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Fakhra Soomro
Department of Zoology,
University of Sindh, Jamshoro,
Sindh, Pakistan.

Riffat Sultana
Department of Zoology,
University of Sindh, Jamshoro,
Sindh, Pakistan.

Muhammad Saeed Wagan
Department of Zoology,
University of Sindh, Jamshoro,
Sindh, Pakistan.

Correspondence
Fakhra Soomro
Department of Zoology,
University of Sindh, Jamshoro,
Sindh, Pakistan.

Influence of food plants on different developmental stages of *Aiolopus thalassinus thalassinus* with special reference to its mating strategies

Fakhra Soomro, Riffat Sultana and Muhammad Saeed Wagan

Abstract
Aiolopus thalassinus thalassinus F. is reported as major pest of maize, alfalfa, millet, wheat, berseem, vegetables and grasses. During the present study, it was reared on four different plants that include: *Madicago sativa, Sorghum bicolor, Zea mays* and *Cynodon dactylon* in order to know its preference on different host plants. It was noted that *S. bicolor* was observed most favorite food plant for this species and *A. thalassinus thalassinus* completed its nymphal development in short time i-e (28.8± 1.57) for ♂ and (26.26± 0.67) for ♀. Opposing to this it take prolong time on the *C. dactylon* and *M. sativa*. The total period of nymphal development as well as maturation period of both sexes of nymphs was faster on *S. bicolor* and slower on *M. sativa*. Mating duration was prolonged on *S. bicolor* (52.28± 1.17 hrs) and shortest on *C. dactylon* (43.48± 2.34hrs), whereas maximum number of mating were noted on *M. sativa i-e* (7.20 ± 0.83) and minimum on *Z. mays* i-e (5.40 ± 0.54). Beside this, it was also observed that survival-ship of insect was significant highest on *S. bicolor* as compare to other treated food plants. Present study recommends that data obtained during this study will help to control this pest in field by cultivation of alternate food plants.

Keywords: Pest, food plants, nymphs, embryonic development, mating, control

Introduction
Phytophagus grasshoppers varies in host plants selection some species have limited host ranges, while few are host specific and highly destructive to valued crops. Oedipodinae grasshoppers are mostly feeding on fodder crops with narrow diet breath [6]. Nymphal stages as well as adults of *Aiolopus thalassinus thalassinus* F. are phytophilous (found in thick grasses and forbs) and chiefly graminivorous (feed on wild and cultivated monocotyledon grasses) [18]. *A. thalassinus thalassinus* reported as serious pest of valued crops from various districts of Sindh [1, 28]. Nymphal stages are found in the field from March to early November and reach to high densities during monsoon season [12]. Duration of nymphal development is an important determinant to find-out overall fitness of organism [26]. Host selection pattern in acridids generally conditioned by ecological requirement as well as general behavior of insect [8]. Grasshoppers interaction with host plants produce adoptive strategies which exist in perfect form today [7]. Development of hoppers after emergence depend on availability of preferred food plants, otherwise there are more chances of higher mortality rate of younger stages [16]. Adult and 4th to 6th nymphal instars of grasshoppers are more vigorous and consumpted valued crops in the field. Hewitt [9] stated that damage to forage crops increases with increasing densities of nymphal stages of grasshoppers [9]. A female insect encountered with a poor quality host plants modifying her oviposition behavior, either by decreasing the number of eggs or reabsorbing the eggs nutrients to increase her longevity [2].
Main objective of this study is to compare the effects of food plants on developmental stages
And mating strategies (i-e duration of maturation, pre-copulatory period, copulation duration, mating interval, number of mating and longevity) of *A. thalassinus thalassinus.* Life parameters, reproductive behavior, development, egg production and growth rate of short horned grasshoppers have been studied by various authors [5, 10, 13-17, 25, 29], while effects of food plants on nymphal development and mating activities of Hemiacridinae was studied by Riffat and Wagan [19-23], from Pakistan. Hopefully, present finding will gives a detail account of influence of food plants on developmental stages and mating strategies of this serious pest. The obtained data will help to manage the outbreak of pest species on seasonal crops earlier to cause any major damage.

Experimental Procedure

Sampling and identification of nymphal stages

Stock of *A. thalassinus thalassinus*, were collected during the year 2015 from agricultural fields, grasses around the periphery of fields and some were collected from water channels from Khairpur, Sukkur, Jamshoro, Hyderabad and Matiari. Nymphal instar were brought in the laboratory and identified under stereoscopic dissecting binocular microscope with the help of keys and description given by Soomro *et al.,* [12]. Riffat and Wagan [24].

Rearing techniques

Insect were mass reared in wooden cages (length 40.5cm width 33.5 cm) than replicates of each stage were shifted in separate glass jar (length 13.5 cm and diameter 8 cm). Four food plants *i-e Madicago sativa, Sorghum bicolor, Zea mays and Cynodon dactylon* were used in equal ratio of 4.64g for experiment. Only 3-4 weeks old plants from agricultural field of Matiari was used in this experiment. Fresh leaves were provided daily. Ordinary glass jars were cleaned daily to remove excretory and uneaten leaf fragments to prevent fungal infection. Both nymph and adults were drawn from this stock culture for all experimental analysis. Insects were reared by following procedure given by Riffat and Wagan [20, 22].

