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ORIGINAL PAPER

# Perception of ultraviolet light by crab spiders and its role in selection of hunting sites

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**Abstract** The perception of ultraviolet (UV) light by spiders has so far been only demonstrated in salticids. Crab spiders (Thomisidae) hunt mostly on flowers and need to find appropriate hunting sites. Previous studies have shown that some crab spiders that reflect UV light use UV contrast to enhance prey capture. The high UV contrast can be obtained either by modulation of body colouration or active selection of appropriate backgrounds for foraging. We show that crab spiders (*Thomisus* sp.) hunting on *Spathiphyllum* plants use chromatic contrast, especially UV contrast, to make themselves attractive to hymenopteran prey. Apart from that, they are able to achieve high UV contrast by active selection of non-UV reflecting surfaces when given a choice of UV-reflecting and non-UV reflecting surfaces in the absence of odour cues. Honeybees (*Apis cerana*) approached *Spathiphyllum* plants bearing crab spiders on which the spiders were high UV-contrast targets with greater frequency than those plants on which the UV contrast of the spiders was low. Thus, crab spiders can perceive UV and may use it to choose appropriate backgrounds to enhance prey capture, by exploiting the attraction of prey such as honeybees to UV.

**Keywords** Chromatic contrast · Sensory ecology · Sensory exploitation · Sensory trap · Visual ecology

## Introduction

Many animals are sensitive to ultraviolet (UV) light. This seems to occur in almost all taxonomic groups (Tovée 1995; Briscoe and Chittka 2001). Among invertebrates, UV sensitivity is an ancient trait and is known in many insects including honeybees (Briscoe and Chittka 2001; Kevan et al. 2001). The importance of visual signals or cues, especially in the UV range, in either legitimate communication or sensory exploitation has been of considerable interest in both invertebrates and vertebrates (Endler 1993). The role of UV in mate choice has been demonstrated in taxa as diverse as butterflies (Papke et al. 2007), jumping spiders (Lim et al. 2007, 2008), birds (Cuthill et al. 2000; Hausmann et al. 2003), and reptiles (Fleishman et al. 1993). The perception of UV also plays a prominent role in predator–prey interactions in varied taxa (Chittka 2001; Franks and Noble 2004; Håstad et al. 2005) including the selection of hunting sites in jumping spiders (Li and Lim 2005). Therefore UV perception could have important impacts on predator–prey interactions in other spider taxa also, such as in crab spiders (Thomisidae). However, the perception of UV by spiders has only been shown in salticids (De Voe 1975; Lim and Li 2006) to date, although UV receptors have been found in ctenids (Walla et al. 1996). Whether thomisids can perceive UV has not been demonstrated.

Crab spiders are usually ambush predators on flowers, and attack butterflies, bees and other floral visitors (Lovell 1915). They can influence pollinator visitation to flowers (Dukas and Morse 2005) by exploiting the sensory biases of prey (Heiling et al. 2006). In keeping with their sit-and-wait life style, some thomisids spend considerable amounts of time well camouflaged on flowers, blending with their backgrounds (Chittka 2001). Some of them even change colour to match their background (Oxford and Gillespie 1998). To date there exist reports of two strategies used by crab spiders to ambush hymenopteran prey. The European crab spider *Thomisus onustus* appears cryptic to prey as

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well as their own predators, i.e. birds, by merging with the background (Théry and Casas 2002; Théry et al. 2005). On the other hand, the high chromatic contrast, especially UV contrast, of the Australian crab spider *Thomisus spectabilis* (Heiling et al. 2003; Heiling and Herberstein 2004) and of *Misumena vatia* (Greco and Kevan 1994) is effective in attracting prey and may thus exploit the UV sensitivity of their hymenopteran prey (Heiling et al. 2003). The choice of hunting site by spiders could be a hard-wired phenomenon or a consequence of learning. Crab spiders could use visual, olfactory and/or tactile cues to find hunting sites (Morse 1988; Aldrich and Barros 1995; Chien and Morse 1998; Heiling et al. 2004). Their foraging decisions could also be affected by past experiences and floral condition (Morse 2000a, b). While the effectiveness of chromatic contrast, especially of the UV component, has been demonstrated in thomisid–prey interactions (Heiling et al. 2003, 2005a, b, 2006; Heiling and Herberstein 2004), whether crab spiders can perceive UV and can use this information in choosing backgrounds that would allow themselves to be maximally detected against the background and also make themselves highly attractive to prey is not known.

