea* sp. nr. *lutea*, were obtained from ARQU-ICIPE where they had been reared continuously on *C. cephalonica* for several generations. Egg cards, in which eggs were glued onto Xerox paper using gum acacia, containing approximately 30 host eggs of *C. cephalonica* were made and used in the experiment.

Same age no-choice glass tube tests were carried out. Host eggs of *C. cephalonica* of the following ages: 12, 24, 36, 48 and 60 hours old, kept in a controlled room at 25±2°C and 70±5% RH, were tested against parasitoid ages (1, 2 and 3 day old). To test the effect of the host age on parasitism and acceptance by the parasitoids, one day old mated individual *Trichogramma* sp. nr. *mwanzai* and *Trichogrammatoidea* sp. nr. *lutea* female parasitoids were separately permitted access to one egg card, each with about 30 eggs in 3½ inch glass vials for 24 hours. The card containing host eggs was then withdrawn and kept in a clean sterilised glass vial to observe adult emergence. The same procedure was repeated for the other host eggs and parasitoid ages. The different host egg ages were each replicated 6 times. The number of parasitised host eggs and the sex ratio of emerged parasitoids were recorded. This experiment was maintained at 25±2°C, 65±10% R.H. and 12L: 12D.

2.3 Data Analysis

Insect counts were transformed into $\log_{10}(x + 1)$. In host age optimisation studies, insect counts were transformed into $\log_{10}(x + 10)$. Percentage data were arcsine transformed (Sokal and Rohlf, 1981). Development time, parasitism, sex ratio and adult emergence were subjected to repeated measures of analysis of variance (ANOVA) for a complete randomised design using the General Linear Model procedure (SAS Institute; 2000). Student-Newman Keul's (SNK) procedure was used to separate the means, as a post ANOVA procedure.

3.0 RESULTS

3.1 Developmental Time

The average developmental time from egg to adult differed significantly ($F = 28.79$ $df = 16{,}3190$ $p = 0.0001$) for all the feed materials compared. The shortest developmental periods (46.73, 51.08 and 54.41 days) were recorded in maize + wheat bran, rice + wheat bran, and wheat + wheat bran respectively. It is also noteworthy that the differences between these three shortest developmental periods were not statsitcally significant. The longest developmental period of 83 days was recorded in rice bran (Table 1).

3.2 Number of Moths Emerged

There was significant difference in the number of adult moths that emerged from the different feed material ($F = 28.79$ $df = 16{,}3190$ $P = 0.0001$). The highest numbers of moths that emerged (1098) was recorded in wheat, while the lowest numbers (3.75, 192.00, 114.00, 109.25, and 72.75) were respectively recorded for rice + rice bran, wheat + rice bran, maize + rice bran, sorghum + rice bran, millet + rice bran (Table 1).

3.3 Percent Female Emergence (Sex Ratio)

The percentage of female moths that emerged differed significantly for the different feeds that were compared ($F = 28.79$ $df = 16{,}3190$ $P = 0.0001$). The percentages of females emerged from maize, sorghum, rice, millet and wheat (71.83, 70.11, 70.05, 73.88 and 66.93) respectively were not significantly different. However, they produced significantly higher percentage of emerged females relative to the other feeds (Table 1).

3.4 Quantity of Eggs Produced

There was significant difference in volume of eggs produced for the different feeds that were compared (F = 43.14 df = 16,51 P = 0.0001). The volume of eggs recorded in maize was significantly higher compared to the other feeds. There was no recovery of eggs from rice bran (Table 1). With regard to cost of production, maize was found to be the most productive, with egg recovery of 5.28 g and also the most economical feed material for mass rearing *C. cephalonica,* requiring KShs 60.60 per gram of eggs (Table 2).

3.5 Parasitisation of Host Eggs

The mean numbers of host eggs successfully parasitised in different host egg ages exposed to one day-old adult *Trichogrammatoidea* sp. nr. *lutea* were significantly different (F=2.69 df=5,24 P=0.046). However, host egg ages for two day-old (F=1.97 df=5,24 P=0.53) and three day-old adult parasitoids (F=0.85 df=5,24 P=0.53) were not significantly different. The mean number of successfully parasitized eggs between the different host egg ages for one day-old *Trichogramma* sp. nr. *mwanzai* (F=1.12 df=5,24 P=0.37) and three day-olds (F=1.66 df=5,24 P=0.183) were not significantly different, unlike those of two day-olds (F=4.12 df=5,24 P=0.008). Generally there was decrease in parasitism with increase in host age for two day and three day old *Trichogrammatoidea* sp. nr. *lutea,* except for 60-hour-old host eggs (fig 1).

