Influence of food sources on developmental period of *Rhyzopertha dominica, Tribolium castaneum* and Sitophilus oryzae

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Abstract

Nutrient status of host has a profound influence on biology, colonization, rate of feeding and survival of an insect. To know the influence of different food sources on developmental period of three key pests of stored products viz., the lesser grain borer, Rhyzopertha dominica (F.), *the rust red flour beetle,* Tribolium castaneum (Herbst.) *and the rice weevil,* Sitophilus oryzae (L.), *a laboratory study was conducted on their natural food sources at 28-30^0 C temperature and 65-70% relative humidity. When* R. dominica *was reared on whole wheat, paddy, sorghum and broken wheat, the egg period was lowest (4.73) in wheat and highest (6.38) in paddy, larval period was minimum (28.20) in wheat to maximum (33.40) in paddy, pupal period ranged from 5.00 to 7.00 in wheat and paddy, respectively and the total development period ranged from 37.93 days in wheat to 46.78 days on paddy and were significantly different at p=0.01%. Similarly, wheat, rice, sorghum flour and wheat flour were used for rearing* T. castaneum *which revealed that, egg, larval, pupal and total development period were significantly different and ranged from 3.40 to 5.10, 23.00 to 27.12, 5.40 to 8.60 and 31.80 to 40.82, respectively. The lowest overall development period was found on wheat flour and highest was on rice.* S. oryzae, *when reared on wheat, rice, sorghum and maize grains recorded egg period from 4.00 (sorghum) to 6.00 (maize) days, larval duration from 27.00 (sorghum) to 32.00 (maize) days, pupal period from 7.00 (sorghum) to 9.00 (maize) days and total development period ranged from 38.00 (sorghum) to 47.00 (maize) days, which showed significant difference at p=0.01%.*

Keywords: *Rhyzopertha dominica, Tribolium castaneum*, *Sitophilus oryzae,* food sources, developmental period.

Introduction

The lesser grain borer, *Rhyzopertha dominica,* the rust red flour beetle, *Tribolium castaneum* and the rice weevil, *Sitophilous oryzae* are categorised as polyphagous, cosmopolitan pests in storages all around the globe (Bell, 2000; Champ and Dyte, 1977) and are sampled in feed, seed grains, grain spillages and bulk storages throughout the year. The food sources infested and quantum of infestation by these three major grain pests are more when compared to other storage insect pests. The influence of different food sources on insect pests favours for completion. Biology is absolutely varied from one food source to other which in turn favours their existence in different commodities.

The lesser grain borer is a major pest of wheat, rice and millets in India and around the world (Champ and Dyte, 1977) and it can attack a wide variety of stored foods including cereals, seeds, dried fruit and almost all grains and more particularly wheat, barley, sorghum and rice, commodities such as seeds, drugs, cork, timber and paper products. Similarly, *T. castaneum* is a cosmopolitan pest which primarily attacks milled grain products, such as flour and cereals, it mainly feeds on grain dust and broken grains, but not the undamaged whole grains, however it does considerable loss to grains damaged by other insects (Odeyemi *et al*., 2005). Polyphagous nature of *T. castaneum* has made the pest to feed on wide range of commodities and products including various processed food products *viz.,* biscuits, cacao, cottonseed, dried fruits, drugs, legume seeds, milk chocolate, nuts, powdered milk, spices, herbarium and museum collections (Dars *et al.,* 2001; Mason, 2003). However, *S. oryzae* infests the cereal grains throughout the world and causes substantial losses to stored grains amounting to 18.30 per cent (Gallo *et al*., 2002) and its infestation alone resulted in sorghum grain loss of 61.3 per cent over a period of five months which reduced the value of sorghum for milling and bread quality besides exhibiting short life cycle with high built in populations (Borikar and Tayade, 1979). The two species of it have different behaviour i.e., *S. oryzae* has a marked preference for wheat but field infestations are rarely observed, while *S. zeamais* strongly prefers corn, whose infestation in the field during the pre-harvest period constitutes an important event for the infestation that takes place in the storages (Likhayo and Hodges, 2000).

