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Effect of Temperature on Development of *Pardosa pseudoannulata* (Bosenberg & Strand, 1906) and *Neoscona mukerjei* Tikader, 1980, Predominant Spiders of Rajasthan

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***Abstract* – The effect of temperature on the development pattern of *Pardosa pseudoannulata* (Bosenberg & Strand, 1906) and *Neoscona mukerjei* Tikader, 1980 was studied. A stock culture of both the spiders was maintained in the laboratory at 25±2 ºC and 70±5% RH in BOD incubator. An actual determination of particular instars during experiments conducted on *P. pseudoannulata* and *N. mukerjei*, was carried out by counting and separating the subsequent exuviae shed off by developing spiderlings time to time throughout the moulting process. The results showed that female *P. pseudoannulata* had 7 instars while males 6 instars, although some males matured at the seventh instar, while in case of *N. mukerjei*, females matured after 9 instars and males got maturity after 7 instars. However, in these experiments development periods fluctuated at various temperatures (i.e. 20, 25 and 30˚C). Male *P. pseudoannulata* required 79.57±0.38 days at 20˚C for attaining adulthood, while at 25˚C and 30˚C, this period was recorded to be 74.54±1.2 and 82.49±0.47 days, respectively. Female *P. pseudoannulata* took 90.28±0.69, 85.24±0.69 and 93.06±0.91 days to become an adult at 20˚C, 25˚C and 30˚C, respectively. *N. mukerjei*, revealed that males took 98.06±0.48 days, 85.05±1.6 and 96.85±2.34 days for attaining the adulthood at 20˚C, 25˚C and 30˚C, respectively. On the other hand, females required 105.88±0.41, 97.25±1.29 and 106.92±0.5 days to get adult stage at 20˚C, 25˚C and 30°C, respectively. Analysis of variance (ANOVA) revealed that data on effect of temperature on development periods were found significantly different at three temperature ranges. 25°C temperature was found as most suitable temperature range for male and female (*P. pseudoannulata* and *N. mukerjei)* at which minimum development period was recorded. The length of development period of different instars of male and female of both spider species was found to be significantly higher at 20˚C and 30˚C.**

***Keywords* – *Pardosa pseudoannulata* (Bosenberg & Strand, 1906), *Neoscona mukerjei* Tikader, 1980, Temperature, Development.**

I. Introduction

Spiders play an important role in keeping the pest population under check in the cultivated crops [1]. Spiders have higher host finding ability and capacity to consume greater number of prey than other field inhabiting predators [2]. Therefore, it is almost true to say that spiders catch and devour more insects than other insectivorous animals put together. In this respect, spiders attract our attention for their use as bio-control agent. However, the role of spiders in the natural biological control of agricultural pests has recieved limited investigations.

The purpose of the present study was to develop an efficient biological tool to control pest population using spiders, as continuous and injudicious use of wide range of pesticides has caused many side effects, including loss of biodiversity, the problem of secondary pest resurgence, insecticide resistance, residual toxicity and environmental pollution. Considering these aspects a suitable IPM module can be prepared using spiders for the management of insect pests which will definitely sustain the balance of nature. This strategy needs thorough knowledge of life cycle and developmental pattern of spiders. Temperature influences spider behaviour viz., prey hunting [3], web building [4], Sexual signaling [5], [6] habitat selection [6] Courtship and copulatory behaviour [7], [8] survival [9], fertility [10], overall activity [11]. However, the effect of temperature on growth and development has received relaively little attention to date [9], [12], [13]. Hence, an attempt has been made to analyze the influence of temperature on the biology of *Pardosa pseudoannulata* and *Neoscona mukerjei*, predominant spider species of Rajasthan, under laboratory conditions.

II. Material and Methods

To observe the effect of temperature on biology of *P. pseudoannulata* and *Neoscona mukerjei*, spiders were collected and reared in simulated laboratory conditions and culture was maintained at 25˚C using BOD incubator. Spiders so collected from study area were kept individually in separate glass containers to prevent cannibalism. *Drosophila melanogaster* was also cultured in laboratory condition as the diet source for rearing spider species. To provide and maintain the proper feeding for spiders, collected specimens were kept in separate glass cages, each of which was marked and numbered. Each glass cage consisted of a lantern chimney fixed over a petridish containing sterilized and moist sand. The chimney was covered by a piece of muslin cloth and the sand was to be kept moist by putting a few drops of distilled water over it daily in order to provide humidity as the spiders do not thrive under dry conditions. Marked male and female individuals were placed together in the same glass cage in order to provide them mating opportunity. During this period, the larvae of prey insects were provided them as food in adequate number to prevent cannibalism. After three days males and females were separated as they had mated and kept in another glass cages, separately. The newly hatched spiderlings were separated in small containers, the lid of which had a few small holes for aeration and one moderately big hole for feeding. A small strip of paper was inserted into the container to provide additional support to the spiderlings.