In this paper we investigate the visual ecology of the crab spider *Thomisus* sp. on *Spathiphyllum* plants. These plants have spadix inflorescences which are sites with a high frequency of hymenopteran and dipteran prey visits. We study the effect of spathe development and corresponding changes in visual parameters of the inflorescence on the utilisation of inflorescences as hunting sites by crab spiders. We specifically examine the role of spectral reflectance differences between the spider and inflorescences in aiding spider choice of a hunting site using the spectral sensitivities of the honeybee (*Apis mellifera*) as a generic prey taxon. We show by a choice experiment that crab spiders can perceive the difference between a UV-reflecting and a non-UV reflecting background and preferentially select the background that will generate maximum contrast. We further demonstrate that honeybees (*A. cerana*) approach with greater frequency those *Spathiphyllum* surfaces bearing crab spiders where the spiders have high UV-contrast compared to those with lower UV-contrast, thus clearly revealing the adaptive significance of the background selection strategy of the spiders.

## Materials and methods

### Study site and animals

We studied white crab spiders *Thomisus* sp. present on *Spathiphyllum* (Araceae) inflorescences within the campus of the Indian Institute of Science, Bangalore, India (12°58′N and 77°35′E). These exotic aroids are planted in dense clumps within flower beds. We classified the development of the *Spathiphyllum* inflorescence into five stages (Fig. 1a).

| | |
|---|---|
| Phase A | A small bud is present at the end of the peduncle; the spathe is not yet opened |
| Phase B | The spathe is open and bright white in colour, but the flowers are not yet developed |
| Phase C | The flowers are mature, the anthers have dehisced, and pollen can be observed adhering to the spadix (i.e. cone) |
| Phase D | The flowers are pollinated, the cone appears dark and the spathe is turning green |
| Phase E | The spathe and cone are completely green and fruit formation is complete |

Throughout this paper, cone refers to the inflorescence of the plant, while the word spathe (unless specified) may be used to refer to the cone + leaf-like parabolic structure, as when referring to B or C spathes, for example. Spiders hunt *only* on the cones.

To determine if white crab spiders (*Thomisus* sp.) preferentially select spathes of a particular phase as hunting grounds, we collected observational data on the natural presence of adult crab spiders on the cones of the five phases of spathes. We also recorded the abundance of spathes in these phases. Observations were made over three 24-h periods, with individual inflorescences in a patch being examined for the presence of spiders at three-hourly intervals.

### Spectral reflectance of spiders and *Spathiphyllum*

The spectral reflectances (300–700 nm) of *Spathiphyllum* and crab spiders (*Thomisus* sp.) were measured using a S2000 Ocean Optics spectrometer with a DT-MINI deuterium-tungsten-halogen light source attached to a computer running OOIBase32$^{TM}$ spectrometer operating software (Ocean Optics, Dunedin, FL, USA). Relative reflectance spectra were recorded using an Ocean Optics WS-1 white barium sulphate standard. Measurements were taken from cone, inner and outer surfaces of spathes, pedicel and leaf of the *Spathiphyllum* for each of the five phases; however, only values for the cones are reported here since spiders hunt only on this part, and move to the leaf-like portion only after prey capture (Fig. 1b). Adult crab spiders occupying B and C spathes of *Spathiphyllum* plants were collected for measurements. Reflectance spectra of spiders were recorded from prosoma and opisthosoma separately. Ten replicates were recorded for spiders and for each phase of the *Spathiphyllum* plants.