3.6 Mean Number of Adult Progeny Emerged from Parasitized Eggs

Mean numbers of parasitized host eggs that emerged differed between the different host ages for 2-day-old T. sp. nr. *lutea* (F = 2.88 df = 5,24 P = 0.036). However, host egg ages for parasitoid ages 1 day (F = 2.30 df=5,24 P = 0.077) and 3 day (F = 1.03 df = 5,24 P = 0.423) were similar. Mean numbers of parasitized host eggs that emerged between the different host egg ages for T. sp. nr. *mwanzai*, 2-day-old were different (F = 4.28 df = 5,24 P = 0.0063). Host egg age 60 hours recorded the least mean numbers of adults that emerged (fig. 2). Parasitoid ages 1 day (F = 0.95 df = 5,24 P = 0.469) and 3 day (F = 1.65 df = 5,24 P = 0.186) were similar.

3.7 Percentage of females in the Progeny (Sex ratio)

The mean percent female progeny that emerged in *Trichogrammatoidea* sp. nr. *lutea,* parasitoid age of 1 day (F = 2.77 df = 4,19 P = 0.057), 2 days (F = 0.56 df=4,20 P = 0.694) and 3 days (F = 0.9 df=4,13 P=0.493) were similar for the different host egg ages. However, significant differences (F = 2.60 df = 4,17 P = 0.043) were observed for 2-day-old *Trichogramma* sp. nr. *mwanzai.* Host egg age of 60 hours recorded the lowest percentage of females. Parasitoid age of 1 day ($F = 0.77$ $df = 4,20$ $P = 0.555$) and 3 day ($F = 0.66$ $df = 4,17$ $P = 0.628$) were similar (Figure 3).

4.0 DISCUSSION

Providing feed that is rich in nutritional requirements for moths has been considered responsible for high rice moth productivity (Awang and Lee, 1998). The results of this study showed that the type of feed used for rearing the moths influenced the average developmental time, which is consistent with the findings of Peng and Chen (1989) and Sahayaraj *et al.* (2001). The number of moths that emerged was also influenced by the type of feed component used for rearing. Significantly higher number of parasitoids were recorded in wheat as compared to the other feeds.

The type of feed used for rearing also affected percent female progeny produced from the different feeds. Millet, maize, sorghum and rice did not differ significantly in percent number of female progeny for the different feeds. Feed component used had a significant influence on the volume of eggs produced. The volume of eggs produced from maize was significantly higher than the volume of eggs produced from the other feeds. Almasi *et al.* (1987) reported that the largest number of vitellogenous eggs in *Plodia interpunctella* Hübner were found in the ovarioles of females that had been fed on maize or sunflower seeds compared to those on wheat and kale. In later studies, Ashraf *et al.* (1994) observed that the fecundity of *S. cerealella* moths was higher on wheat followed by maize and rice. This difference in results could be attributed to the differences in dietary requirements between the two moths that would ensure maximum fecundity of the progeny arising from the different feed material. Wu (1993) also observed a higher yield of rice moth eggs if a combination of rice bran and crashed corn was used in place of brown rice. From the results of this study, maize could be of better nutritive value for rearing *C. cephalonica* since this diet was responsible for the higher productivity in eggs that was achieved compared to the other feeds.

Judging by the average developmental time from egg to adult, number of adult moths that emerged, fecundity of the females, and with regard to cost of production (Table 2), maize was found to be the most productive/economical feed material for mass rearing *C. cephalonica*. This is a welcome finding, given the plenty supply of maize in Kenya most of the year.

For *Trichogrammatoidea* sp. nr. *lutea*, the rate of parasitism was not affected by either parasitoid age or the different host ages investigated except for one day old parasitoid. However, two day-old *Trichogramma* sp. nr. *mwanzai* showed significant differences in the number of eggs parasitised. Monje *et al.* (1999) investigated the influence of host egg age (*Diatrea saccharalis* and *S. cerealella*) on acceptance and parasitism by *T. gallo* and found that within the group of freshly laid (0-6 h) to 3-day-old eggs, no clear cut tendency for stronger parasitization of younger or older eggs was evident, neither for eggs of *D. saccharalis* nor for eggs of *D. rufescens*.