In storages of various grains and processed food materials, these three pests are the major among all insect pests and main source of quality deterioration by way of direct feeding on the grain, resulting in chemical changes in grain content besides contamination with moult skin, body parts and also by spreading the pathogenic microorganisms. In case of serious infestation in the flours, the flour turns yellowish and mouldy, has a pungent, disagreeable odour and becomes unfit for human consumption (Egal *et al.,* 2005) and further facilitates development of aflatoxin. Prevention of losses in stored products due to insects is of paramount importance and for this the life history, habits and habitats are necessary to have thorough understanding of the situation favourable to the pest and to know the vulnerable stages of insect pest infesting different food sources which could be taken advantage for the effective management so as to avoid the further burden in the storages both in terms of quality and quantity of the stored product. Keeping in view of the importance of different food sources, present study on life history parameters of three major pests of storage were undertaken.

Materials and methods

Collection of insects and rearing

Samples of test insect, *R. dominica*, *T. castaneum* and *S. oryzae* were collected from wheat storage godown, rice and wheat storage section of FCI and sorghum and rice storages of Food Corporation of India, Central Warehousing Corporation, Coimbatore, Tamil Nadu, India, respectively. The collected insects were reared on their natural medium *viz.,* wheat for *R. dominica*, wheat flour with Brewer's yeast for *T. castneum* and wheat and rice for *S. oryzae* under laboratory condition for 2 generations at 28±2^{0}C temperature and 65-70 % relative humidity before start of the experiments.

Food sources

Four reliable food sources *viz.,* wheat, paddy, sorghum and broken wheat for *R. dominica;* wheat, rice, sorghum flour, wheat flour for *T. castaneum* and wheat, rice, sorghum and maize for *S. oryzae were* used. The experimental materials were subjected to cold sterilization at -20^0 C to destroy the presence of field carry over infestation of insect pests. Experimental cultures were kept at dark for better oviposition by the beetles. In order to reduce the risk of microbial infection to the media, all surfaces of the equipments used in the experiments were swabbed with solution of 70% alcohol before and after handling the insects.

R. dominica: Specific Techniques

Ten pairs of adult insects with equal ratio of male and female were taken from the stock culture. Adults were sexed by the method given by the Bousquet (1990). The *R. dominica* first inactivated by placing them in to a small Petri dish containing the broken wheat kernels and examined under the stereo binocular microscope, as described by Bousquets (1990). All the food sources were treated as separate treatments and each treatment was replicated five times. From the stock culture, newly emerged adults were released in a container containing 1 kg of food sources for egg laying. Containers were observed every day until eggs hatched and days required for the egg incubation was recorded on different food sources. After eclosion, grubs crawl and reach to the food sources and started infestation. The first instars were carefully removed from rearing containers using a bit of paper and made to climb on vertically held paper strips and were then dropped into the vials containing different food sources (treatments). The larval and pupal periods were recorded as the period spent inside the grains in case of wheat, paddy and sorghum grains. Larval development period was counted from the day of emergence of first instar to the day on which the larvae gradually showing the changes in morphological differences towards pupation. The pupal development period was counted from the time of changes appeared in morphology of larvae to the emergence of adults. Based on the time required for egg to adult development, the total development time was calculated.

T. castaneum : Specific Techniques

Five hundred grams of each food source were taken separately in 1000 ml plastic containers and 10 pairs of adult insects of 2 to 3 week old were released per container from pure culture. *T. castaneum* adults were first inactivated by placing them into a small Petri dish over crushed ice for a few seconds as reported by Shazali and Smith (1986) and then examined under stereo binocular microscope for sex characters as described by Halstead (1963). The newly emerged 10 pairs of adult beetles were released into different food sources. About 250 mg of equilibrated media were used for study in 10 x 2.5 cm glass vials and adult beetles were transferred to vials containing fresh food sources every 2 days. Eggs were extracted by passing through a 0.335 mm mesh sieve. The eggs were kept in a 5 cm Petri dish with small quantity of respective food sources and examined for 7 days following the first hatching. For conducting development studies with newly hatched larvae on different food sources, they were transferred singly using a camel hair fine brush to 1 gram of different media in glass vials. After 10 days, the vials were examined daily for pupation and eventually adult emergence.

