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DETAILED STUDIES ON THE BIOLOGY OF *DERMESTES ATER* DEGEER (DERMESTIDAE: COLEOPTERA) UNDER DIFFERENT TEMPERATURES AND RELATIVE HUMIDITY; AND ON FOUR DIFFERENT DIETS OF ANIMAL ORIGINS

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AUTHOR'S CONTRIBUTION

The sole author designed, analyzed, interpreted and prepared the manuscript.

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ABSTRACT

Detailed biology of dermestid beetle,*Dermestes ater* was studied under differentexperimental conditions and on four different diets of animal origin.

There were 7 larval instars in all the experimental conditions. The incubation period varied, at room temperature 22.4 – 29.8° C (25.61 ± 0.1) and humidity 47.5 – 86% (66 ± 0.3) it was 5 – 8 (6.31 + 0.27) days, at constant temperature of 30° C and 65% RH it was 5 – 7 (5.69 + 0.24) days and at 35° C and 65% RH 4 – 5 (4.30 + 0.15) days.

Total life-cycle period under laboratory conditions, at room temperature 22.4 – 29.8° C (25.61 ± 0.1) and relative humidity of 47.5 – 86% (66 ± 0.3), at different temperature and relative humidity (30° C and 65% RH, 35° C and 65% RH) are as follows:

Total larval period was 43 – 56 (49.5 ± 1.16), 38 – 45 (40.57 ± 0.81) and 30 – 42 (35.8 ± 2.13) days, pupal period was 8 – 11(9.5 + 0.36), 7 – 9 (7.71 + 0.36) and 5 – 7 (6.0+ 0.45) days and life-cycle period was 62 – 72 (65.42 ± 0.96), 50 – 57 (54.29 ± 0.84) and 42 – 53 (46.40 ± 2.06) days respectively.

On dried silkworm pupae, dried silk moths, feathers of white leghorn and an equal mixture of fur of goat and sheep, total larval period was 39-53 (47.78 ± 1.64), 41-56 (50.86 ± 2.13), 34-61 (58.20 ± 1.24) and 58-69 (63.50 ± 2.26) days, pupal period was 8-11 (8.78 ± 0.37), 8-11 (9.57 ± 0.43), 9-11 (11.0 ± 0.63) and 9-13(11.0 ± 0.82) days, and life-cycle period was 55-71 (63.33 ± 1.76) days 50 – 57 (54.29 ± 0.84) days, 60-72 (67.29 ± 1.66) days and (81.75 ± 2.39) 76-87days respectively.

Keywords: Biology; dermestid beetle; *Dermestes ater*; dried silkworm pupae; silk moths; bombyx mori; feathers and fur.

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1. INTRODUCTION

Dermestid beetles feed on a wide variety of food materials of both animal and vegetable origin [1]. According to review article [2] insect pests including dermestid beetles found attacking different types of animal products.

Ecology and classification of dermestid beetles of Palearctic fauna is given by Zhantiev [3]. According to Hava [4] the family Dermestidae includes 66 genera and 1648 species and subspecies.

The beetle *Dermestes ater*, commonly called black ladder beetle, the larvae feed on different materials of animal origin.Only few authors have studied some aspects of the biology of D.ater.

Roth and Willis [5] studied oviposition, longevity and the larval stages after rearing on meat of several types and fishmeal. Different species of dermestid beetles including *D. ater* are attracted by the odour of silkworm cocoons the Sericin and Fibroin proteins and damage the cocoons [6]. According to Mroczkowski [7] the larvae feed on dead pupae and adults of silkworm. Coombs [8] made an attempt to study the development, fecundity and longevity under different temperatures and relative humidity. Ansari and Basalingappa [9,10] studied the per cent infestation of silkworm cocoons of Bombyxmori by the larvae of D.ater and reported the beetle from silkworm cocoon markets, filature centers in Karnataka (India) and at sericulture museum, CSR& TI, Mysore where the larvae found boring into the cocoons of all varieties including non-mulberry silkworm cocoons. Kumar et al. [11] reported as a pest of silkworm pupae and adults. Veer et al. [12] reported damaging stored silkworm cocoons and their products in India. In a review article of Rajendran and Hajira Parveen the beetle and the larvae found attacking different animal products. Kumar et al. [13] reported from the corpse of 48 year old man in Bukit, Mertejam, Penang in Malaysia.Shashikanta [14] repoted the grubs and adults attack silkworm pupae and moths in India. Siddayya and Kujar [15] studied the life cycle on tassar cocoons; and Natikar and Meganathan [16] on bivoltine double hybrid (FC1 and FC2) mulberry cocoons.

