The Behavioural Strategy of Orb Weaving Spider *Zygiella Indica* Tikader & Bal, 1980 (Araneae: Araneidae).

M. P. Chikhale[1], Santape G. B.[2]

[1,2]Rajarshee Shahu Science College Chandur Railway,
Dist. Amravati Maharashtra, India (444904)

Abstract: ***Web building spiders are excellent models for the behavioral study in an ecosystem. Webs of spiders are the proverbial symbols of this group of animals; however the variation of webs is enormous. The aim of the present study was focus on orb web biology of a poorly known araneoid spider Zygiella indica Tikader & Bal, 1980 (Araneae: Araneidae). The study was carried out during 2013 and 2014 in the coffee plantation at Chikhaldara in the state of Maharashtra, India. We calculated mesh width, web area, web asymmetry and web height as well as radial and spiral counts. In our study, Zygiella indica settle on hub, repaired and constructed hub in 28.91 ± 1.26 sec .and construction of web was completed in 41.58 ± 0.41 min. We recorded the height of constructed webs at that ranged from 130 cm to 142 cm from ground. We collected 56 preys of insect orders from 24 webs in study time. Prey recorded from webs on order Diptera > Homoptera > Coleoptera > Hymenoptera. We estimated the average mesh width was 2.34 ± 0.03 mm. Average web asymmetry of measured 24 web was recorded as 0.34 ± 0.009 in the present investigation. In our study we calculated the average area of the web was as 339.43 ±9.3 cm². We conclude that Zygiella indica always maintain the basic web architecture during prey capture and it reflects many selection pressure in the environment.***

Keywords: Zygiella indica, Web architecture, Coffee plantation, Chikhaldara, Prey capture.

1. Introduction

Web building spiders are excellent models for the behavioral study in an ecosystem. They strongly affect the density of insect population. Webs of spiders are the proverbial symbols of this group of animals, however the variation of webs is enormous and although it would be an exaggeration to claim that webs are typically studied as tools used by spiders for foraging, the webs spun by most spiders are better considered to be structural modifications of the spiders immediate environment that influence a variety of traits. In addition to prey acquisition, such as defense against predators [1], [4].

The Orb-weaving spiders have a variety of behavioural strategies to alter web architectures in response to variation in the environment [8], [14], [11]. Individual orb-weaving spiders can increase or decrease the sizes of webs [30], [33], [19]. The web building behavior of orb-weaver spiders shows three distinct phases: construction of the frame and radii, weaving of an auxiliary spiral and weaving of the sticky or capture spiral [9]. Variation in the design of the webs directly influence the length, kind and number of prey entangled [21]. Presence of potential prey affects web building in an orb-weaving spider *Zygiella x-notata* [25], behavioural analysis of web building anomalies in the orb-weaving spider *Zygiella x-notata* [32]. We focus on orb web biology of a poorly known araneoid spider *Zygiella indica* Tikader & Bal, 1980, which possess diagnostic a characteristic i.e. spiral-free a sector in the upper part of the orb web [18].

Zygiella indica is a common orb-web spider in the coffee growing area of Chikhaldara in the state of Maharashtra, India. The present study was carried out to understand the ecological role of this species in the coffee growing area, which will be helpful the web construction behavior of this species. The architecture of spider webs reflects many selection pressures in the environment.

2. Materials and Methods

Study Area

Chikhaldara claims the distinction of being the coffee growing area in the state of Maharashtra, India. Chikhaldara is situated in the hills of Satpura ranges in Amravati district and is situated at an altitude of 1118m.(21^0 – 21' N &77^0 - 22'E).The present study was carried out during 2013 and 2014 in the coffee plantation at Chikhaldara . During the study the daily temperature ranged from 18 ± 4 °C (at night) to 27±4°C (during the day).

Characteristics of the web

We measured web characteristics of *Zygiella indica* Tikader & Bal, 1980 directly in the field (n = 24; 11 in 2013 and 13 in 2014)). For this purpose study was conducted in the evening (1700 hours to 1900 hours). Only the webs of adult specimens were used for the study. Before recording the web data, each web was sprayed with cornstarch using sprayer to improve the resolution for measurement and measured them with a tape measure (Fig.1).

