THE EFFECT OF FISH MOISTURE CONTENT ON OVIPOSITION, FECUNDITY AND DEVELOPMENT OF THE HIDE BEETLE, *Dermestes maculatus* DEGEER (COLEOPTERA: DERMESTIDAE)

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ABSTRACT

Oviposition, fecundity and development of Dermestes maculatus in Clarias ebriensis with different moisture contents (14%, 36%, 41%, 56%, 66%, 73%, 77%) were investigated from January to April, 2003. Catfish of different moisture content and a pair of male and female D. maculatus constituted a treatment and each of the seven treatments was replicated thrice. The treatment with fish of 14% moisture content served as the control. Generally, the pre-oviposition period, egg incubation period, oviposition peak, percentage number of eggs hatching to larvae, duration of larval emergence, larval developmental period and duration of pupal emergence were all moisture-dependent. At 29^0 C and 58% RH, fecundity ranged from 54-598 eggs. The eggs measured 3.38±0.44 mm in length. The larvae had five larval instars which measured 3.28±0.71, 6.06±0.82, 8.04±0.75, 10.83±0.97 and 13.0±0.29 mm in length respectively. Larval developmental period was 16-23 days and larvae fed voraciously and bored into the flesh and head capsule of fish. Pupae measured 7.65±0.29 mm in length and adults emerged from ≥ 50% of pupae in all treatments. Total developmental period was 59 days.

Key words: *Dermestes maculatus,* Oviposition, Fecundity, Development, *Clarias ebriensis,* Moisture content

INTRODUCTION

Traditionally cured fish are generally prone to infestation by a variety of beetle pests throughout storage, transportation and marketing. This often results in substantial loss of the economic value and quality of the cured fish. Daget (1966) reports that losses due to beetles may reach 25-30% of the 6000-9000 t per year of dried and smoked fish marketed in the regions of the Middle Niger and Chad basin in West Africa. Osuji (1985) estimates the loss at 30-50%. The major beetle pests responsible for this loss are *Necrobia rufipes* (DeGeer) and *Dermestes* species. At least seven *Dermestes* species – *D. maculatus* DeGeer, *D. ater* Kuster, *D. frischii* Kugelmann, *D. lardarius* Kuster, *D. haemorrhoidalis* Kuster, *D. carnivorous* Fabricius and *D. peruvianus* Laporte de Castelnau – infest cured fish in tropical developing countries (Johnson and Esser, 2000). The first four of these *Dermestes* species have been recorded in tropical Africa (Blatchford, 1962; Green, 1967; Proctor, 1972; Osuji, 1974a, 1975). Of these, *D. maculatus* is cosmopolitan and dominant in sub-saharan countries (Johnson & Esser, 2000).

In Nigeria, some information exist on the biology of *D. maculatus* (Taylor, 1964; Toye, 1970; Osuji 1974a, b, 1975). However, none of these workers considered the effect of different fish moisture contents on the developmental biology of the hide beetle. This paper investigates this and presents data on oviposition, fecundity and development of *D. maculatus* in *Clarias ebriensis* with different moisture contents.

MATERIALS AND METHOD

Adult *D. maculatus* were collected from infested fish bought from the Nsukka main market. The beetles were separated into males and females. The males were readily identified by the presence of a shallow pit with a tuft of erect, dense, golden-yellow hairs on their 4th abdominal sternite (Osuji, 1985).

A total of 42 adult *Clarias ebriensis* (185-222 g) were collected from the Adani fish market and randomly sorted into seven groups

of six catfish each. The six catfish in a group were arbitrarily dried either to moisture content of 14%, 36%, 41%, 56%, 66%, 73% or 77% using the hot-air oven method (AOAC, 1995). In this method, 5 g fish sample was weighed in a previously weighed clean and dry aluminium dish with a Mettler PC 2000. The fish in the aluminium dish was dried in an oven at 100^0 C for 24 h, and then cooled in a dessicator, and weighed. The percentage moisture content of the fish sample was calculated as: b-a/c-a x 100, where a= weight of empty aluminium dish, b= weight of aluminium dish and fish before drying, and c= weight of aluminium dish and fish after drying.