The aim of present study was to know the biology of the beetle Dermestesater under different temperature and relative humidity and on four different diets at room temperature and relative humidityand to know the dietary effect on the developmental process.

2. MATERIALS AND METHODS

The larvae of different instars of *Dermestes ater* were collected from the mini filature center and grainage at Rayapur, Hubli-Dharwad(India) and reared on dried silkworm pupae of Bombyxmori in plastic containers under laboratory conditions. Freshly emerged imagines were collected from the laboratory rearing stock and were allowed to mate. The mated females were separated and kept them singly in the plastic containers (3" x 2") provided with silkworm cocoons as substrate for egg-laying. After oviposition, the eggs laid during first two days were collected and used to study the entire life-cycle at room temperature of 22.4 – 29.8^{o} C (25.61 $\pm$ 0.1) and relative humidity of 47.5 – 86% (66 $\pm$ 0.3), at different temperature (30^{o}C and 65% RH, 35^{o} C and 65%RHand on dried silkworm pupae of Bombyxmori; and on four different diets of animal origin such as dried silkworm pupae and moths of Bombyxmori, feathers of white leghorn and an mixture of fur of goat and sheep under laboratory conditions, room temperature 22.4 – 29.8^{o} C (25.61 $\pm$ 0.1) and relative humidity of 47.5 – 86% (66 $\pm$ 0.3). The diets are selected from Sericulture, Poultry and Animal husbandry. The diets were replaced by fresh food after every week.

3. RESULTS

There were 7 larval instars in all the experimental conditions. The incubation period varied; at room temperature 22.4 – 29.8^{o} C (25.61 $\pm$ 0.1) and humidity 47.5 – 86% (66 $\pm$0.3) it was 5 – 8 (6.31 + 0.27) days, at constant temperature of 30^{o} C and 65% RH it was 5 – 7 (5.69 + 0.24) days and at 35^{o} C and 65% RH 4 – 5 (4.30 + 0.15) days.

The last instar larvae observed, stopped feeding and remained quiescent for 3-5 (4.2 $\pm$ 0.3) days. At the last larval instar, the larval skin found split along the mid dorsal line and the split commenced from the epicranial suture and extended backwards up to the seventh abdominal segment. The newly formed pupae remained within the last larval skin, the exuviae. At the end of pupation, the imagines emerged and remained as quiescent stage in the last larval skin for 5-7 (6.2$\pm$0.4) days. The pupal covering was found shriveled up and attached to the tip of the abdomen of imagines.

Total incubation period, larval period, pupal period and total life-cycle period under laboratory conditions, at room temperature 22.4 – 29.8^{o} C (25.61 $\pm$ 0.1) and relative humidity of 47.5 – 86% (66 $\pm$ 0.3), at different temperature (30^{o} C and 65% RH, 35^{o} C and 65%RH; and on four different diets of animal origin (dried silkworm pupae and dried silk moths of B.mori, feathers of white leghorn and fur of goat and sheep in 1:1 ratio) are detailed in tables 1-4.

Total life-cycle period under laboratory conditions, at room temperature 22.4 – 29.8^{o} C (25.61 $\pm$ 0.1) and

relative humidity of 47.5 – 86% (66 ± 0.3), at different temperature and relative humidity (30°C and 65% RH, 35°C and 65%RH)are as follows.

Total larval period was 43 – 56 (49.5 ± 1.16), 38 – 45(40.57 ± 0.81) and 30 – 42(35.8 ± 2.13) days, pupal period was 8 – 11(9.5 + 0.36), 7 – 9(7.71 + 0.36) and 5 – 7 (6.0+ 0.45)days and life-cycle period was 62 – 72(65.42 ± 0.96), 50 – 57(54.29 ± 0.84) and 42 – 53 (46.40 ± 2.06) days respectively under three experimental conditions.

On dried silkworm pupae, dried silk moths, feathers of white leghorn and an equal mixture of fur of goat and sheep, total larval period was 39-53 (47.78 ± 1.64), 41-56 (50.86 ± 2.13), 34-61(58.20 ± 1.24) and 58-69 (63.50 ± 2.26)days, pupal period was 8-11 (8.78 ± 0.37), 8-11(9.57 ± 0.43), 9-11(11.0 ± 0.63) and 9-13(11.0 ± 0.82)days, and life-cycle period was 55-71(63.33 ± 1.76) days 50 – 57 (54.29 ± 0.84) days, 60-72 (67.29 ± 1.66) days and (81.75 ± 2.39) 76-87days respectively.