We identified following web characters from araneoid web literature [2], [16], [17], [10]. Primary radii, number of vertical sticky spirals, number of horizontal sticky spirals, non-circulating sticky spirals below hub, non-circulating sticky spirals above hub, web width (in cm), web height (in cm) from the collected spiders were measured. Measurement of body length in mm (n = 8). and web characteristics recorded in the field. Time requirement for completion the web was noted (n = 8).The height from the ground level of web is measured from ground level to first vertical number of non-circulating sticky spirals below hub. The preys collected from the webs of spiders and identified up to order level.

We calculated the following parameters:

i) Mesh width, defined as the number of SS per centimeter of web-height [10].
ii) Web area cm^2 are calculated by Blackledge & Gillespie (2002) method:

$$\text{Web area cm2} = \left(\frac{\text{web width}}{2}\right) \times \left(\frac{\text{web height}}{2}\right) \times \pi$$

iii) Web asymmetry is calculated according Blackledge and Gillespie (2002), Zschokke (1993) and Kuntner et al. (2008 b).

$$\text{Web asymmetry} = 1 - \left(\frac{\text{web width}}{\text{Web height}}\right)$$

iv) Web width is the horizontal distance between outermost spirals [10].
v) Web height is the vertical distance between outermost spirals [10].

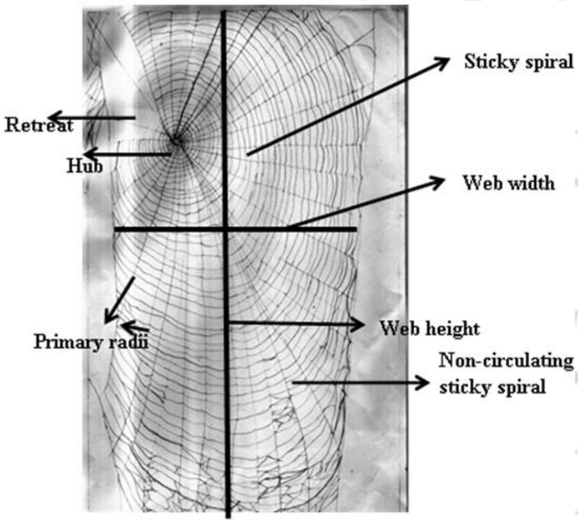

Fig .1 Web of *Zygiella indica* Tikader & Bal, 1980

3. Results and Discussion

Orb web spiders are often considered generalist predators that consume all insects entering their webs [9].We documented webs of several *Zygiella indica* in the coffee growing area. We monitored web between 1700 hours to 1900 hours during field visit it is also observed that, *Zygiella indica* was not on web and web was in disturbed condition. *Zygiella indica* first came on hub position and start to remove all dead prey debris and damaged web silk threads. In our observation, *Zygiella indica* first cleaned unwanted threads and started to repair damage web, first up all old radii and then spirals repaired. In our study, radii of vertical top frame constructed first then radii of vertical bottom frame constructed followed by path clocked-wise direction After construction of radii, followed by construction of spiral, non-circulating sticky spirals below hub and then non-circulating sticky spirals above hub. After construction of non-circulating sticky spirals, *Zygiella indica* started construction of vertical sticky spirals and horizontal sticky spirals in is anticlocked-wise direction. Microhabitat and/or prey size and weight might influence the radial and spiral numbers [29].

Spider; it needs energy and time, but the spider has a reward (quantity and quality of prey caught) [26]. In our study, *Zygiella indica* settle on hub, repaired and construct the hub in 28.91 ± 1.26 sec .and also Total repaired and construction of web was completed in 41.58 ± 0.41 min. by *Zygiella indica*. Pasquet *et al*., 1994 studied. Presence of potential prey affects web building in an orb-weaving spider *Zygiella x-notata* and observed that the time taken for a web building by *Zygiella* was less than one hour. Most of the constructed height of webs were ranged from 130 cm to 142 cm were recorded from ground level.

Table 1: Web parameters in the field (means ± SE) of *Zygiella indica* Tikader & Bal, 1980.

Web parameters	Measurements
Primary radii	20 ± 1
Vertical number of sticky spirals	*65* ± 3
Horizontal number of sticky spirals	38 ± 1
Non-circulating sticky spirals below hub	20 ± 1
Non-circulating sticky spirals above hub	6 ±1
Web width (cm)	18.20 ± 0.31
Web height (cm)	27.75 ± 0.28
Spider size	5.91 ± 0.16

Table 2: Derived web parameters from the field (means ± SE) of *Zygiella indica* Tikader & Bal, 1980.