S. oryzae : Specific Techniques

Sexes were determined under microscope for inoculating the beetles into different food sources. Beetles were developed by infesting the four different food sources with freshly emerged 10 pairs of adults. About 20 rice weevils were enclosed in 250 g of different media in each bottle and these bottles were kept in ambient conditions. Damaged grains were replaced every day. Daily 10 grains from the day of oviposition to egg hatching were dissected to determine the incubation period. On hatching, the larvae of rice weevil were allowed to feed individually inside the grains in specimen tube of 10 cm x 2.5 cm size having 5 gram grains. Five grains were dissected out to see the different stages of the larvae. The dissection of grains was made upto the pupal stage. The period between egg hatching and pupation was observed as larval period. The pupal period of the pests was studied by observing the same larvae for pupation inside the grains. The observations were made till the adult emergence. The period between formations of pupae till the adult emergence was noted as pupal period.

Statistical analysis

All the experiments were conducted by following the complete randomized design, with food sources serving as different treatments and five replications for each treatment were maintained. The data were subjected to analysis of variance (ANOVA) by using the AGRES statistical package to determine the significant differences between

Treatments.LS means were used for separating means at α =0.05 level.

Results and discussion

Influence of food sources on egg, larval, pupal and total development period in days for *R. dominica, T. castaneum* and *S. oryzae* were significant. The total period of development in all the three species were significantly lengthened when they were reared on different food sources.

Influence on R. dominica

The egg, larval, pupal and total developmental period for *R. dominica* was significantly higher in paddy (6.38± 0.74, 33.40±1.10, 7.00±0.71 and 46.78±2.00 days, respectively) (Table 1). The other two media *viz*., paddy and wheat flour recorded egg durations of 5.56± 0.44 and 5.20± 0.50 days, respectively, which significantly differed from each other at p=0.05%. The larval period was lower on wheat i.e. 28.20±0.84 days. However, on sorghum and wheat flour, it was 30.40±0.55 and 31.60±0.55 days, respectively which also differed significantly at p=0.05% from the paddy. The pupal duration showed significant differences

Table 1. Influence of different food sources on life history parameters of R. dominica

	Life history parameters (days)			
Food sources	Egg period (days)	Larval period (days)	Pupal period (days)	Total Development Period (days)
Wheat	4.73±0.54[a]	28.20±0.84[a]	5.00±1.00[a]	37.93±2.65
Paddy	6.38±0.74[d]	33.40±1.10[d]	7.00±0.71[c]	46.78±2.00
Sorghum	5.56±0.44[c]	30.40±0.55[b]	6.00±1.35[b]	41.96±1.73
Broken wheat	5.20±0.50[b]	31.60±0.55[c]	5.40±0.62[a]	42.20±3.00
SEm	0.068	0.3317	0.2335	-
CD (0.01%)	0.200	0.9688	0.6819	-
CV	1.98	1.70	3.31	-

Means of five replications; Means followed by the same letter in the column do not differ significantly by DMRT at P = 0.01

in paddy (7.00±0.71 days) and sorghum (6.00±0.35 days). Total development period was significantly higher in case of paddy (46.78±2.00 days) followed by wheat flour (42.20±3.00 days), sorghum (41.96 ± 1.73 days) whereas the significantly lower number of days were noticed in wheat grains (37.93± 2.65 days).