4. DISCUSSION

It is well established fact that the temperature and relative humidity influences the developmental process of insects. There are significant variations in theresults of earlier studiesmade by different authors and compared with that of present study (Table 5).

Attempts were made to study the biology of *Dermestes ater* by Siddayya and Kujar and Natikar and Meganathan and compared with the present results as detailed in Table 5.

There were7 larval instars under all the experimental conditions, whereas Siddayya and Kujara (2016) reported 6 instars and Natikar and Meghanathan reported 5 instars.

The incubation period under three experimental conditions was 5 – 8 (6.31 + 0.27) days, 5 – 7 (5.69 + 0.24) days and 4 – 5 (4.30 + 0.15) days respectively; and when studies on four different diets, it was 5-8 days; whereas Siddayya and Kujara (2016) reported 7.33 ± 0.33 days and Natikar and Meghanathan reported 3.29 – 6.00 (4.35 ± 0.87) days.

Total larval period under three experimental conditions was 43 – 56 (49.5 ± 1.16), 38 – 45 (40.57 ± 0.81) and 30 – 42 (35.8 ± 2.13) days and on four different diets it was 39-53 (47.78 ± 1.64), 41-56 (50.86 ± 2.13), 34-61 (58.20 ± 1.24) and 58-69 (63.50 ± 2.26) days, whereas Siddayya and Kujara reported 102 days and Natikar and Meghanathan reported 30.69 – 36.52 (34.64± 0.95) days.

Table 1. Life cycle of *Dermestes ater* at room temperature, 22.4 – 29.8°C (25.61 ± 0.1) and relative humidity 47.5 – 86% (66 ± 0.3)

Stages in Life-cycle	Length (mm)	Breadth (mm)	Duration (Days)
Eggs	0.9 - 1.3	0.5 - 0.7	5 – 8
(Incubation period)	(1.11 + 0.02)	(0.59 + 0.01)	(6.31 + 0.27)
I instar	1.6 – 2.0	0.9 – 1.2	4 – 6
	(1.91 ± 0.03)	(1.11 ± 0.02)	(5.0 ± 0.21)
II instar	2.8 – 3.5	1.4 -1.5	4 – 5
	(3.29 ± 0.06)	(1.46 ± 0.01)	(4.42 ± 0.15)
III instar	4.5 -4.9	1.9 – 2.0	5 – 7
	(4.78 ± 0.03)	(1.49 ± 0.02)	(5.92 ± 0.26)
IV instar	5.4 – 6.2	2.2 – 2.3	5 – 7
	(6.04 ± 0.07)	(2.26 ± 0.02)	(6.33 ± 0.19)
V instar	7.9 – 8.2	2.6 -2.8	6 – 8
	(8.07 ± 0.03)	(2.71 ± 0.02)	(6.92 ± 0.26)
VI instar	9.3 – 9.5	3.0 – 3.1	9 14
	(9.42 ± 0.02)	(3.06 ± 0.02)	(11.58 ± 0.58)
VII instar	11.9 – 12.5	3.2 -3.3	13 -16
	(12.28 ± 0.09)	(3.29 ± 0.01)	(14.0 ± 0.38)
Total Larval period	---	---	43 – 56
			(49.5 ± 1.16)
Pupal Period	6.0 -6.3	2.5 – 2.9	8 – 11
	(6.17 ± 0.04)	(2.79 ± 0.04)	(9.5 + 0.36)
Imago	6.3 – 7.1	3.2 – 3.5	---
	(6.78 ± 0.08)	(3.35 ± 0.03)	
Total Life-cycle	---	---	62 – 72
			(65.42 ± 0.96)

Table 2. Life cycle of *Dermestes ater* at constant temperature of 30° C and relative humidity 65%