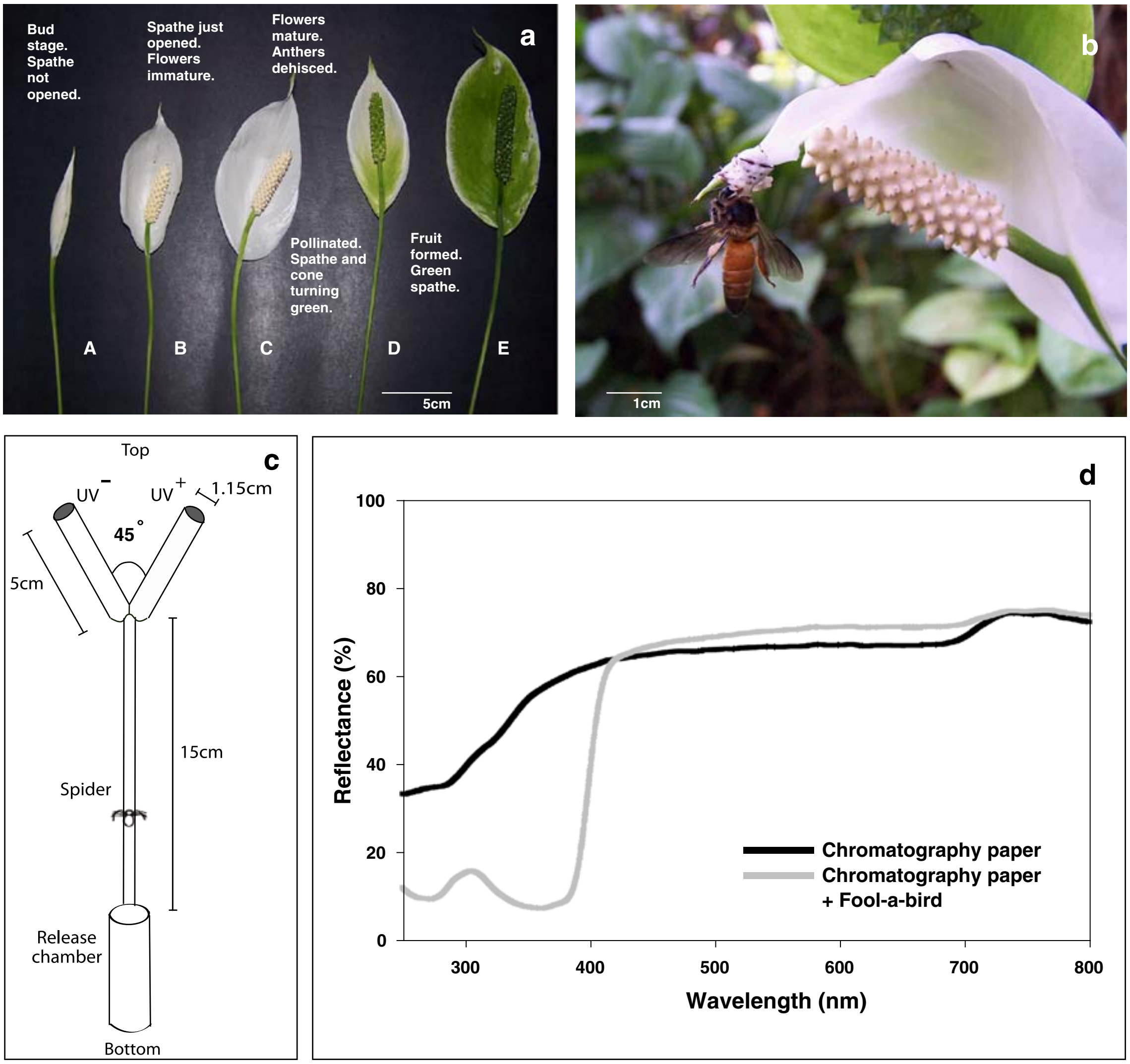


**Fig. 1** **a** Phases of spathe development (A–E) in *Spathiphyllum*; classification based on external morphology and colouration. **b** White crab spider (*Thomisus* sp.) preying on *A. cerana* on *Spathiphyllum* **c** Sketch of the experimental set-up for the choice tests. The spider was released onto the stalk from a chamber at the base. **d** Reflectance spectra of the UV-reflecting surface (chromatography paper) and non-UV reflecting surface (chromatography paper + Fool-a-bird) after lamination showing the decrease in the UV reflectance of the chromatography paper after spraying with Fool-a-bird

