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Colour change in the green lynx spider, *Peucetia viridans* (Araneae: Oxyopidae)

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Summary

Females of the green lynx spider, *Peucetia viridans* (Hentz), generally match their background when they are gravid. In the laboratory, *P. viridans* can change components of its colour to match green, purple, yellow and white backgrounds. This ability should offer a selective advantage against visual predators.

Introduction

Many examples are known of spiders resting on backgrounds that match their natural body colour. For example, a green species of *Miagrammopes* (Uloboridae) exhibits a preference for moss-covered twigs as a web-monitoring site (Opell, 1986), and females of *Miagrammopes animotus* Chickering match the colour of their egg sacs, presumably to offer protective resemblance from predators (Opell, 1989). Spiders of the genera *Misumena, Misumenoides* and *Misumenops* (Thomisidae) often blend with their backgrounds, which may provide protection from predators (Jennings, 1971). *Xysticus deichmanni* Sørensen (Thomisidae) blends with its background to gain predator protection and to remain inconspicuous to prey (Kevan, 1972).

As early as 1893, Bell reported colour change in a spider, but he gave no details nor the identity of the spider. *Floronia bucculenta* (Clerck) (Linyphiidae) changes its body colour to match the background (Bristowe, 1958) as does the araneid *Phonognatha wagneri* (Rainbow) (Kaston, 1965). The thomisid, *Misumena vatia* (Clerck) can change colour from white to yellow and back to white again to match its background; however, when placed on red flowers, it does not change colour to match the background (Packard, 1905; Hinton, 1976). In addition, immature *M. vatia* spiderlings cannot alter their colour (Gabritschevsky, 1927).

Peucetia viridans (Hentz) is a vivid green spider with varying degrees of white on the abdomen and red on the legs and body. Although earlier workers (Duncan, 1949; Brady, 1964; Hall & Madon, 1973) noted red markings on *P. viridans*, the overall colour is reported as bright translucent green.

In the field, we noted that gravid females of *P. viridans* on green foliage were varying shades of green, those on *Verbena brasiliensis* were reddish purple, those on golden rod (*Solidago altissima*) were greenish yellow, and those on *Eupatorium hyssopifolium* and Queen Anne's lace (*Daucus carota*) were pale green or whitish in colour. The purple, yellow, and white coloration was most pronounced on the dorsal abdominal chevrons, legs, and lateral abdomen. However, the purple colour often became pronounced over the entire body.

To test for an ability to match their background, we collected gravid female spiders, placed them on different colour backgrounds, and measured colour change.

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Materials and methods

On 31 August 1992, we collected 60 gravid females of *P. viridans* from green foliage. Spiders were housed individually in plastic containers (10.0 cm diameter × 6.5 cm high). Each container was supplied with moist cotton, and all spiders were fed three house flies (*Musca domestica*) three times per week.

On 1 September 1992, four judges ranked the hue, value, and chroma of each spider overall and of the lateral abdomen of each spider and of the backgrounds. Judges used the Munsell Book of Color (Anonymous, 1967) to rank the spiders, allowing judges to measure colour objectively. Each spider was matched to a colour tile, and hue, value and chroma were read off the tile. Hue is determined by the spectral position of the most strongly represented wavelengths; value is the darkness or lightness of a colour where black is zero and white is one; and chroma is the intensity of a colour's hue. Females 25–35 years old were used as judges because they have a low probability of having colour-vision problems (Hill, 1987; J. R. Aspland, pers. comm.). After judging, spiders were assigned randomly to one of 60 containers holding an artificial cloth leaf or flower (15 each of green, purple, yellow, and white). Container bottoms and the walls and shelves of the rearing room were covered with paper of the appropriate colour to match the flowers or leaves.

Spiders were housed in containers with artificial leaves or flowers for 16–17 days, and the containers were randomised on the shelves daily within their colour groups. On 17 September, the first spider oviposited. On 17–18 September, the four judges again ranked the hue, value and chroma of each spider overall and of the lateral abdomen. Spiders were removed from flowers before judging and placed in plastic containers. Spiders were held until oviposition and then released. All 60 spiders in the experiment produced offspring.

To determine whether spider colour was influenced by background colour, a paired, one-tailed, t-test (Zar, 1984) was used to test the following hypotheses:

H_o: (Spider colour after − Background colour) ≥ (Spider colour before − Background colour)

H_a: (Spider colour after − Background colour) < (Spider colour before − Background colour)

Rejection of the null hypothesis (H_o) at $p<0.05$ was considered evidence of a colour shift by spiders toward their background colour. The following equations were used to calculate total spider colour before and after placement on the leaves or flowers. Differences in hue, value and chroma before and after treatment were also calculated and analysed separately to determine which component of total colour, if any, was changing.

$$\frac{\sqrt{(X_{SB}-X_G)^2+(Y_{SB}-Y_G)^2+(Z_{SB}-Z_G)^2}}{\sqrt{(X_{SA}-X_G)^2+(Y_{SA}-Y_G)^2+(Z_{SA}-Z_G)^2}}$$

where X=hue, Y=value, Z=chroma, SB=spider before, SA=spider after, G=background.

