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Web structure and efficiency of prey capture in *Neoscona vigilans* (Blackwall, 1865) (Araneae: Araneidae)

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Abstract
Spiders are well known for their web architecture and potential as bio-control agents. A web building spider relies on its web to capture prey for its sustenance. In this paper we described the web structure of *Neoscona vigilans* and its efficiency of prey capture. Observations were made on different web variables namely, spider orientation, web symmetry, spider size, web morphometry, mesh width and size of prey captured in the web. Significant correlations were obtained for different body sizes of spiders and web diameter, spider size and height of web for this species. Whereas there was strong negative correlation between mesh width and size of prey captured in the web. We conclude from these co-relative studies that for efficient prey capture *N. vigilans* construct webs at different heights and of different sizes but always maintain the basic web structure, where the role of mesh width depends on the biology of prey.

Keywords: Araneidae, mesh size, *Neoscona vigilans*, prey, spider, web diameter.

1. Introduction

Spiders constitute one of the most important components of the generalist predator fauna, very well known for keeping check on outbreaks of insect populations [9, 11, 13, 15]. Of which spiders belonging to family Araneidae are exclusively orb-weavers. They are sit-and-wait predators as soon as any vibrations in the web are felt they rush near the insect and knock down its movements by throwing strands of silk. The basic orb-web structure consist of radial threads, frame threads and sticky spirals, out of which radial threads & frame threads are supporting threads in web stability whereas sticky spirals helps in capturing prey [8].

The art of building geometrically complex webs by spiders is their inborn instinct which varies amongst species and amongst the individuals of same species. But the crucial orb-web characteristics related to a particular species is well maintained [23]. Construction of web involves lot much of energy and time, once the web is completed it cannot be modified easily, so for better foraging success each spider has to make a wise decision prior to construction of web [14]. Other than prey availability there are factors like web support, wind direction, temperature, humidity and silk supply which influence the pattern and site selection for web construction [21]. But along with these factors one of the most important factor observed was their previous prey capture experiences which compels them to construct asymmetrical webs instead of symmetrical ones; alteration in size of web and time of web construction [1, 10].

Efficiency of prey capture is directly related to individuality of web and also on the vibrations created by struggling prey in helping spiders to locate its prey efficiently [17, 20]. Therefore web design plays an important role as it acts as trap for its prey. However, majority of studies on spiders were restricted to spider identification, species richness, its distribution, seasonal variations in spider diversity, tolerance or effect of insecticide and their efficiency as bio-control agents. But there were very few studies related to species specific web patterns description along with its efficiency of prey capture adding on to its ecological role and importance.

Thus looking into the importance of web for the survival of spiders, the present study was designed to know the web structure and efficiency of web constructed by *Neoscona vigilans* (Blackwall, 1865) in capturing prey. *N. vigilans* is a common species found in Gujarat, but information on ecological importance of this particular species is lacking. Thus the information on species specific web geometry and its effectiveness in the number of prey capture is beneficial in fulfilling the ecological void for this particular species. In addition to this it will also help in taxonomic diagnosis at species level, adding on to its natural history

Information and emphasizing its economic importance in keeping check on insect populations.

2. Materials and Methods

Neoscona vigilans is a common spider in Gujarat (personal observations). This spider starts constructing their webs during dusk and consumes them in the following morning. They are basically nocturnal and relay on prey entangled in their web during night hours. In order to observe their web pattern and its efficiency, study was conducted in the Bhat village of Jambughoda wildlife sanctuary which is located between latitudes 22º20'-20º33' N and longitudes 73º35'-73º45' E in the Panchmahal and Vadodara districts of Gujarat State, India. It consists of Southern Tropical Dry Deciduous forest type [6] with large patches of *Tectona grandis* and *Madhuca longifolia* trees interspersed with agricultural fields.