## Prey's perception of spider and plant colour

Since bees (*A. cerana*, *A. dorsata*) are frequent visitors to *Spathiphyllum* at our study site and are often caught here by the spiders (Fig. 1b), we used the information on *A. mellifera* colour receptor sensitivity to examine the location of spiders and cones in prey colour perceptual space, using the colour hexagon (Chittka 1992). We calculated the $x$ and $y$ coordinates of all the recorded spectra in the colour hexagon using a generic leaf reflectance as background as well as B spathe reflectance spectrum (average spathe spectrum was used) as background. The standard daylight spectrum (D65), average honeybee receptor sensitivities, and the average generic leaf reflectance spectrum were taken from Chittka and Kevan (2005). To determine if the hymenopteran prey can distinguish between the spider and cones we calculated the mean Euclidean distance (overall chromatic contrast) between the positions of spider and cones at different phases in colour space (Chittka 1992) and also the chromatic contrast for the individual receptors (UV, blue, green) from their individual excitation values.

Overall chromatic contrast $(\Delta S) = \sqrt{(\Delta x)^2 + (\Delta y)^2}$ We also compared the chromatic contrast between the spider opisthosoma and B and C cones.

For example, chromatic contrast for the UV-receptor $\Delta S_{\mathrm{UV}} = \frac{\left(E_{\mathrm{spider,\,UV}} - E_{\mathrm{cone,\,UV}}\right)}{\left(E_{\mathrm{spider,\,UV}} + E_{\mathrm{cone,\,UV}}\right)}$ where $E$ = receptor voltage signal (excitation). $E$ values were taken from spectral sensitivity curves for the different colour receptors given in Chittka and Kevan (2005).

The crab spider's opisthosoma is the largest part of the body and further it also forms the major exposed part of the spider when the spider is on a cone. Furthermore, the spider orients itself on the cone (usually with prosoma facing downwards) such that its opisthosoma is maximally presented to the prey. Therefore we examined the chromatic contrast for the spider opisthosoma.

### Choice experiment: spider selection of UV-reflecting or non-UV reflecting backgrounds

To investigate if crab spiders can perceive UV and may use this ability in finding suitable hunting grounds, we performed a choice experiment under natural daylight conditions. We offered crab spiders a simultaneous choice between UV-reflecting and non-UV reflecting surfaces by constructing models resembling the cones of spadix inflorescences (Fig. 1c). UV-reflecting chromatography paper was laminated to a matte finish. To make non-UV reflecting surfaces, we sprayed Fool-a-bird (Visio Outdoors Inc., Spokane, WA, USA: a patented mixture of chemicals that absorbs completely in the UV region), on the paper, dried it in a hot air oven and then laminated it to a matte finish. The reflectances of the two surfaces were measured after lamination (Fig. 1d). The lamination was done to exclude any possible odour cues from interfering with spider choice. The two cylindrical structures, with UV-reflecting and non-UV reflecting surfaces, were attached to a stalk at an angle of 45° from each other in order to give a simultaneous choice to the crab spiders (Fig. 1c). The stalk was wrapped with green matte-finished paper to resemble the peduncle of the spadix inflorescence. The whole set-up was placed in bright sunlight and experiments were only conducted on cloudless days since cloud cover cuts UV. The spiders were allowed to climb onto the stalk from a release chamber and when a spider came onto the top of a particular cone within a 10 min test period, that cone was marked as selected by the spider. After each trial the cones and the stalk were wiped with alcohol, to remove any chemical cues left by the previous trial. Two control experiments to determine any side-bias in the set-up were performed by giving the spiders a choice between only UV-reflecting surfaces or non-UV reflecting surfaces. The same spiders used for the control experiments were used for the test runs.