Derived web parameters	*Results*
Mesh width in mm	2.34 ± 0.03
Web area cm^2	*339.43* ±9.32
Web asymmetry	0.34 ± 0.009

Table 3: Prey captured by *Zygiella indica* Tikader & Bal, 1980

Taxon	Numbers
Diptera	14
Coleoptera	7
Homoptera	12
Hymenoptera	5
Araneae	2
Unidentified	16

According to our observations, webs were usually vertical with open hubs. The hubs were slightly displaced toward the top frame. In araneids and nephilids hubs are often displaced towards the top vertical orb webs frame [20], [16], [17]. Some webs showed noticeable sign of damage and repair. We observed the females typically rested in their webs on hub, during night. During day *Zygiella indica* rested inside their retreats away from the web and connects to the hub via a distinct signal line. The presence of the off-web retreat is probably homologous in these genera [10].

We observed that web is distrubed they run to the retreat area or the jump off the web. Gregoric et.al.2010, study the web architectures of *Leviellus thorelli*, *Parazygiella montana*, *Stroemiellus stroemi,Zygiella keyserlingi and Zygiella x-notata* and investigated like *Argiope*, *Azilia*, *Nephilengys*, *Nephila* and *Clitaetra* they do not shake their body on the web when threatened but rather run to the retreat or jump off the web. For the jumping and flying insects web is an effective trap. Orb-webs design will influence prey capture success [22]. We collected 56 different type insects belonging to different orders from 24 webs during study period (Table3). Prey recorded from webs on order Diptera > Homoptera > Coleoptera > Hymenoptera (fig. 2). In the field study we recorded a small size moth was trap in her web she bit and wrapped it immediately. Eberhard 1982 also observed that orb-weaving spiders attack prey by biting first and then wrapping and concluded that attack-wrapping was an evolutionarily advanced behavior [6].

We estimated the average mesh width was 2.34 ± 0.03 mm (Table 2). Mesh width is believed to greatly influence prey retention and thus the sizes of prey targeted by webs, although these relationships are difficult to estimate [3]. Sandoval (1994) studies the significant relationship between prey lengths and mesh height in the spider *Parawixia bistriata and* reported that small webs with low mesh height which mostly trapped small dipterans, or large webs with greater mesh height to capture large flying termites.

Average web asymmetry of measured 24 web was recorded as 0.34 ± 0.009 (Table 2) in the present investigation. The values of the hub asymmetry index are close to zero in symmetric webs, slightly above zero in upwardly eccentric webs, or below zero in the less common, downward eccentric shaped web (e.g. Cyclosa or Deliochus in Kuntner et al., 2008; Nakata, 2010). Similar indexes were termed hub displacement [17].

In our study we calculated the average area of the web was as 339.43 ±9.3cm^2.Herberstein & Elgar 1994 observed the effect of web design on prey capture rates and conclude that in diurnal orb-weaving spiders *Eriophora transmarine* and *Nephila plumipes* , increasing the web area will reflect in a higher prey interception, hence, higher prey capture rate. Pavol and Gryglákovå1, 2005 recorded factors affecting the foraging success of the wasp-like spider *Argiope bruennichi* in role of web design and record the web area of spiders increased the proportion of stabilimentum area decreased and number of prey caught increased.

4. Conclusion

The present study was conducted in the coffee growing area at Chikhaldara, Maharashtra, India. The web characteristics of *Zygiella indica* is an effective trap device for prey capture and hence it will be needed to focus on more study on the web construction behavior of *Zygiella indica* which will helpful for the study of evolution of the orb web and determination of the spider diversification in future.

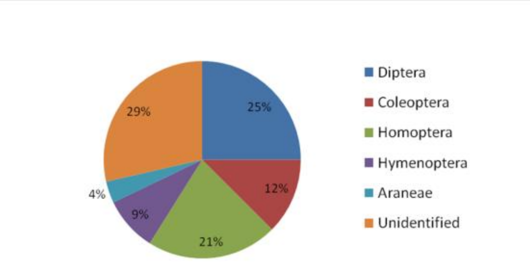

Fig2:Prey captured by *Zygiella indica* Tikader & Bal, 1980

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