Results

Three of the four judges agreed in their assessment of colour change involving both lateral abdomen (Table 1) and overall spider colour (Table 2). The fourth judge detected no significant difference between the spiders' lateral abdomen before versus after placement on the background, and obtained different results for the overall spider colour. Because three judges agreed in their results, we reject the null hypothesis and conclude that spider colour shifted toward the background.

Spiders on green leaves were the only ones that showed a significant change in total colour toward the background, and the value and chroma contributed to this change. This trend was evident for both the lateral abdomen (Table 1) and the overall spider (Table 2). For spiders on purple flowers, judges detected a change in the value of the spider toward the value of the background for the lateral abdomen and the overall spider. The hue of spiders on yellow flowers approached the hue of the background for the lateral abdomen and the overall spider. The chroma of the lateral abdomen of spiders on white flowers approached the chroma of the background.

Discussion

Peucetia viridans is found predominantly on green foliage (Neck, 1978; Willey & Adler, 1989), and the value and chroma of females changed to match the background when on artificial green leaves. A pink *P. viridans* spider has been observed on pink flowers of a corona vine, *Antigonon leptopus* (Neck, 1978), and brown or yellow *P. viridans* spiders have been observed on dull green and yellow buckwheat, *Eriogonum fasciculatum* (Gertsch, 1949). When on purple, yellow or white backgrounds, at least one of the three components of colour changed to match the background. Because the spiders were collected from green plants, they might have been able to change value and chroma within one colour more readily than if adapting to a new colour. Additionally, judges might have had more difficulty detecting a change in hue from green to green. Similarity in value should offer protection from predators that function in low light conditions or lack colour vision, while similarity in hue and chroma should offer protection from predators with colour vision (Opell, 1989). Therefore, on their predominant background, green foliage, *P. viridans* females may be well camouflaged from both invertebrate and vertebrate predators.

Peucetia viridans often matches its background and has the ability to alter its colour when placed on a different background colour. *Peucetia viridans* has a greater ability to match different background colours than any other spider studied to date because it can change components of body colour to match green, purple, yellow and white backgrounds. This ability may afford protection to *P. viridans* females as they mate, forage, and guard their egg sacs. *Peucetia viridans* may be particularly vulnerable to birds because the spiders often feed and oviposit in the tops of plants (Willey, 1988). Future studies should examine whether colour change in *P. viridans* is reversible and whether immatures, males, and nongravid females are capable of colour change. Because the discriminatory ability of

Judge	Background colour	Total	Hue	Value	Chroma
1	Green	**	—	**	*
	Purple	—	—	**	—
	Yellow	—	*	—	—
	White	NA	NA	—	**
2	Green	**	—	**	**
	Purple	—	—	**	—
	Yellow	—	*	—	—
	White	NA	NA	—	**
3	Green	**	—	**	**
	Purple	—	—	**	—
	Yellow	—	*	—	—
	White	NA	NA	—	**
4	Green	—	—	—	—
	Purple	—	—	—	—
	Yellow	—	—	—	—
	White	NA	NA	—	—

Table 1: Total colour change, and hue, value and chroma change of the lateral abdomens of females of *Peucetia viridans*. All females were collected from green foliage. NA=not applicable; hue cannot be determined for white. —=not significant; *=$p<0.05$; **=$p<0.01$.

Judge	Background colour	Total	Hue	Value	Chroma
1	Green	*	—	**	**
	Purple	—	—	**	—
	Yellow	—	*	—	—
	White	NA	NA	—	**
2	Green	**	—	**	**
	Purple	*	—	**	—
	Yellow	—	*	—	—
	White	NA	NA	—	—
3	Green	*	—	*	*
	Purple	—	—	**	—
	Yellow	—	—	—	—
	White	NA	NA	—	—
4	Green	—	—	—	*
	Purple	—	—	—	—
	Yellow	*	*	**	—
	White	NA	NA	**	—

Table 2: Total colour change, and hue, value and chroma change of females of *Peucetia viridans* overall. All females were collected from green foliage. NA=not applicable; hue cannot be determined for white. —=not significant; *=$p<0.05$; **=$p<0.01$.

observers differs, future studies possibly should use more judges. We have noted that in the field after oviposition, the lateral abdomen of *P. viridans* turns brown to match its egg sac and the colour of the dying plants, so future studies should also examine post-oviposition females.

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