Spiderlings of *P. pseudoannulata* and *N. mukerjei* were taken and put at three different ranges of temperatures- 20˚C, 25˚C and 30˚C, respectively. Three sets of *P. pseudoannulata* and *N. mukerjei* each were used to observe the effect of temperature on their developmental pattern. Each set was consisted of 15 spiderlings which was marked and numbered as F1 to F15 for Ist set, F16 to F30 for IInd set and F31 to F45 for IIIrd set. Thus, the experiment was replicated fifteen times for each range of temperature. Various biological parameters viz., incubation period, development period and number of molts in males and females were studied. The period from egg laying to hatching was recorded as incubation period; the period from hatching to become an adult was recorded as development period. An actual determination of particular instars during experiments was carried out by counting and separating the subsequent exuviae shed off by developing spiderlings time to time throughout the moulting process. The data so generated were subjected to Analysis of variance (ANOVA) to determine the effect of temperature.

III. Result and Discussion

It was found that female *P. pseudoannulata* had 7 instars while males had 6 instars, although some males matured at the seventh instar, while in case of *N. mukerjei*, females matured after 9 instars and males got maturity after 7 instars. The difference between male and female maturity periods have been shown already by several studies [14], [15] which provide a clear variation among developmental patterns of male and female spiders. According to the data recorded on biology of *P. pseudoannulata* and *N. mukerjei* during present study, male *P. pseudoannulata* required 79.57±0.38 days at 20˚C, 74.54±1.2 days at 25˚C as development period while at 30˚C, this period was recorded to be 82.49±0.47 days. Female *P. pseudoannulata* took 90.28±0.69, 85.28±0.69 and 94±0.91 days to become an adult at 20˚C, 25˚C and 30˚C, respectively (Table 1). In the same way, data collected pertaining to the development of *N. mukerjei*, revealed that males took 98.06±0.48 days and 85.05±1.6 days for attaining the adulthood at 20˚C and 25˚C, respectively. On the other hand, females required 105.88±0.41 and 97.25±1.29 days to get adult stage at 20˚C and 25˚C, respectively. At 30˚C, male and female spiders required 96.85±2.34 and 106.92±0.5 days, respectively (Table 2).

However, the data revealed that development periods fluctuated at various temperatures (i.e. 20, 25 and 30˚C) for the same species, but development periods were also fluctuating at same temperature according to male and female individuals of the same species. The results are in accordance with [9] who documented increased rate of development of juveniles over successive temperature increments up to 30.8˚C then decreased rate at 32.8˚C and females developed faster than males. ANOVA revealed that data on maturity periods proceeded by F- test, were found statistically significant at three different temperature ranges. 25°C was found as most suitable temperature range for male and female both, at which minimum development period was recorded. For male *P. pseudoannulata*, the minimum average development period was recorded as 74.40±1.2 days at 25°C, which was found significantly less than that at other two temperatures (ANOVA, F= 6.452; P=1.89). Similarly, at 25°C, female had the minimum development period on an average 85.28±0.69 days (ANOVA, F= 10.85; P= 1.15). For male *N. mukerjei*, the minimum development period was recorded to be 85.20±1.6 days at 25°C temperature, which was found significantly less than that at other two temperatures (ANOVA, F= 5.474; P= 1.36). Similarly, female *N. mukerjei* had the minimum development period on an average 95.50±1.29 days (ANOVA, F= 2.205; P = 0.0158) at 25°C temperature.

Results of present study on the effect of temperature on development of both the spiders are in consonance with [12], [16], [17], [18]. The observations made by [19] on quantitative relationship between the temperature and the speed of development of *Lycosa pseudoannulata* showed that the rate of development of spiderlings increased as the temperature rose up to 28°C. Above this temperature, the speed of development decreased rapidly as the temperature rose up to 36°C. The present experiments conducted on biology of *P. pseudoannulata* and *N. mukerjei*, revealed that most of spiders survived for three or four months and then most of them died during the period of observation. This agrees with [20] who noted that the tropical araneid *Metabus gravidus* (Cambridge) became mature after five-seven months and that very few individuals survived longer than a year. However, the results of present study have some contradiction to the results obtained by [14], who concluded that a rise of temperature from 20 to 30˚C, approximately halved the length of development period in spiders.