Similar results were obtained by Bulut (1990) and Takada *et al.* (2000). Moreover, Zhang *et al.* (1995) found that the rate of parasitism of *T. dendrolimi* of age 18-24h on the Asian corn borer *Ostrinia furnacalis* Guenée was reduced by one half times compared to those of 0-6h old and in addition the time spent by the parasitoid on or near the host eggs (contact time) was also significantly reduced. These apparent disparities could be explained in a number of ways, among which are the different parasitoids used and initial host deprivation, which could have modified the oviposition behavior of females (Fleury and Bouletréau, 1993).

The mean number of adult progeny that emerged for both parasitoids also followed a similar trend as that of mean number of successfully parasitised eggs. The percentage of female progeny was neither affected by host age nor parasitoid age for *Trichogrammatoidea* sp. nr. *lutea.* These results conform to those obtained by Takada *et al.* (2000). For *Trichogramma* sp. nr. *mwanzai,* only parasitoid age two days showed significant difference in percent female progeny. The differences in results could be attributed to variations between candidate parasitoid species.

These results indicate that the response of parasitoids to host age was independent of the parasitoid species that were studied, since both accepted all the ages of the host eggs that were tested. The results suggest that all the parasitoid host age combinations tested are suitable for mass rearing. It is recommended that further studies on initial host deprivation and effect of host age on contact time and the actual acceptance time for oviposition on older eggs needs to be investigated in these native trichogrammatid species.

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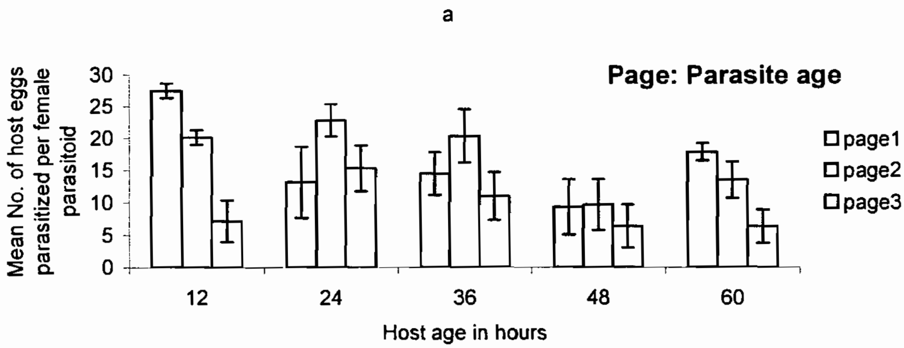


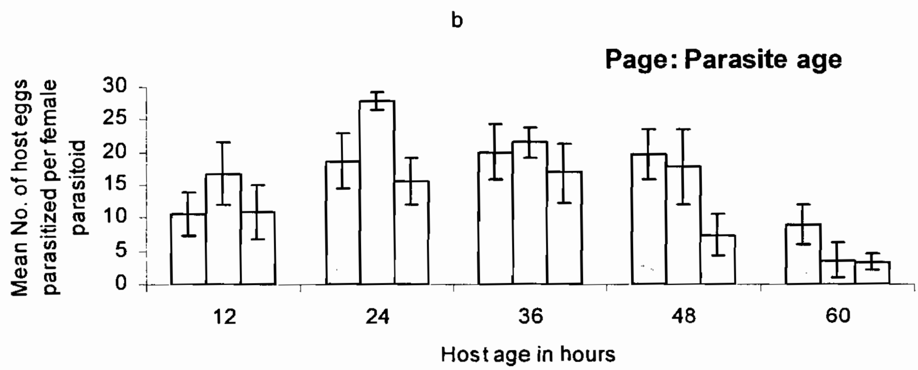
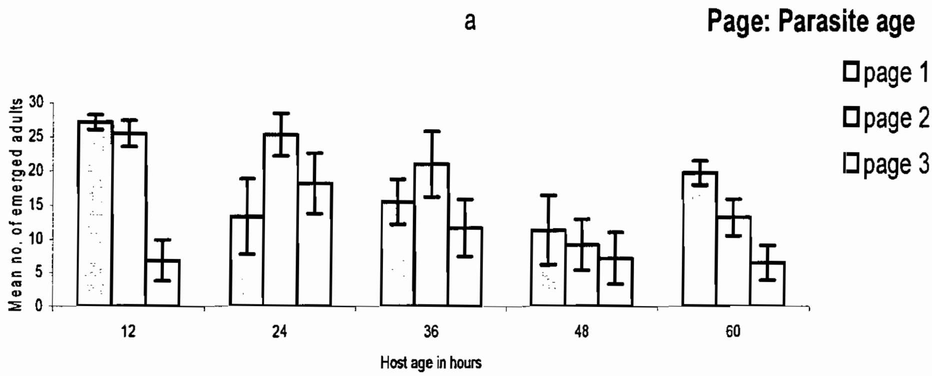