Adult males of *D. maculatus* were paired with adult females. Each pair was provided with two catfish either of 36%, 41%, 56%, 66%, 73% or 77% moisture content in a separate plastic plate and these served as treatment 1, 2, 3, 4, 5 or 6 respectively. The treatment with a pair (a male and a female) of the beetle and two fish of 14% moisture content served as the control. Free water was added by wet cotton wool in each plate because Dick (1937) and Taylor (1964) have shown that this enhances egg production and the period of oviposition. Each plastic plate was covered with mosquito plastic gauze held in place with a rubber band. The gauze facilitated the supply of oxygen to the beetles but prevented contamination with other pests. Each treatment was replicated thrice.

After copulation, the time it took the female in each replicate to start ovipositing, the oviposition period, the number of eggs laid, the number of eggs that died, the number that developed to larvae, the developmental period of the larvae, the number of pupae developing from the larvae and the number of adults emerging from the pupae were carefully recorded in all treatments. The lengths of the eggs, the larval instars and the pupae were measured with an ocular micrometer. The total developmental period of the beetle was recorded. Regression analyses of fish moisture content on peak oviposition, percentage dead eggs, egg incubation period, percentage of eggs hatching to larvae, duration of larval emergence, mean larval development period, percentage dead larvae, duration of pupal emergence, percentage dead pupae and percentage of eggs developing to adults were performed using the straight line curve, $Y = \alpha + \beta X$.

A mercury thermometer and a hygrometer fixed within the experimental laboratory were employed in determining the prevailing temperature and relative humidity conditions between January and April, 2003, which was the period of this study.

RESULTS

The mean temperature was 29.1 ± 0.73^0 C, whereas the mean relative humidity was 58.4±0.41 % throughout the experimental period. There was no significant difference in these climatic factors in the treatments ($P>0.05$).

Oviposition: The pre-oviposition period (that is, the number of days before egg laying) of the females in the control was longer than in the other treatments ($P<0.05$). All female *D. maculatus* in all treatments laid eggs. The females in treatment 6 started oviposition earlier than others, followed by treatment 5 (Table 1). Oviposition peaked on the ninth day in the control and significantly earlier in the other treatments. The correlation between peak oviposition and fish moisture content was strong ($r=0.76$) and significant ($P<0.05$). Oviposition period in the control was longer than in the other treatments in which the oviposition period fluctuated between 6 and 9 days (Table 1). This table also shows that the number of eggs laid by the females ranged from 54 to 598 depending on the fish moisture content. Thus, the number of eggs in treatment 6 was higher than the number in the other treatments ($P<0.05$). Generally, the number of eggs laid by the females increased as the fish moisture content increased.

Freshly laid eggs were white in colour and oval in shape, being bluntly pointed at both ends. The eggs were laid singly or in batches of 2-8; they measured 3.38±0.44 mm in length. More eggs died in treatment 6 than in the other treatments ($P<0.05$), and the correlation between percentage dead eggs and fish moisture content was fairly strong ($r = 0.62$). The incubation period (that is, the time it took the eggs to start hatching after oviposition) lasted from 3 to 5 days and was moisture-dependent ($r = 0.56$).

Larval Development: The percentage number of eggs hatching to larvae decreased as the fish moisture content increased ($r = 0.62$). A higher correlation existed ($r = 0.96$) in the inverse relationship between duration of emergence of the larvae and fish moisture content (Fig. 1). There were five larval instars. The first to the

Table 1: Developmental parameters of *D. maculatus* in different fish moisture levels

Treatments	Fish moisture contents (%)	Pre-oviposition period (days)	Oviposition period (days)	Number of eggs laid	Number of eggs hatching to larvae (%)	Number of larvae developing to pupae (%)	No. of pupae emerging as adult (%)
Control	14	12	20	54	43(79.63)	14(33.56)	10(71.43)
1	36	5	8	164	115(70.12)	29(25.22)	21(72.41)
2	41	6	7	59	39(66.10)	14(35.54)	12(85.71)
3	56	5	9	147	133(90.48)	22(16.54)	20(90.9)
4	66	5	6	97	73(75.26)	28(38.36)	14(50.0)
5	73	4	8	246	102(41.46)	28(27.45)	24(85.71)
6	77	3	8	598	120(20.07)	30(25.0)	20(66.07)