Stages in Life-cycle	Length (mm)	Breadth (mm)	Duration (Days)
Eggs (Incubation period)	0.9 - 1.3 (1.1 + 0.03)	0.5 - 0.7 (0.57 + 0.01)	5 – 7 (5.69 + 0.24)
I instar	1.6 – 2.0 (1.91 ± 0.03)	0.7 – 1.2 (1.05 ± 0.04)	4 – 5 (4.50 ± 0.17)
II instar	2.5 – 3.5 (3.28 ± 0.10)	1.4 -1.5 (1.47 ± 0.02)	3 – 4 (3.43 ± 0.20)
III instar	4.7 -4.9 (4.79 ± 0.03)	1.9 – 2.0 (1.93 ± 0.02)	4 – 6 (4.86 ± 0.34)
IV instar	6.0 – 6.2 (6.07 ± 0.03)	2.1 – 2.3 (2.26 ± 0.03)	5 – 6 (5.29 ± 0.18)
V instar	7.9 – 8.2 (8.04 ± 0.05)	2.6 -2.8 (2.70 ± 0.02)	5 – 7 (6.0 ± 0.38)
VI instar	8.2 – 9.5 (9.26 ± 0.18)	3.0 – 3.1 (3.03 ± 0.02)	7 - 12 (9.0 ± 0.89)
VII instar	10.9 – 12.4 (12.13 ± 0.19)	3.2 -3.3 (3.28 ± 0.02)	10 -11 (10.4 ± 0.25)
Total Larval period	---	---	38 – 45 (40.57 ± 0.81)
Pupal Period	6.0 - 6.3 (6.14 ± 0.06)	2.4 – 2.9 (2.74 ± 0.08)	7 – 9 (7.71 + 0.36)
Imago	6.6 – 7.1 (6.92 ± 0.09)	3.3 – 3.4 (3.36 ± 0.03)	---
Total Life-cycle	---	---	50 – 57 (54.29 ± 0.84)

Table 3. Life cycle of *Dermestes ater* at constant temperature of 35° C and relative humidity 65%

Stages in Life-cycle	Length (mm)	Breadth (mm)	Duration (Days)
Eggs (Incubation period)	0.9 - 1.3 (1.13 + 0.03)	0.5 - 0.7 (0.58 + 0.01)	4 – 5 (4.30 + 0.15)
I instar	1.8 – 2.0 (1.94 ± 0.02)	1.0 – 1.2 (1.09 ± 0.02)	3 – 4 (3.33 ± 0.21)
II instar	2.9 – 3.5 (3.23 ± 0.11)	1.4 -1.5 (1.42 ± 0.02)	3 – 4 (3.60 ± 0.25)
III instar	4.7 -4.9 (4.8 ± 0.05)	1.9 – 2.0 (1.92 ± 0.02)	4 – 5 (4.60 ± 0.25)
IV instar	5.9 – 6.1 (5.98 ± 0.04)	2.1 – 2.3 (2.25 ± 0.05)	4 – 6 (4.80 ± 0.37)
V instar	7.4 – 8.2 (7.92 ± 0.15)	2.7 -2.8 (2.72 ± 0.02)	4 – 5 (4.80 ± 0.20)
VI instar	9.3 – 9.5 (9.36 ± 0.04)	2.9 – 3.1 (3.0 ± 0.03)	8 - 11 (9.0 ± 0.89)
VII instar	11.9 – 12.5 (12.13 ± 0.19)	3.2 -3.3 (3.27 ± 0.03)	9 -10 (9.33 ± 0.33)
Total Larval period	---	---	30 – 42 (35.8 ± 2.13)
Pupal Period	6.1 - 6.3 (6.20 ± 0.05)	2.5 – 2.9 (2.78 ± 0.07)	5 – 7 (6.0 + 0.45)
Imago	6.6 – 7.1 (6.92 ± 0.09)	3.3 – 3.4 (3.36 ± 0.03)	---
Total Life-cycle	---	---	42 – 53 (46.40 ± 2.06)

Table 4. Life-cycle of *Dermestes ater* on four different diets of animal origin at room temperature of 22.4 – 29.8° C (25.61 ± 0.1) and relative humidity 47.5 – 86% (66 ± 0.3)

Diet	Incubation period of egg (days)	Larval period (days)	Pupal period (days)	Total period (days)
Dried silkworm pupae	5-8 (6.83 ± 0.32)	39-53 (47.78 ± 1.64)	8-11 (8.78 ± 0.37)	55-71 (63.33 ± 1.76)
Dried silk moths	5-8 (6.50 ± 0.37)	41-56 (50.86 ± 2.13)	8-11 (9.57 ± 0.43)	60-72 (67.29 ± 1.66)
Feathers of white leghorn	5-8 (6.90 ± 0.38)	54-61 (58.20 ± 1.24)	9-13 (11.0 ± 0.63)	70-80 (76.20 ± 1.74)
Mixture of fur of goat and sheep (1:1)	5-8 (6.91 ± 0.29)	58-69 (63.50 ± 2.26)	9-13 (11.0 ± 0.82)	76-87 (81.75 ± 2.39)