Figure 1: Effect of host and parasitoid age on mean number of successfully parasitised eggs for and Trichogrammatoidea sp. nr. lutea (a) and Trichogramma sp. nr. mwanzai (b)



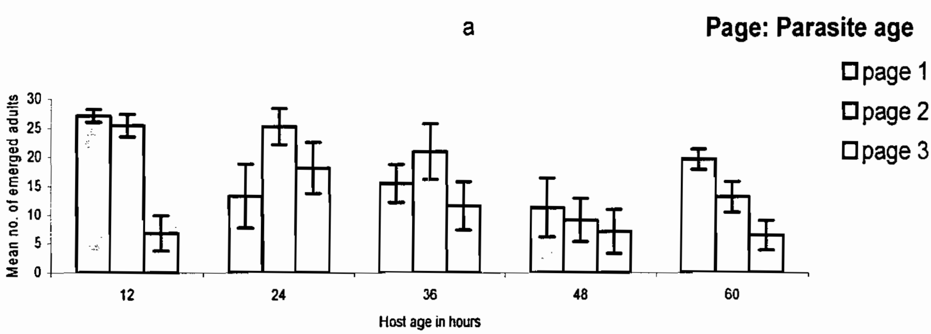
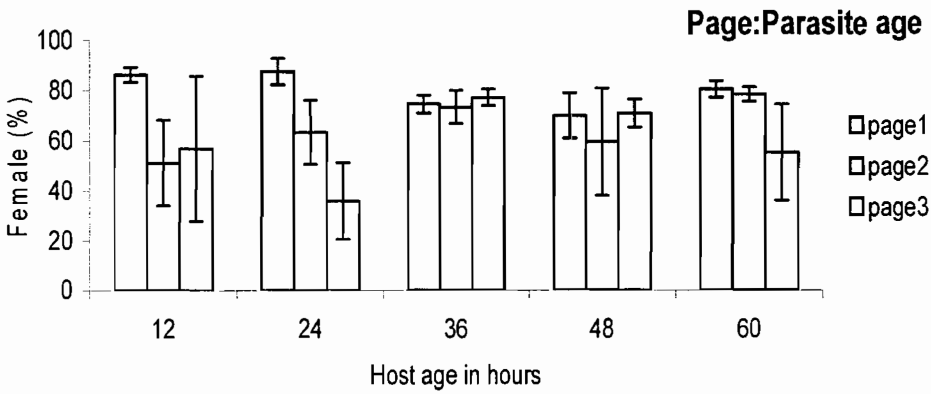


Figure 2: Effect of host and parasitoid age on mean number of adult progeny that emerged for and Trichogrammatoidea sp. nr. lutea (a) and Trichogramma sp. nr. mwanzai (b)

a



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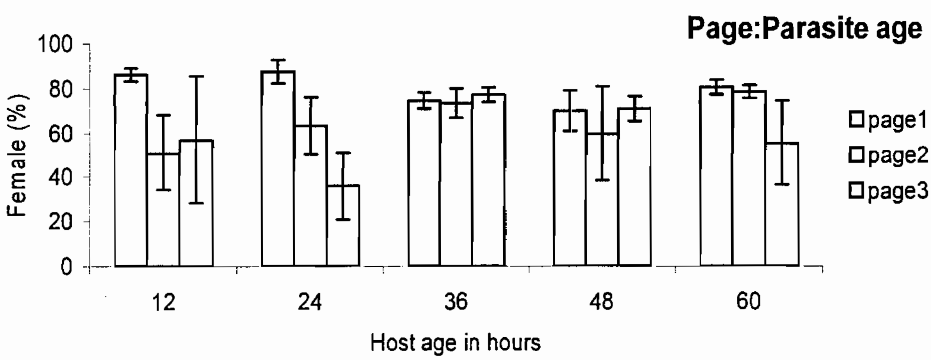

Figure 2: Effect of host and parasitoid age on mean percent female progeny produced for and Trichogrammatoidea sp. nr. lutea (a) and Trichogramma sp. nr. mwanzai (b)

Table 1: Effect of feed composition (Mean ± se) on rice moth (Corcyra cephalonica) developmental time, number of moths that emerged, sex ratio and volume of eggs produced