To investigate *N. vigilans* webs, continuous field observations were made for six months i.e. from July 2014 to December 2014 when these spiders were found to be abundant in study site. Once the spider web was spotted, observations were made on spider orientation (upward facing, sideways or downwards facing) and web symmetry (symmetrical or asymmetrical). Latter adult spiders and prey exuviae were collected by hand pick method from each web before taking the morphometry of web. For prey preference studies, the insects which were discarded by spider were not considered, only those insects were included which were fed by spiders during the observation time. All these collected spiders and prey exuviae were taken to the laboratory for further identification and body-length measurements, which were latter preserved in 70–80% ethanol (ethyl alcohol) and stored separately in clear Tarsons polypropylene (PP) sampling containers (50 ml). Identification up to species level for spider [18] and up to order level in case of prey [3, 5, 16] was done using standard monographs. Body-length (anterior tip of cephalothorax/Head to posterior tip of abdomen) measurements were taken using Mitutoyo™ Dial Caliper. Regarding web morphometry parameters, standard Stanley non-magnetic measuring tape was used; all measurements were taken in centimeters. For height of web, measurements were taken from the ground level to the centre of hub. Diameter of the webs were taken four times at 90 degrees to each other; for mesh size the mean distance between two consecutive sticky spirals were taken into consideration.

For comparing different observations Pearson's Correlation was used and the graphs were prepared using Microsoft Excel.

3. Results & Discussion

The web structure of *Neoscona vigilans* includes hub, with a large hole in the center (an "open hub") (Fig. 1); strengthening zone and free zone not very distinct. Number of sticky spirals varies from a range of 36 to 58; Number of radii ranges from 22 to 26 in number. Out of 15 webs observed, most of the individuals of *N. vigilans* (80%) were found to prefer upside down orientation (Fig. 2) while resting in the hub. All upside down oriented spiders preferred to construct symmetrical webs (Fig. 3) which allow them to attack entangled prey in very short duration. Nakata and Zschokke (2010) [12] also got similar observation when they studied the preference of upside down orientation in spiders of the genus *Cyclosa* and concluded that upside down facing spiders were able to knock down their prey significantly faster as compared to spiders facing upwards.

Only 20% of the spiders preferred asymmetrical web (Fig. 4) and they were found to change their orientations either upwards, sideways or upside down depending on the area of prey capture. The reason for such behavior was that, these spiders were comparatively smaller in size than the spiders oriented upside down and hence there capture area was smaller in size which reduces the number of prey captured. Therefore these spiders don't want to miss on to any of the prey entangled in their webs by orienting randomly. Also there are other additional factors like energy consumed in constructing larger web, which influence the spiders to construct asymmetric webs for better prey capture efficiency [7].

Fig 1: Web of *Neoscona vigilans* with spider being removed showing open hub

Fig 2: Web of *Neoscona vigilans* showing the orientation of spider upside down

Fig 3: Symmetrical web of *Neoscona vigilans*

Fig 4: Asymmetrical web of *Neoscona vigilans*

When the spider size was correlated with web diameter, we found a strong positive correlation (Fig. 5). This implies that as the spider size increases their requirement for prey also increases and hence they construct larger webs with large capture area, which in turn increases the chances of more prey getting entangled in their webs. Here it also implies that for constructing larger webs it needs more space in-between the branches of vegetation/trees where they usually constructs there webs.

To confirm the assumption we correlated the spider body size with height of web which was measured from the ground level to the centre point of hub. Here also we observed strong positive correlation (Fig. 6) which suggests that as the height increases they get larger area to construct their webs. This is due to the reason that the branches of the vegetation or trees don't have much complex branching at the mid-level of their heights which benefits these spiders for their web construction. It also implies that at higher heights the possibility of capturing large sized insects increases then webs at lower heights, and with increased web size, the daily number of prey trapped in the web increases resulting into long-term endurance of spider [19].