The duration from egg laying to hatching of spiderlings from the egg-sac (incubation period) was recorded to be 25 and 28 days for *P. pseudoannulata* and *N. mukerjei*, respectively. The present data on incubation period for *P. pseudoannulata* and *N. mukerjei* (25 and 28 days, respectively) have quite similarity with the incubation period to be 25.4 days (range=24-28; N=8) recorded by [21] for *Cyrtophora moluccensis* (Doleshall) during the study of its life cycle in laboratory conditions in Yap, Caroline Islands. He also found that the spiderlings had been at instar II, when they left the cocoon (egg-sac). However, reference [10] recorded mean time until hatching as 30.87 days in the green lynx spider, *Peucetia viridens*.

IV. Conclusion

It is concluded from our data that development of spider is temperature dependent. Thus, complete knowledge of temperature dependence spider development should be taken into account during their utilization as a biocontrol agent in insect pest management.

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Table 1: Developmental periods (in Days) for *Pardosa pseudoannulata* at different temperatures

Molts	20°C		25°C		30°C	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
I	25.00±0.0 (5.000)	25.00±0.00 (5.000)	25.00±0.00 (5.000)	25.00±0.0 (5.000)	23.00±0.00 (4.796)	23.00±0.00 (4.796)
II	10.47±0.64 (3.236)	12.15±0.73 (3.486)	10.23±0.47 (3.199)	10.59±0.4 (3.254)	9.65±1.10 (3.107)	11.93±0.94 (3.453)
III	7.73±0.47 (2.780)	10.18±0.48 (3.190)	7.46±0.64 (2.731)	11.94±0.83 (3.455)	11.71±0.75 (3.423)	10.18±0.48 (3.190)
IV	7.68±0.85 (2.771)	10.58±0.50 (3.252)	8.40±1.04 (2.899)	11.59±0.4 (3.404)	12.95±0.91 (3.599)	12.98±0.44 (3.603)
V	11.70±0.85 (3.421)	11.39±0.24 (3.376)	10.71±0.75 (3.273)	8.93±0.83 (2.988)	10.47±0.64 (3.236)	11.18±0.48 (3.344)
VI	16.99±0.40 (4.122)	8.63±1.31 (2.938)	12.74±0.47 (3.569)	7.99±0.31 (2.826)	14.71±0.85 (3.836)	15.58±0.50 (3.948)
VII	-	12.17±0.58 (3.489)	-	9.20±0.20 (3.032)	-	8.95±0.63 (2.992)
Maturity Period (in Days)	79.16±0.38	90.40±0.76	74.40±1.2	85.28±0.69	82.75±0.47	94.0±0.91

Values in Parentheses are square root

Table 2: Developmental periods (in Days) for *Neoscona mukerji* at different temperatures

Molts	20°C		25°C		30°C	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**
I	28.00±0.00 (5.292)	28.00±0.00 (5.292)	28.00±0.00 (5.292)	28.00±0.00 (5.292)	28.00±0.00 (5.292)	28.00±0.00 (5.292)
II	9.18±0.37 (3.031)	10.66±0.33 (3.265)	8.38±0.40 (2.895)	11.33±0.33 (3.366)	10.38±0.40 (3.222)	10.98±0.57 (3.314)
III	7.38±0.40 (2.716)	9.98±0.5 (3.160)7	7.78±0.37 (2.790)	9.66±0.33 (3.108)	9.79±0.37 (3.128)	11.33±0.33 (3.366)
IV	8.59±0.24 (2.931)	11.66±0.33 (3.415)	7.18±0.37 (2.680)	9.33±0.33 (3.054)	9.37±0.50 (3.061)	10.33±0.33 (3.214)
V	10.39±0.24 (3.224)	9.98±0.57 (3.160)	8.76±0.58 (2.960)	7.98±0.57 (2.825)	9.77±0.58 (3.125)	9.33±0.33 (3.054)
VI	10.77±0.58 (3.281)	7.98±0.57 (2.825)	7.18±0.37 (2.680)	7.66±0.33 (2.768)	9.97±0.54 (3.157)	8.98±0.57 (2.997)
VII	11.56±0.67 (3.400)	7.66±0.33 (2.768)	8.78±0.37 (2.964)	6.98±0.57 (2.641)	9.59±0.24 (3.097)	8.98±0.57 (2.997)
VIII	12.19±0.37 (3.491)	8.98±0.57 (2.997)	8.99±0.31 (2.998)	7.33±0.33 (2.707)	9.98±0.44 (3.159)	8.66±0.33 (2.943)
IX	-	10.98±0.57 (3.314)	-	8.98±0.57 (2.997)	-	10.33±0.33 (3.214)
Maturity Period (in Days)	98.2±0.48	106±0.41	85.2±1.6	95.5±1.29	97±2.34	107±0.5

Values in Parentheses are square root