Feed component		*Developmental time (days)*	*No. moths per kg feed*	*% Females emerged*	*Estimate of eggs produced* (cc/kg of feed)
Wheat		52.23±1.08 ghi	1098.00 ± 40.63 a	66.93 ± 1.34 abcd	4.16 ± 0.15 b
Maize		49.31 1.91 hi	839.25 ± 51.81 b	71.83 ± 1.27 ab	5.28 ± 0.33 a
Sorghum		56.24 ± 0.27 efgh	575.75 ± 110.58 c	70.11 ± 1.69 ab	4.09 ± 0.78 b
Rice		66.77 2.58 c	531.75 ± 34.75 c	70.05 ± 1.88 abc	3.42 ± 0.22 bc
Millet		66.01 1.29 cd	99.25 ± 32.82 de	73.88 ± 2.94 a	0.83 ± 0.27 fgh
Wheat bran		57.83± 0.70 defg	597.00 ± 18.91 c	51.49 ± 1.58 def	2.75 ± 0.09 cd
Rice bran		83 ± 0.91 a	3.75 ± 1.31 e	12.50 ± 12.50 h	0.00 h
Wheat + wheat bran		54.41± 1.16 fghi	852.75 ± 7.38 b	55.23 ± 1.35 bcdefg	3.26 ± 0.103 bc
Wheat + rice bran		61.71 ± 4.78 cdef	192.00 ± 15.97 de	39.27 ± 2.16	0.49 ± 0.04 fgh
Maize + wheat bran		46.73 ± 0.91 i	913.50 ± 52.59 b	56.70 ± 1.35 bcde	3.57 ± 0.21 bc
Maize + rice bran		54.99 ± 2.33 fgh	114.00 ± 26.24 de	42.82 ± 2.94 ef	0.56 ± 0.13 fgh
Sorghum + wheat bran		59.07 ± 2.33 cdefg	666.25 ± 58.25 c	49.98 ± 1.57 def	2.14 ± 0.19 de
Sorghum + rice bran		64.13 ± 2.33 cde	109.25 ± 1.89 de	42.58 ± 2.76 ef	0.51 ± 0.01 fgh
Rice + wheat bran		51.08 ± 0.64 ghi	896.00 ± 58.98 b	60.66 ± 1.25 bcd	3.61 ± 0.21 bc
Rice + rice bran		64.11 ± 2.15 cde	264.00 ± 36.01 d	53.59 ± 1.90 cdef	1.24 ± 0.17 fg
Millet + wheat bran		59.18 ± 1.10 cdefg	535.50 ± 41.90 c	48.24 ± 1.62 ef	1.50 ± 0.12 ef
Millet + rice bran		73.77 ± 1.94 b	72.75 ± 14.71 e	52.39 ± 3.47 cdef	0.36 ± 0.07 gh
Statistical	F	28.79	28.79	28.79	43.14
parameters	df	16,3190	16,3190	16,3190	16,51
	P	0.0001	0.0001	0.0001	0.0001

Means followed by the same letter in the same column are not significantly different at P = 0.05 by SNK.

Table 2: Economics of production of the rice moth (Corcyra cephalonica)

Feed component	Quantity of eggs (g)	Feed cost per Kg (Ksh.)	Labor, other costs (Ksh.)	Total cost (Ksh.)	Cost per g of eggs (Ksh.)
Maize	5.28	20.00	300.00	320.00	60.60
Wheat	4.16	45.00	300.00	345.00	82.90
Sorghum	4.09	23.00	300.00	323.00	79.00
Rice	3.42	30.00	300.00	330.00	96.50
Millet	0.83	50.00	300.00	350.00	421.70
Wheat bran	2.75	10.00	300.00	310.00	112.70
Rice bran	0.00	2.50	300.00	302.50	302.50
Wheat + wheat bran	3.26	20.50	300.00	320.50	98.30
Wheat + rice bran	0.49	15.25	300.00	315.25	643.40
Maize + wheat bran	3.57	13.00	300.00	313.00	87.70
Maize + rice bran	0.56	7.75	300.00	307.75	549.60
Sorghum + wheat bran	2.14	13.90	300.00	313.90	146.70
Sorghum + rice bran	0.51	8.65	300.00	308.65	605.20
Rice + wheat bran	3.61	16.00	300.00	316.00	87.50
Rice + rice bran	1.24	10.75	300.00	310.75	250.60
Millet + wheat bran	1.50	22.00	300.00	322.00	214.70
Millet + rice bran	0.36	16.75	300.00	316.75	879.90

Currency exchange rate: KShs 70.00 = US$1.00
Cost per g of eggs (KSh) = Total cost (KSh)/Quantity of eggs (g)