

## Relationship of Web Characteristics and Body Measures of *Leucauge decorata* (Araneae: Tetragnathidae)

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**Abstract.**- Present study was conducted to investigate the relationships between web characteristics and body measures of *Leucauge decorata* (Araneae: Tetragnathidae). For this purpose a rice field ( $800 \text{ m}^2$ ) in village Kirka located in Lahore district was selected. The data of spider's webs and prey was collected in September 2007 and 2008. Most of the *L. decorata* constructed inclined webs at the height that ranged from 40 cm to 123 cm above ground. Spiders recorded from the higher webs (81-120 cm) were larger and heavier than the spiders recorded from the lower webs (40-80 cm). Time required to complete a web was  $1.00 \pm 0.21$  hour. The average diameter of the web was  $25 \pm 6.8$  cm. Principal component analysis (PCA) did not separate the collected spiders on the basis of capture area (web character) and carapace width (body measure). Most of the prey items recorded from the webs belonged to Diptera, Homoptera and Lepidoptera. Prey types and their number collected from the webs of different heights varied significantly. Capture area of *L. decorata* web showed a positive correlation with carapace width and body weight. Web characteristics (i.e., number of radii, number of spirals and mesh height) were not correlated with any of the body measures (i.e., carapace width, total length and wet weight). For prey capture *L. decorata* construct webs of different sizes and at different heights but always maintain the basic web architecture (i.e., number of radii, number of spirals and mesh height).

**Key words:** Web characteristics, body measures, orb web spider.

### INTRODUCTION

Orb-weaving spiders are highly diverse, abundant in the fields and important regulator of pest populations in agro-ecosystems (Levi, 1981; Nyffeler and Benz, 1989; Aiken and Coyle, 2000). To optimize behavioural efficiency and to reduce energetic cost and time, a predator has to make several choices in the fields (Alcock, 1993). These choices are: where to construct a web, where to eat, how much time to dedicate to eating and what types of prey to select for capture and consumption (Henaut *et al.*, 2006).

Orb-web spiders do not usually compete for food or space (Wise, 1993), as different species use different predatory strategies (Henaut *et al.*, 2006). One such strategy that reduces competition is construction of webs, which differ in size, location and general architecture (Rypstra, 1982; Eberhard, 1986; 1990; Sherman, 1994). Webs of spiders act as a filter and trap a large diversity of insects (Henaut *et al.*, 2006). But variation in the design of the webs influence directly the length, kind and number of

prey entangled (Miyashita and Shinkai, 1995).

*Leucauge decorata* (Blackwell, 1864) is a common orb-web spider in agro-ecosystems of Punjab, Pakistan (Tahir and Butt, 2008). In order to understand the ecological role of this species in agro-ecosystems it is necessary to have complete information about the habitat preferences, web construction behaviour, high activity period, food preferences and reproductive biology. Present study is aimed to record the web characteristics and type of prey caught in webs of *L. decorata*, relationship of prey and predator size and also the relationship (if any) between different body measures (i.e., total length, carapace width and wet weight) of *L. decorata* to its various web characteristics (i.e., mesh height, number of spirals, number of radii, capture area). This study will help to evaluate the role *L. decorata* as biological control agent for pests in agro-ecosystems.

### MATERIALS AND METHODS

#### Study site

The study site was a basmati rice field ( $800 \text{ m}^2$ ) in village Kirka located in district Lahore (latitude  $31^{\circ}33'N$ , longitude  $74^{\circ}32'E$ ) about 35 km east from University of the Punjab, Lahore. The

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experiment was performed in September 2007 and 2008. At the time of the experiment the average height of the plants in the fields was  $133 \pm 13$  cm ( $n=50$ ). During the study the daily temperature ranged from  $27 \pm 4$  °C (at night) to  $37 \pm 4$  °C (during the day). The relative humidity was highly variable (68-88%) due to rainy season.

#### *Characteristics of the web*

Web characteristics were measured directly in the field after removing corresponding spider from the web ( $n = 115$ ; 65 in 2007 and 50 in 2008)). For this purpose study was conducted early in the morning (0600-0730) when the webs were clean and undamaged. Only the webs of adult specimens were used for the study. Before recording the web data, each web was sprayed with a fine mist of water and cornstarch using Knapsack hand sprayer (THS-119428) to improve the resolution. Web characteristics recorded were: web diameter, web height from the ground surface, capture area, mesh size, number of radii and number of spirals. Time required to complete a web was also noted ( $n = 25$  each year).

#### *Spider characteristics*

The occupant of each web was collected in a glass tube (5 cm long and 2 cm wide, mouth covered by mesh cloth) and brought to the laboratory for the measurement of body length (in mm), carapace width (in mm) and wet weight (in mg).

