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SURVIVORSHIP OF GROUND SPIDER *Pardosa oakleyi* (GRAVELY) UNDER LABORATORY CONDITIONS ON NATURAL AND ARTIFICIAL DIETS

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The survival rate of *Pardosa oakleyi* (Gravely) was studied under laboratory conditions on natural and artificial diets. Twenty females and ten males were released in separate cages and observed to the last moult, till death of adult individuals. No hatching was observed in cocoons without females. Hatching percentage was recorded 72% on natural diet while on artificial diet it was 62%. First moult existed inside the cocoon, the nest stage emerged from cocoon, climbed on mother's back (grossomere). High mortality rate was observed in earlier stages as compared to later one. Interestingly females showed an increased average life span as compared to males. High survival rate was recorded on natural diet mainly due to balanced diet contents. The artificial diet was good enough to achieve maturity but with long duration and high mortality rate. After analysis it was observed that artificial diet has balanced nutrient profile but lack some hormones essential for proper growth and development. The consumption of artificial food by the ground spider is of indication that mass rearing of such individuals could be employed as they are predator of majority of insect pest species.
Keywords: Ground spider, spiderlings, diet, mass rearing, moults

INTRODUCTION

Agriculture is the backbone of the economy of Pakistan. Many species of phytophagous insects cause serious damage to agricultural crops, orchards, vegetables, wild and ornamental plants. All these agricultural products are badly affected by the insect pests (Siddiqui *et al.,* 2005). A common practice for inhabiting these pest populations in our agro-ecosystems is the use of pesticides. Their indiscriminate use has been increased very much during recent decade in Pakistan. They are not only dangerous for human health but also affect the non-targeted species. Therefore, they are responsible for weakening the natural forces which quietly play a very positive role to limit the pest problems (Rana *et al.,* 2010). Araneae constitute a large part of predatory fauna of the agro-ecosystems in Punjab. They are generalist predators but a few species are specialist predators. The use of spiders as biological control agent in combination with selective and non-persistent insecticides, restricting the number of application to only specific times so as to protect spiders, provide favourable results (Mushtaq *et al.,* 2000). Life history studies have been done on very few species of spiders. There are many reasons but important one is the lack of reliable rearing technique. Spiders are carnivorous; require different behavioural cues from prey to initiate attack and feeding (Riechert and Luczak, 1992). Optimization of critical nutrient requirement is essential and that is Lycosids maintain a mixed diet in the field despite high abundance of a single prey (Greenstone, 1999). Most of the spider species feed on variety of prey species to maintain maximum nutrition for survival and reproduction (Uetz *et al.,* 1992). Another reason is the lack of formulated artificial diets. However, the information about the nutritional requirements of different species is very important. It was reported that few species of wandering spiders Uloborids are facultative nectar feeder (Taylor and Foster, 1996). This confirmed that spiders can use artificial diets as well. Foraging decision influences individual fitness in a variety of ways. Choice of foraging habitat and the type of food has been recognized as being of primary importance through its effects on feeding rates, with derived benefits to growth and reproduction.

Pardosa oakleyi (Gravely) is a dominant species in agro-ecosystems of Punjab, Pakistan being the natural enemy of many insect pests. Baseline information on life history and biology is fundamental for ecological work and is of great importance to investigate the predatory potential of a species.

MATERIALS AND METHODS

Pardosa oakleyi (Gravely) was collected from experimental citrus fruit orchard, Institute of Horticulture Sciences, University of Agriculture, Faisalabad, Pakistan. Direct hand picking and pitfall traps (twenty pitfall traps in one acre) were employed to collect the spiders from grass and under soil cracks. The species mainly found in soil cracks in small nests which went up to depth of 2-5 cm down. Collected

specimens were transferred into jars without any preservative and brought to laboratory for final confirmation. Identified gravid females were selected for biological study.

Twenty females and ten males were placed in separate cages and provided with mixed natural and mixture of artificial foods along with a soaked cotton swab. Natural diet consisted of house fly *Musca domestica,* citrus leafminer *Phyllocnistis citrella* and mosquito larvae. Whereas, the artificial diet consisted of milk + egg yolk (100 ml whole milk + 1 chicken egg yolk), soyabean milk (non dairy beverage) and the mixture in 1:1 ratio (100 ml whole milk + 1 chicken egg yolk and soyabean milk). Soyabean seeds were cleaned manually to remove dust particles and damaged seeds. After cleaning the seeds were soaked in water for one hour. Pretreated soyabean was dehulled manually and grinded with water to make slurry. Slurry was diluted by adding more water at a speed of 1450 rpm. Resulting soyamilk was pasteurized at 80^{o}C for 15 minutes, and cooled up to 25^{o}C approximately. Artificial diets were analyzed for analysis of nutrient profile. Each specimen was observed daily for incubation period, hatching, viable eggs/ cocoons. After emergence each spiderling was reared individually at room temperature in small glass vials. Mashed food was provided to these spiderlings alongwith a soaked cotton swab. Spiderlings were fed on alternate days. Duration in days for each spiderling stage was recorded.

Survivorship (Ix) was calculated by using formula as described by Minervino (1993).

$$Ix = Nx/No$$

(Nx=number of alive individuals, No=number of eggs hatched).