Table 5. Comparison of present results of Biology of *Dermestes ater* with that of other authors

Authors, temperature and humidity, and diet	Incubation period of egg (days)	Larval period (days)	Larval instars	Pupal period (days)	Total period (days)
Siddayya and Kujar (2016)					
Tassar cocoons	7.33 ± 0.33	102	6	7.33 ± 0.33	143
Natikar and Meganathan (2019)	3.29 – 6.00	32.69 – 36.52	5	7.05 – 8.01	43.03 – 48.32
Bivoltine double hybrid (FC1 and FC2) mulberry cocoons.	(4.35 ± 0.87)	(34.64 ± 0.95)		(7.49 ± 0.3)	(46.48 ± 1.68)
Present study:					
22.4 – 29.8° C (25.61 ± 0.1) and humidity 47.5 – 86% (66 ± 0.3) Dried silkworm pupae	5 – 8 (6.31 + 0.27)	43 – 56 (49.5 ± 1.16)	7	8 – 11 (9.5 + 0.36)	62 – 72 (65.42 ± 0.96)
30 C and 65% RH Dried silkworm pupae	5 – 7 (5.69 + 0.24	38 – 45 (40.57 ± 0.81)	7	7 – 9 (7.71 + 0.36)	50 – 57 (54.29 ± 0.84)
35 C and 65% RH Dried silkworm pupae	4 – 5 (4.30 + 0.15)	30 – 42 (35.8 ± 2.13)	7	5 – 7 (6.0 + 0.45)	42 – 53 (46.40 ± 2.06)
Dried silkworm pupae	5-8 (6.83 ± 0.32)	39-53 (47.78 ± 1.64)	7	8-11 (8.78 ± 0.37)	55-71 (63.33 ± 1.76)
Dried silk moths	5-8 (6.50 ± 0.37)	41-56 (50.86 ± 2.13)	7	8-11 (9.57 ± 0.43)	60-72 (67.29 ± 1.66)
Feathers of white leghorn	5-8 (6.90 ± 0.38)	54-61 (58.20 ± 1.24)	7	9-13 (11.0 ± 0.63)	70-80 (76.20 ± 1.74)
Mixture of fur of goat and sheep (1:1)	5-8 (6.91 ± 0.29)	58-69 (63.50 ± 2.26)	7	9-13 (11.0 ± 0.82)	76-87 (81.75 ± 2.39)

Totalpupal period under three experimental conditions was 8 – 11(9.5 + 0.36), 7 – 9 (7.71 + 0.36) and 5 – 7 (6.0+ 0.45) days and on four different diets was 8-11 (8.78 ± 0.37), 8-11 (9.57 ± 0.43), 9-11 (11.0 ± 0.63) and 9-13(11.0 ± 0.82) days, whereas Siddayya and Kujara (2016) reported 7.33 ± 0.33 days and Natikar and Meghanathan (2019) reported 7.05 – 8.01 (7.49± 0.3) days.

Total life-cycle period under three laboratory conditions was62 – 72 (65.42 ± 0.96), 50 – 57 (54.29 ± 0.84) and 42 – 53 (46.40 ± 2.06) days respectively and on four different diets it was 55-71 (63.33 ± 1.76) days 50 – 57 (54.29 ± 0.84) days, 60-72 (67.29 ± 1.66) days and (81.75 ± 2.39) 76-87days respectively, whereas Siddayya and Kujara reported 143 days and Natikar and Meghanathan reported 43.03 – 48.32 (46.48± 1.68) days.

It is surprising to note that the total larval period and life cycle reported by Siddayya and Kujara were nowhere nearer to the reports,neither of Natikar and Meghanathan nor with the present studies.

The variations shown in Table 5 compared with that of other authors and the present study may be/arebecause of the effect of temperature, relative humidity and of course the effect of food materials fed to the larvae of D.ater.
There is a wide range of scope to study the physiological aspects of the larvae based on the chemical composition of different diets which influences the developmental process.

5. CONCLUSION

Biology of Dermestesater was studied under different temperatures and relative humidity and on four diets of animal origin to study the dietary effect on the developmental process. The results compared with that of other two authors and found significant variations.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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