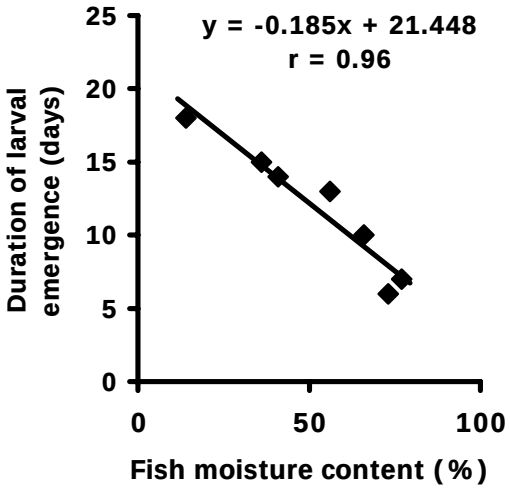

Figure 1: Duration of larval emergence in relation to fish moisture content

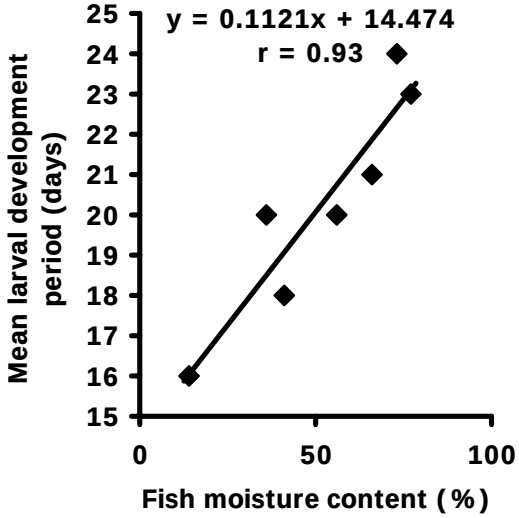

Figure 2: Mean larval development period in relation to fish moisture content

fifth instars measured 3.28±0.71 mm (range 2-4 mm), 6.06±0.82 mm (range 5-7 mm), 8.04±0.75 mm (range 7-9.5 mm), 10.83±0.97 mm (range 10-12 mm) and 13.0±0.29 mm (range 12.5 – 13.5 mm) in length respectively. Thus, the larvae grew bigger as they became older. The larvae bored into the fish flesh and head capsule and fed voraciously, reducing the fish to fragments and powder. The late instar larvae were found mostly in the head capsule. The mean larval developmental period increased with increase in fish moisture content and there was a very strong correlation between them (r = 0.93) (Fig.2). The mean larval developmental period lasted from 16 to 23 days. Over 61% of the larvae in each treatment died and, therefore, did not develop to the pupal stage, though virtually no correlation existed between the percentage dead larvae and fish moisture content (r = 0.23). The pre-pupa stage lasted 2-4 days. It was reached when the late instar larvae stopped all physical activities, such as feeding and movement.

Pupal Development: The percentage of pupae which emerged from the larvae in each treatment was remarkably low. It ranged from 17% in treatment 3 to 38% in treatment 4, though no definite pattern was discerned (Table 1). A strong positive correlation (r = 0.86) existed in the inverse relationship between the time it took all the pupae to emerge and fish moisture content (Fig. 3). The pupae were white in colour and measured 7.65±0.79 mm (range 7-8.6 mm) in length. The percentage dead pupae fluctuated without any definite pattern and showed a total lack of correlation (r = 0.09) with the fish moisture content.