1. Influence of food plants on the embryonic development

Immature nymphs from stage (1st to 6th) were isolated (both male and female) after the isolation 15 replicants of each stage were taken out and they were shifted into glass jars, and 04 selected food plants were serve to them. Daily observation was noted. No. of days for each molting were counted for each selected food plant as well as total developmental period up to the emergence of adults were calculated to analyze the differences in the conversion of different stages on different food plants.

2. Influence of food plants on mating strategies

Adults (24 hrs. old) emerge from final nymphal stage were paired and housed in separate glass jars. Five pairs were treated separately on each of food plants. Every jar was marked with separate No. all maintained under room temperature where temperature ranged between (32±2 and 39±2 ^{0}C) and relative humidity was (25±5 and 55±5%). Fresh cut and washed leaves of each food plants were provided to mating pairs between 24hrs interval. Careful observation was made to note the age of maturation, pre-copulatory period, and maturation duration. Total No. of mating and longevity of both sexes on each treated food plant was noted.

Statistical Analysis

Experimental data was subjected to one way analysis of variance (ANOVA) (SPSS-16.0 software) with repeated measure and average was determined by least significant test (LSD).

Results

Life history statistics of *A. thalassinus thalassinus*

1. Development of various stages on different food plants

During the present study it was found that *A. thalassinus thalassinus* pass through 6th nymphal stages and 7th stage being adult in both sexes on all treated food plants. It was noted that stage (I-III) nymphs fed on *S. bicolor* lead to faster development as compare to nymphs fed on *M. sativa*, which was not significantly different from those reared on *Z. mays* and *C. dactylon*. The 4th nymphal stage took slightly longer period as compare to 5th and 6th nymphal stages in all housed food plants. Significantly longer time of development was taken by *M. sativa* male instars i-e (9.6±0.29) and female instars i-e (8.64± 0.36) days, while shorter developmental period was observed on *S. bicolor* male and female instars i-e (6.76±0.41) and (5.76±0.36) days. The rate of development for 5th and 6th nymphal stages were significantly faster on *S. bicolor* and slower on *M. sativa*. However, in all four provided food plants female nymphal instars were grown faster than male nymphal instars. It was concluded that, total nymphal period was significantly faster in term of development on *S. bicolor* in both sexes of nymphal instars i-e (28.8 ±1.75 days) for male and (26.26 ± 0.57days) for female. The prolong and slow rate of development was observed when nymphs were fed on *M. sativa* i-e (39.64± 1.75 and 36.00± 0.99) in both male and female instars respectively (Table 1).

Table 1. Effects of various food plants on different developmental stages of *A. thalassinus thalassinus*

Instar	Sex	Food Plants Days (Mean ± SD)				
		M. sativa	***S. bicolor***	***Z. mays***	***C. dactylon***	**F. (0.05)**
1st	----	2.62± 0.35^c	1.86 ± 0.27^a	1.78 ± 0.19^a	2.4 ± 0.29^b	(2.16) 04.36^{ns}
2nd	♂	4.18 ± 0.60^c	3.06 ± 0.26^a	3.36 ± 0.49^b	4.28 ± 0.29^c	(3.72) 07.85^{ns}
	♀	3.68± 0.50^c	2.84 ± 0.27^a	3.12 ± 0.34^b	3.56 ± 0.36^c	(3.30) 06.11^{ns}
3rd	♂	6.9 ± 0.43^c	4.24 ± 0.73^a	5.48 ± 0.39^b	6.8 ± 0.31^c	(5.85) 11.34*
	♀	6.16 ± 0.32^d	3.86 ± 0.58^a	4.26 ± 0.27^b	5.86 ± 0.35^c	(5.03) 09.60^{ns}
4th	♂	9.6 ± 0.29^d	6.76 ± 0.41^a	7.94 ± 0.33^b	8.38 ± 0.46^c	(8.17) 14.84^{ns}
	♀	8.64 ± 0.36^d	5.76 ± 0.36^a	6.96 ± 0.32^b	7.7 ± 0.33^c	(7.26) 13.09^{ns}
5th	♂	8.14 ± 0.26^c	6.08 ± 0.39^a	7.1 ± 0.5^b	7.16 ± 0.27^b	(7.12) 13.09^{ns}
	♀	7.5 ± 0.38^c	5.76 ± 0.23^a	6.82 ± 0.30^b	6.72 ± 0.25^b	(6.70) 13.09^{ns}
6th	♂	8.2 ± 0.46^d	6.8 ± 0.29^a	7.28 ± 0.34^b	7.88 ± 0.27^c	(7.54) 13.09^{ns}
	♀	7.36 ± 0.48^c	6.18 ± 0.43^a	7. 00 ± 0.29^b	7.64 ± 0.51^d	(7.04) 13.09^{ns}
Total Duration	♂	39.64 ±1.75^d	28.8 ±1.57^a	32.9 ± 1.56^b	37.1 ± 0.96^c	(34.01) 61.96*
	♀	36.00 ± 0.99^d	26.26± 0.57^a	29.72 ± 0.89^b	33.84 ± 1.00^c	(31.45) 54.98*