R. dominica egg, larval, pupal and total developmental period were shorter when reared on wheat and broken wheat as wheat is its primary food source, but it was quite higher on paddy. It clearly depicted the preference of the food sources. Our findings are in line with Kumawat (2007), who recorded *R. dominica* egg period as 5.3 to 9.4 days, larval and pupal period as 24.2 to 44.8 days on whole wheat grains and pupal duration as 5.0 to 6.7 days on broken wheat at 85±5 % RH and 40±1^0 C. Similar results were obtained in *Lasioderma serricorne* F. whose adult stage was completed in a shorter time on wheat flour compared to the other sources and this faster development could be because of the balanced and essential nutrients present in the wheat (Mahroof and Phillips, 2008). Wheat flour is nutritionally rich in valuable proteins, complex carbohydrates, vitamins and minerals (Cornell and Hoveling, 1998) necessary for growth and development of *L. serricorne*, and the flour could also lack the defensive chemicals present in other hosts tested.

Influence on T. castaneum

Development period significantly differed on different food sources, particularly with reference the egg period of *T. castaneum* (Table 2). Significantly lesser number of days were recorded in wheat flour (3.40± 0.41) and higher in rice (5.10±0.74) compared to wheat (4.00±0.57) and sorghum (3.80± 0.67). Larval duration on wheat flour and sorghum flour recorded 23.00± 0.71 and 24.00±0.79 days, respectively and were significantly differing from wheat (26.00 ±0.94) and rice (27.12± 0.50) at P=0.05%. Observation on pupal period was significantly differing in all food sources in which, more days were observed in the rice (8.60±0.89) followed by wheat (7.40±0.82), sorghum (6.40±0.82) and wheat flour (5.40±0.55). Total development period was significantly superior in rice which recorded 40.82±3.56 days followed by wheat (37.40±2.40) and sorghum (34.20±2.31).

Influence of sorghum flour and wheat flour were significantly greater when compared to wheat and rice used for rearing the *T. castaneum* in the present study. *T. castaneum* prefer broken grains or it requires the primary infestation by other insect. The total developmental period was also lower in sorghum flour and wheat flour which recorded 34.20 and 31.80 days, respectively. *T. castaneum* preference to flours was more and completed the life cycle early compared to the grains in storages. Our findings are in line with findings of Fleming and Gross, (1990) when *T. castaneum* reared on mango indicated that mango nuts had less duration or longevity of life stages than other commodities and which had less mean developmental period in mango nuts. Our findings are in line with Mahroof and Phillips (2008), who studied the egg, larval and pupal development time of the cigarette beetle, *L. serricorne* on seven food sources *viz.,* ground chili, paprika, cayenne pepper, chewing leaf tobacco, cigar tobacco, commercial insect bait and wheat flour which recorded varied duration from 3 to 5, 38 to 92 and 4 to 18 days, respectively.

Influence on S. oryzae

Egg duration of *S. oryzae* significantly differed among different food sources. Maize recorded 6.00 ± 0.94 days which was significantly superior to the sorghum (4.00± 0.50) and was on par with wheat flour 6.00 ±0.60 at P=0.05% (Table 3). Larval period also differed and was recorded in

Table 2. Influence of different food sources on life history parameters of T. *castaneum*

Food sources	Life history parameters: Egg period (days)	Larval period (days)	Pupal period (days)	Total Development Period (days)
Wheat	4.00±0.57^c	26.00±0.94^b	7.40±0.82^c	37.40±2.40
Rice	5.10±0.74^d	27.12±0.50^b	8.60±0.89^d	40.82±3.56
Sorghum flour	3.80±0.67^b	24.00±0.79^a	6.40±0.82^b	34.20±2.31
wheat flour	3.40±0.41^a	23.00±0.71^a	5.40±0.55^a	31.80±3.00
SEm	0.0806	0.5698	0.3464	-
CD (0.01%)	0.2355	1.6644	1.0118	-
CV (%)	3.13	3.60	4.88	-

Means of five replications; Means followed by the same letter in the column do not differ significantly by DMRT at P = 0.01