Adult: Between 50 and 91% of adults emerged from the pupae in all treatments (Table 1). The newly hatched adult, often found in the head capsule, had reddish-brown head and yellowish-

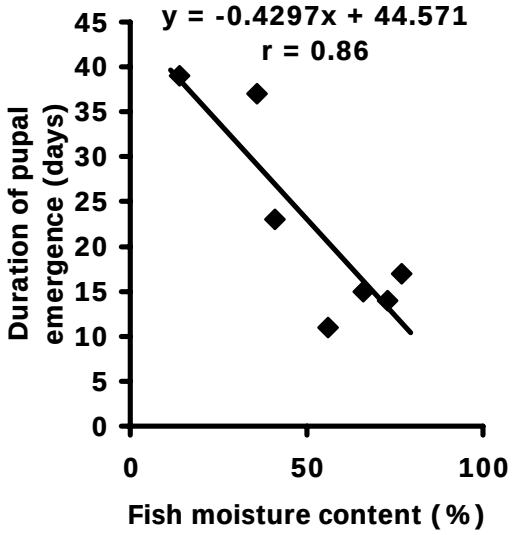

Figure 3: Duration of pupal emergence in relation to fish moisture content

brown elytra, which later became black. The abdomen was white in colour. There was moderate correlation (r = 0.77) in the inverse relationship between percentage eggs which developed to adult and the fish moisture content.

DISCUSSION

The longer pre-oviposition and oviposition periods of *D. maculatus* females in the control are attributed to the low fish moisture content (14%). This level of fish moisture seems to prohibit oviposition by the beetle and probably explains why 'banda', made up of cut pieces of mainly *Clarias* species, is charred and dried to moisture content of 15% before storage (Osuji, 1977). To provide a better condition for egg laying, the fish in the control absorbed moisture from the free water in the plate which then enabled it to became gradually more conducive for egg deposition. This process was undoubtedly accomplished over a period of time, hence the longer oviposition period and the fewer number of eggs (54) laid. Our preliminary investigation before the start of this study showed that dipterans, particularly blow flies, found very high levels of fish moisture content extremely suitable for egg deposition, as also do *D. maculatus* females of this study, which laid very high numbers of eggs on fish with moisture content of 73% and 77%. However, the vast majority of the eggs laid at these high fish moisture levels died resulting in the low percentage ($\leq$ 42%) number of eggs hatching to larvae as against the high percentage ($\geq$ 66%) observed at the other fish moisture levels, which had fewer eggs (Table 1). It is probably this observation that led Osuji (1977) and Johnson and Esser (2000) to assert that fish with moisture content of 32-47% are very suitable for infestation with dermestid eggs.

The fecundity of female *D. maculatus* (54-598 eggs), though extremely variable, compares favourably with that reported for dermestids by Kreyenberg (1928, 198 – 845 eggs), Taylor (1964, 160 eggs), Osuji (1985, 250 eggs) and Michael (2000, 318 eggs). The lower limit of 54 eggs recorded in the control is the lowest dermestid fecundity so far reported. It appears that the eggs laid on the fish with lower moisture content (14-66%) at the warm, dry period of January to April were very viable such that a higher percentage of them survived to adult life. This is consistent with Osuji (1974a,b), Proctor (1977) and Barwal and Devi (1993) who have shown acceleration of development in dermestids during the warm, dry season, given fish with the right moisture level and high lipid content. *C. ebriensis*, as well as other *Clarias* species, has high lipid level of $\geq$ 16.4% (Osuji, 1974b; Ezenwaji, 1989) and this nutritional requirement makes the clariid good substrate for the rapid development of *D. maculatus.* That this is indeed so is collaborated by the short larval developmental stages and period reported here. The larval stages (5 instars) are short, falling into the lower limit reported by Osuji (1975, 1985, 5 - 7 instars) but contrasting with Taylor (1964, 6 - 10 instars) and Michael (2000, 7 - 9 instars). Similarly, the larval developmental period of 16-23 days is considerably less than those reported by these workers (Taylor, 1964, 39 – 46 days; Osuji, 1975, 33.5 days; Michael, 2000, 50 days). The temperature (29^0C) and relative humidity (58%) which prevailed during the warm, dry period also appear to be optimum for dermestid development.

An overview shows that female *D. maculatus* is able to lay eggs on fish with varying moisture levels (14-77%). The eggs at the lower moisture levels (14-66%) survive much better than the eggs laid at higher fish moisture levels. Low moisture levels, the nutritional status of *C. ebriensis* and the climatic conditions enable acceleration of the development of *D. maculatus* in *C. ebriensis*. It may be in this way that high numbers of *D. maculatus* are maintained in dry *Clarias* species marketed in Nigeria resulting in high quality and economic losses.

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