Note: Mean in the same row followed by the same letters are not significantly different from one another at 5% level of probability *=$p\leq0.05$ NS=not significant $p\geq0.05$

2. Mating strategies of copulatory pairs on different food plants

Maturation period was noted faster in both sexes when feed on *S. bicolor* than *M. Sativa,* followed by *Z. mays* and *C. dactylon*. Maximum pre-copulatory period was noted on *C. dactylon* with (6.98± 1.13 days) while minimum period was noted on *S. bicolor* with (3.86± 0.56 days). The duration of copulation was significantly prolonged on *S. bicolor* (52.28± 1.17) than *C. dactylon* (43.48± 2.34). The interval between each mating remain maximum when feed on *S. bicolor* and

minimum when feed on *Z. mays*. There was significantly higher number of mating were recorded when reared on *M. Sativa* and lower number of mating on *C. dactylon*. The adult survival period was significantly higher in female insects as compare to male. Whereas, survival was significantly higher on *S. bicolor* in both sexes (10.14± 1.12 ♂ and 13.0± 0.99♀) days and lower on *M. sativa* (7.2± 0.49♂ and 9.90± 1.09♀) days (Table 2).

Table 2. Mating strategies of *Aiolopus thalassinus thalassinus* on different food plants under laboratory conditions

Food Plants	Duration of maturation (Days) (Mean ± SD)		Duration of Pre-copulatory period (Days) (Mean ± SD)	Duration of copulation (Hrs) (Mean ± SD)	Interval between each mating (Hrs) (Mean ± SD)	Total No. of Mating	Longevity (Mean ± SD)	
	♂	♀					♂	♀
M. sativa	8.2 ± 0.46^{d}	7.36 ± 0.48^{c}	6.42 ± 1.32^{c}	47.06 ± 1.07^{b}	3.50 ± 0.52^{b}	7.2 ± 0.83^{d}	7.2±0.49^{a}	9.9±1.09^{a}
S. bicolor	6.8 ± 0.29^{a}	6.18 ± 0.43^{a}	3.86 ± 0.56^{a}	52.28 ± 1.17^{d}	3.97 ± 0.35^{c}	6.6 ± 0.54^{c}	10.04± 1.12^{d}	13.9±0.99^{d}
Z. mays	7.28 ± 0.34^{b}	7.00 ± 0.29^{b}	4.58 ± 0.74^{b}	49.24 ± 1.11^{c}	2.92 ± 0.31^{a}	5.4 ± 0.54^{a}	9.22±0.64^{c}	11.38±0.92^{b}
C. dactylon	7.88 ± 0.27^{c}	7.64 ± 0.51^{d}	6.98 ± 1.13^{d}	43.48 ± 2.34^{a}	2.93 ± 0.43^{a}	5.8 ± 0.83^{b}	8.7±0.07^{b}	12.44±1.05^{c}
F. (0.05)	(7.54) 13.09^{ns}	(7.04) 13.09^{ns}	(5.46) 09.60^{ns}	(48.01) 84.65*	(3.33) 06.11^{ns}	(6.25) 11.25^{ns}	(8.79) 16.58*	(11.90) 21.82*

Note: Mean in the same column followed by the same letters are not significantly different from one another at 5% level of probability *=$p\leq$0.05 ns=not significant $p\geq$0.05

Discussion

Influence of food plants can be measured through the fastest rate of development, survival and fitness of instars to transfer in to adult stage. Successful mating and longest survival of species and fecundity are also significantly affected by proper food enrich in nutrients. Roff [27], stated that nutritional quality of food plants offered influence on the survival, rate of larval development, adult emergence and longevity of insects. Significant fastest rate of hopper's development was noted on one food plant than other quite different because of nutritional composition support faster development and softness of foliage preferred by early instars. During the present study, nymphal duration of *A. thalassinus thalassinus* up to emergence of adults were shortest when reared on *S. bicolor* followed by *Z. mays, C. dactylon* and *M. sativa*. The mating strategies were also significantly influenced when reared on different food plants. Previously Chesler [4], noted five stages in both sexes of *A. thalassinus* and stated that it complete development in 64 days but he failed to give host plant association. Whereas, Popov [18], recorded five instar in male while female having six. During the present study we have observed 6th nymphal instar in both sexes on all provided food plants and strongly disagreed the earlier finding of [3, 4, 18]. At present we have recorded fastest development on *S. bicolor* beside this it was prolonged on *M. sativa* and it was average on *Z. mays* and *C. dactylon*. It was also confirmed that male instars taken slightly longer duration to complete developmental period than female instars. The present data strongly correlated with the earlier finding of Riffat and Wagan [22], they also obtained flucated results for the development *Hieroglyphus perpolita* on different host plant. Present study might be viable guideline to initiate control measures for pest species at appropriate time.

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