#### *Prey characteristics*

Prey items present in the webs of spiders were also collected and identified to the level of order only. For prey collection webs of spiders located at two different heights (*i.e.*, 40-80 cm and 81-120 cm) from ground were selected. Body size (length from head to the tip of the abdomen) of each insect was also recorded to determine the correlation (if any) between the predator size and prey length.

#### *Statistical analysis*

Kolmogorov-Smirnov test was used to check the normality of the data before statistical analyses. As there was no significant difference in data collected during two years so it was pooled together

for statistical analyses. Size of insects trapped in the webs at each height (*i.e.*, 40-80 and 81-120) was compared using Mann-Whitney U test, whereas the number of insects of each order trapped at each height was compared using Chi-square test. Principal component analysis (PCA) was performed to investigate whether studied spiders could be separated into different groups on the basis of capture area (web character) and body measure (carapace width). Capture area and carapace width was used for the PCA as significant difference was observed both in the capture area and carapace width among studied species (Table 1) and these parameter has been used for PCA in previous studies (Prenter *et al.*, 2008). To determine the relationships between body measures (carapace width and total body length and body weight) and web characteristics (capture area, mesh size, number of radii and number of spiral) of spiders Pearson's correlation was used. Relationship between the predator size and prey length was also subjected to the regression analysis. All statistical analyses were performed using Minitab 13.3.

## RESULTS

Most of the specimens of *L. decorata* (93%) constructed inclined webs at the height that ranged from 40 cm to 123 cm from ground. Out of 115 studied spiders, 76% constructed webs above 80 cm height while remaining 24 % below this height. Spiders recorded from the upper webs (81-120 cm) were significantly larger ( $D.F = 1, 48; F = 3.44; P < 0.005$ ) and heavier ( $D.F = 1, 48; F = 3.33; P < 0.005$ ) than the spiders recorded from the lower webs (40-80 cm). Time required to complete a web was  $1.00 \pm 0.21$  hour. The average diameter of the web was  $25 \pm 6.8$  cm. Although the mesh height of upper webs was higher than lower webs but the difference was non significant ( $D.F = 1, 48; F = 3.17; P > 0.05$ ). After constructing a web *L. decorata* were found waiting their prey at the centre of the web (hub). Different web characteristics and body measures recorded during the present study are given in the Table I. Results of Pearson's correlation showed that web characteristics of *L. decorata* were related differently to the various body measures. Web capture area of *L. decorata* increased

significantly with carapace width ( $r = 0.54$ ;  $P < 0.01$ ) and body weight ( $r = 0.49$ ;  $P < 0.01$ ) but body length of *L. decorata* was not related to the capture area ( $P > 0.05$ ). Similarly the number of radii, number of spirals and mesh height were not correlated with any of the body measures ( $P > 0.05$  for each case). Principal component analysis (PCA) indicated that collected spiders could not be separated clearly on the basis web carapace width and capture area (Fig. 1).

**Table I.- Web characteristics and body measures (means  $\pm$  SE) of *Leucauge decorata*.**

	<b>Measurements</b>		<b>P-value</b>
	<b>40-80 cm</b>	<b>80-120 cm</b>	
<b>Web characteristics</b>			
Web diameter (cm)	17 $\pm$ 4.8	25 $\pm$ 6.8	*
Capture area (mm <sup>2</sup> )	6487 $\pm$ 912	8521 $\pm$ 789	*
Number of radii	17 $\pm$ 4	17 $\pm$ 4	ns
Number of spirals	21 $\pm$ 2	21 $\pm$ 3	ns
Mesh height (mm)	1.6 $\pm$ 0.9	1.9 $\pm$ 0.4	ns
<b>Body measures</b>			
Carapace width (mm)	1.7 $\pm$ 0.34	2 $\pm$ 0.63	*
Body length (mm)	7.12 $\pm$ 1.2	7.42 $\pm$ 1.6	ns
Wet weight (mg)	25 $\pm$ 6.4	32 $\pm$ 9.4	*

**Table II.- Prey items caught by *Leucauge decorata* at two different heights.**

<b>Prey orders</b>	<b>% prey at different heights</b>	
	<b>40-80 cm</b>	<b>81-120 cm</b>
Diptera	33	41
Homoptera	24	17
Lepidoptera	11	19
Coleoptera	5	2
Orthoptera	9	7
Hymenoptera	4	5
Araneae	2	1
Unidentified prey	12	8

A total of 727 prey items of different insect orders were recorded from 115 webs. The main prey orders caught by *L. decorata* in the webs at different heights are given in the Table II. Most of the prey items recorded from the webs belonged to three orders *i.e.*, Diptera, Homoptera and Lepidoptera. Number of prey items collected from upper webs were different from those collected from lower webs

(Mann-Whitney Test,  $U = 36$ ;  $P = 0.04$ ). Significant difference was also observed when number of insects of different prey orders was compared at two different heights ( $X^2 = 14.34$ ;  $d.f. = 1$ ;  $P < 0.001$ ). There was a significant positive correlation between carapace width of *L. decorata* and prey lengths taken by this species ( $r = 0.97$ ;  $P < 0.001$ ).