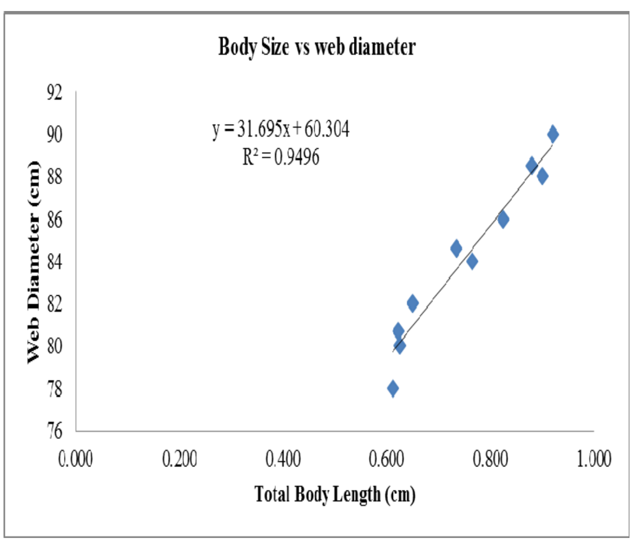

Fig 5: Body size of *Neoscona vigilans* versus its web diameter

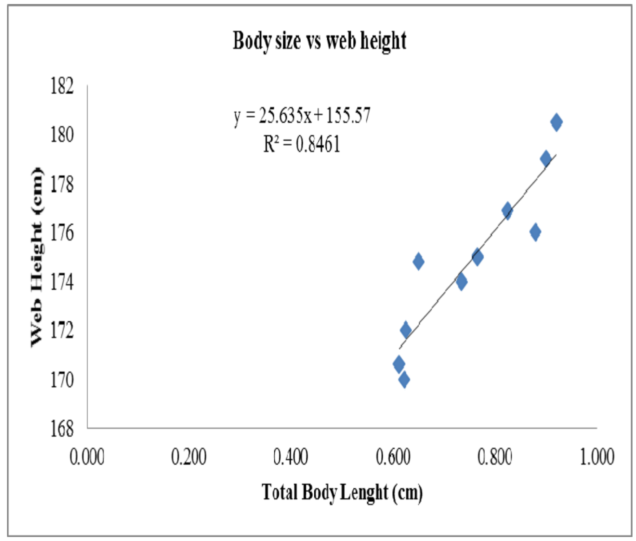

Fig 6: Body size of *Neoscona vigilans* versus its web height from ground level

To prove this assumption and to see the prey capture efficiency of web, a correlation study between the mesh width and prey size was done. We found a negative correlation (Fig. 7) which implies that the size of prey entangled in the web does not depend on the mesh width. Rather it depends on the sticky nature of the capture area which helps them to retain their prey for longer time so that they can approach and knock down the prey entangled in the web [2].

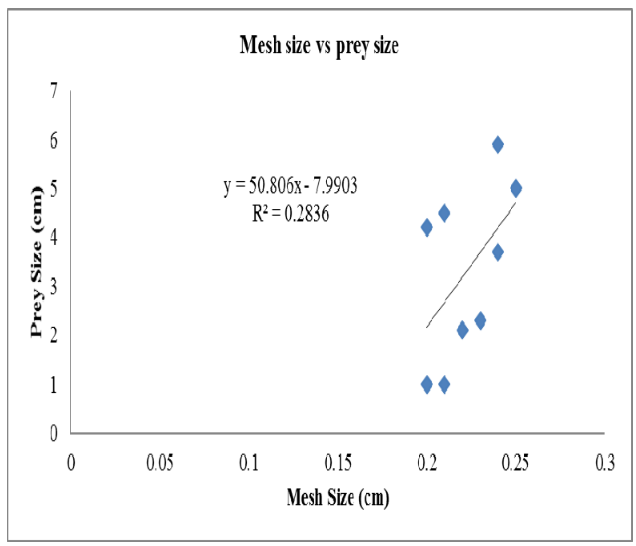

Fig 7: Mesh size in web of *Neoscona vigilans* versus prey size caught in web

N. vigilans is very common orb-weaver in gardens, agricultural fields and forest areas (personal observation). But its prey capture efficiency has not been observed previously. These are nocturnal spiders which construct their webs during dusk and consume them during dawn. *N. vigilans* web was found to be efficient in capturing insects ranging from Dipterans to Ephemeropteran, Neuropteran, Coleopteran, Hemipteran, Orthopteran, Lepidopteran and Odonates irrespective of the mesh size and web asymmetry. Despite the fact that the narrow mesh size is efficient in capturing even the small sized insects but this efficiency will not be considered if the availability of prey is abundant [22]. In case of orb-weavers their web structure defines their efficiency of prey capture and ultimately results into efficient bio-control agent.

From economic point of view, the spiders do not actually eat all the insects captured in the web but rather destroys them and helps in keeping check on insect populations [4]. Due to such economic reasons the studies on species specific web structure and its prey capture efficiency becomes important. Efficiency of the prey capture depends not only on web characteristics but also on the biology of insect to some extent. Hence, the present study supports that for prey capture *N. vigilans* construct webs at different heights and of different sizes but always maintain the basic web structure (i.e. number of radii, number of spirals, web symmetry, web orientation and mesh width).

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