Table 3. Influence of different food sources on life history parameters of S. oryzae

Food sources	Life history parameters			
	Egg period (days)	Larval period (days)	Pupal period (days)	Total Development Period (days)
Wheat	5.00±0.79[b]	29.00±0.81[b]	8.60±0.40[b]	42.60±2.36
Rice	5.60±0.60[bc]	30.00±1.58[b]	9.00±0.65[b]	44.60± 3.22
Sorghum	4.00±0.50[a]	27.00±1.00[a]	7.00±0.55[a]	38.00±2.65
Maize	6.00±0.94[c]	32.00±1.00[c]	9.00±1.00[b]	47.00±3.00
SEm	0.3564	0.7178	0.3860	-
CD (0.01%)	1.0409	2.0965	1.1275	-
CV (%)	4.94	3.85	4.27	-

Means of five replications; Means followed by the same letter in the column do not differ significantly by DMRT at P = 0.01

the range of 27 to 32 days. In case of pupal period, it was significantly higher in sorghum, i.e., 7.00±0.55 days than the rest of the food sources such as wheat (8.00 ±0.40), rice (9.00 ±0.65) and wheat flour (9.00 ±1.00). Considering all the parameters of *S. oryzae*, the total development period was higher in case of wheat flour (47.00±3.00) followed by rice (44.60±3.22), wheat (42.60±2.36) and sorghum (38.00± 2.65). In the present study, *S. oryzae* preference of sorghum and wheat was significantly higher compared to rice and maize. The duration of total development period was very low in case of sorghum (38.00 days) when compared to maize which recorded 47.00 days *S. oryzae* completed life cycle of 9 days earlier in sorghum than in maize. Present findings are in line with Consoli and Filho (1995) who studied the biology of *Sitotroga cerealella* (Oliv.) on five natural diets of different corn (maize) genotypes which displayed the longest developmental time (43.5 days). However, Shazali and Smith (1986) reported a shorter developmental period (26.3 days) for *S. cerealella* when it was reared on sorghum. They also observed that differences in the period of developmental of *S. cerealella* when it was reared on different corn, rice and sorghum varieties. The present findings are also in line with Kavitha and Shekharappa (2006) who recorded the total larval period of 21-30, pupal period of 7-8 days and total life cycle from egg to adult of 35-46 days when *S. oryzae* was reared on pop sorghum grain variety under laboratory condition. On the total developmental period, our findings are in agreement with Howe (1952), who reported 21 to 46 days and Bheemanna (1986), who reported 38 to 53 days of total life cycle on sorghum hybrid CSH-5. The possible reason for variation in duration could be the difference in temperature, relative humidity and also change in host nutrition containing varied level of amino acids, vitamin and minerals in the different food sources.

Many damaged or broken food source influence in early completion of life cycle compared to the undamaged or whole grains because of the preferences and release of volatiles or essentials metabolites from the damaged grains making stored product pest to adapt faster compared to undamaged. This can be evident from the report of Allotey and Azalekor (2000) who recorded significant differences in the developmental periods of *Corcyra cephalonica* that ranged from 33.2 ±20.2 to 45.3 ± 21.8 days when reared on groundnut, bambara groundnut and powdered cowpea at 27.5±30^0 C and 60±73% relative humidity and the mean developmental periods ranged from 33.3 days on powdered cowpea to 45.3 days on whole bambara groundnut, indicating that development of *C. cephalonica* was most rapid on powdered cowpea. Cox *et al*. (1981) noted that the physical forms of the food media (whole, broken, or flour) did affect the developmental periods of *C. cephalonica* on different food media. From the study it was evident that host nutrition influences greatly in differing the life history parameters of insects. In all the three pests when reared on their principal food sources expressed varied duration of developmental periods that could be used for identification of their infestation in the storage. However, this could also facilitate us for identification of vulnerable stages and their time of occurrence. Further, management strategy could then be directed for successful management of stored grain pest infestation in various grain storages.

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