## DISCUSSION

In the present study it was observed that most of the adult *L. decorata* constructed inclined webs at different heights in the rice fields. Inclined webs and variations in the web heights in different species of *Leucauge* have been reported in other studies as well (Eberhard, 1988; Henaut *et al.*, 2006). Spiders in the high webs were larger and heavier than spiders in lower webs in the present study (Table I). The result is in accordance with the findings of Ibarra-Nu'n~ez *et al.* (2001) and Henaut *et al.* (2006). The difference in the web site selection among spiders might be for reducing intraspecific competition. Most of the observed spiders (76%) constructed webs above 80 cm. Larger and heavier orb web spiders seek the larger prey that can be caught at higher sites in and between plant canopies. Similarly a more open web structure with a larger capture area may be an adaptation to target the capture of larger prey (Uetz *et al.*, 1978). High and large webs help to capture more insects especially larger size flying insects (Kajak, 1965; Nentwig, 1982, 1985). More insects were observed in the webs at 81-120 cm height as compared to 40-80 cm height. This result is contradictory to the findings of Henaut *et al.* (2006) who reported more insects at 60 cm height as compared to 160 cm height above ground in a similar study.

In the present study most of the prey recorded from the webs belonged to Diptera, Homoptera and Lepidoptera. Hymenoptera, which was reported as dominant prey in the webs of *Leucauge* species in earlier studies (Chaco'n and Eberhard, 1980; Ibarra-Nu'n~ez *et al.*, 2001) was not recorded as a major prey item in the webs of *L. decorata* in the present study. Hymenoptera with good vision and maneuverability in flight may detect and evade the webs resulting in an under-representation of this prey orders in spider webs (Land, 1997).

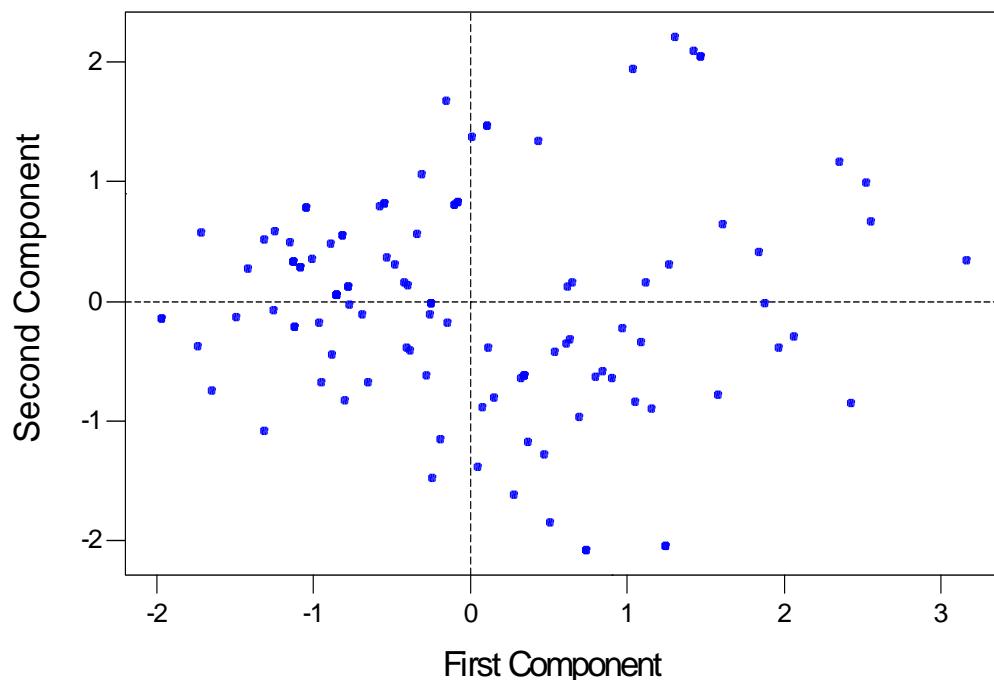


Fig. 1. Result of principal component analysis. Please note that first component represents carapace width, while the second component represents the capture area.

Results of Principal component analysis (PCA) showed that studied spiders could not be separated on the basis of carapace width and capture area. In the present study capture area increased significantly with carapace width. Similar results were reported by Heiling *et al.* (1998). A larger capture area results in high prey interception (Chacon and Eberhard, 1980). Mesh height did not relate to any of body measures in the study contrasting the results of Eberhard, 1988 and Heberstein *et al.* (2000). Some other studies also failed to find consistence relationship between mesh height and prey size (Heberstein and Heiling, 1998). It is concluded that for prey capture *L. decorata* construct webs of different sizes and at different heights but always maintain the basic web architecture (*i.e.*, number of radii, number of spirals and mesh height).

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