RESULTS AND DISCUSSION

***Survivorship of P. oakleyi on mixed natural diet*:** Female carries cocoon throughout the incubation period (from egg laying to hatching of spiderlings). Ten females with cocoon were released in separate cages and provided with mixed natural diet. An average incubation period was recorded as 10 days. Hatching percentage was recorded as 78% (Table 1). No hatching took place in the cocoons without female. The hatched spiderlings remained inside the cocoon where two moults took place and pre-larva changed into spiderling. Enders (1996) studied that Lycosid spiders have higher egg production. After emergence the spiderlings climbed on mothers back and ride until they able to move independently. This period is known as brood care and female do not feed in this phase. Foelix and Chu-Wang (1973) reported that the mother accesses her offspring during hatching and spiderlings climb on her back. All the spiderlings passed six developmental stages before reaching adulthood. An average duration for third spiderling stage was 18 days with 75% survival rate. For fourth spiderling stage the duration increased to 21 days with 65% survival rate. Similarly for fifth, sixth, seventh and eighth spiderling stage the average duration was 29, 26, 29 and 20 days with 62%, 57%, 52% and 50% survival rate, respectively (Table 2). Overall it was observed that at 4th developmental stage mortality was greatly reduced while during 6th and 8th developmental stage the mortality was comparatively low (Table 3). Mortality rate at 3rd and 4th stage spiderling was in accordance with Minervino (1993). Large body size decrease mortality which is attained by extending growth period (Clader, 1984). The average duration of maturity period for male was recorded as 112 days ranged from 112-120 whereas, for female it was 126 days ranged from 121-134 (Table 2). There are reports of low mortality rate by *Hibana velox, Chiracanthium inclusum and Trachelas volutes* on combination of natural diets (Amalin *et al.,* 2002). Similar trend of comparatively less mortality or in other words better survival rate was observed with combined natural diets.

***Survivorship of P. oakleyi on mixture of artificial diet*:** Ten females with cocoon were released in separate cages and provided with mixture of artificial diet. An average incubation period was recorded as 14 days. Hatching percentage was recorded as 62% (Table 1). No hatching was observed in the cocoons without female. The hatched spiderlings remained inside the cocoon where two moults took place and pre-larva changed into spiderling. During brood care average time spent on mother's back was 4 days. An average duration for third spiderling stage was 22 days with 65% survival rate. For fourth spiderling stage the duration increased to 29 days with 61% survival rate. Similarly for fifth, sixth, seventh and eighth spiderling stage the average duration was 34, 28, 32 and 17 days with 55%,

Table 1. Record of hatching of ten cocoons by *P. oakleyi* on mixed natural and artificial diet

No. of cocoons	1	2	3	4	5	6	7	8	9	10	Total	Mean±SD
Natural Diet												
No. of eggs	30	35	32	29	30	35	28	33	38	29	319	31.9 ±5.5
Hatched	24	29	26	22	23	23	25	28	28	20	248	24.8 ±3.4
Artificial Diet												
No. of eggs	38	26	30	22	28	27	22	29	32	20	274	31.0±3.9
Hatched	20	16	20	15	16	17	16	18	18	14	170	16.0±4.9

Hatching was 78% and 62% at natural and artificial diet, respectively.

Table 2. Duration (days) mean, standard deviation and range of life cycle of *P. oakleyi* on mixed natural and artificial diet

Developmental stages	Natural diet		Artificial diet	
	Mean±SD (days)	Range (days)	Mean±SD (days)	Range (days)
3rd spiderling stage	18 ± 2.04	15-22	22 ± 2.38	18-24
4th spiderling stage	21 ± 5.50	17-26	29 ± 3.54	27-34
5th spiderling stage	29 ± 5.13	26- 32	34 ± 4.60	32-39
6th spiderling stage	26 ± 4.50	22- 31	28 ± 2.04	27-33
7th spiderling stage	29 ± 5.0	27-35	32 ± 4.08	30-36
8th spiderling stage	20 ± 4.78	18-24	17 ± 2.54	17-23
adult male	112 ± 7.12	108- 115	128 ± 8.78	126-139
adult female	126 ± 8.02	122- 130	136 ± 10.02	133-140

Table 3. Survivorship of all the developmental stages of *P. oakleyi* on mixed natural and artificial diet

Developmental stages	Natural diet	Artificial diet
	I_x	I_x
3rd spiderling stage	61.74	64.50
4th spiderling stage	68.25	68.00
5th spiderling stage	69.76	62.12
6th spiderling stage	70.00	63.04
7th spiderling stage	66.66	66.72
8th spiderling stage	72.00	69.00
adult male	-	-
adult female	-	-

51%, 47% and 45% survival rate, respectively. The average duration of maturity period for male was recorded as 128 days ranged from 126-130 whereas, for female it was 136 days ranged from 132-140 (Table 2). After reaching maturity, the male members survive for three days while females remained alive for five days. Overall the lowest mortality rate was observed during 4th and 8th developmental stage (Table 3). Behavioral and ecological differences regarding survival rate of various spiders' species should not be ruled out. Generally it is said that combination diet contained balanced nutrients essential for proper growth and development. Among the nutrients carbohydrates, sugar, potassium, magnesium and zinc were available in soya milk. Cholesterol is a common sterol and a precursor of ecdysone, an important molting hormone in addition to fat, saturated fat, sodium, protein, Vitamin A, Vitamin D, calcium, and phosphorous (Foelix, 1982; Singh, 1984). Egg yolk is considered to be a best source for cholesterol. The presence of above discussed nutrients probably explains the higher percent survival and normal development of spiders on the combination diet and also a proved that the experimental species is also a nectar feeder as reported by Taylor and Foster (1996).

***Conclusion*:** Summarizing all this it is suggested that natural diets are more suitable as compared to formulated artificial diets. But an artificial is equally suitable for some specific species of spiders. In the absence of natural food these animals can be provided with artificial food and mass rearing of such important predatory species against serious crop pests could be employed.

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