### Choice experiment: Honeybee approaches to *Spathiphyllum* cones with and without spiders

To determine the effect of UV contrast between spider and cone on honeybee behaviour, we conducted a series of outdoor experiments in which we recorded honeybee (*A. cerana*) approaches to B and C cones with and without spiders (+cones and −cones). We used bees from hives of *A. cerana* within the Indian Institute of Science campus. These bees were trained using feeders to visit the experimental area. In the first of these experiments, we gave bees a choice of A, B, C, D and E cones, all without spiders (−plants; i.e. spider-minus plants), arranged in a semicircular array, with one plant of each type. In the next set of experiments, we gave bees a choice of B and C cones, in a semi-circular array, eight plants in all, four of each type, and in various combinations (B+ versus B− , B+ versus C− , C+ versus C− ; B– versus C+ , B+ versus C+ ; where *plus* indicates cones with spiders and *minus* indicates cones without spiders). Each potted plant had one erect spathe of the appropriate phase, and each plant was separated from its neighbour by about 15 cm. Freshly caught wild spiders of approximately similar sizes were used for each experiment, and one live spider was carefully positioned at the centre of each cone. Once each experimental array was assembled, the feeders were removed, and the number of bee approaches to the cones was recorded for 20 min after which the experiment was terminated. A bee flight to within a couple of centimeters of a cone was considered as an approach to the cone, and at such short distances, bees are likely to be using chromatic contrast (Heiling et al. 2005a). Since live spiders were used in these experiments, and since bees once caught by spiders may release alarm pheromones which attracted more bees to the spot, thus interfering with the experiment, only the number of bee approaches to the cones within the 20-min period was recorded. Furthermore, to preclude learning by bees in response to potential predation attempts by crab spiders (Ings and Chittka 2008), each experiment was conducted on different days over several weeks. All experiments were done on cloudless and sunny days to ensure adequate ambient UV, and were performed between 09.00 and 11.00 hours as this ensured good bee activity under the natural conditions of the experiment.

## Results

### Differential utilisation of different phases of *Spathiphyllum* spathes by adult crab spiders

In the field, crab spiders occurred singly on individual cones, while several cones of the same plant may be occupied by spiders. The proportions of adult crab spiders were highest on B spathes (61.1%; $n = 27$ spiders). In contrast, the proportion of spiders found on A (0.0%; $n = 0$), C (12.0%; $n = 1$), D (10.7%; $n = 2$) and E (16.2%; $n = 10$) spathes were much lower. There was thus a bias in the choice of hunting ground ($\chi^2 = 34.31$, $df = 4$, $P < 0.0001$, $n = 40$;

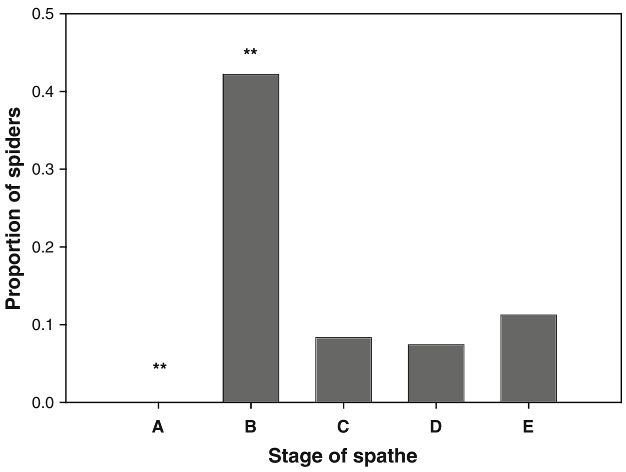


**Fig. 2** Proportion of spiders observed on different phases of spathe development showing the over-utilisation of B spathes and the under-utilisation of A spathes. $*P < 0.05$, $**P < 0.001$ in binomial tests

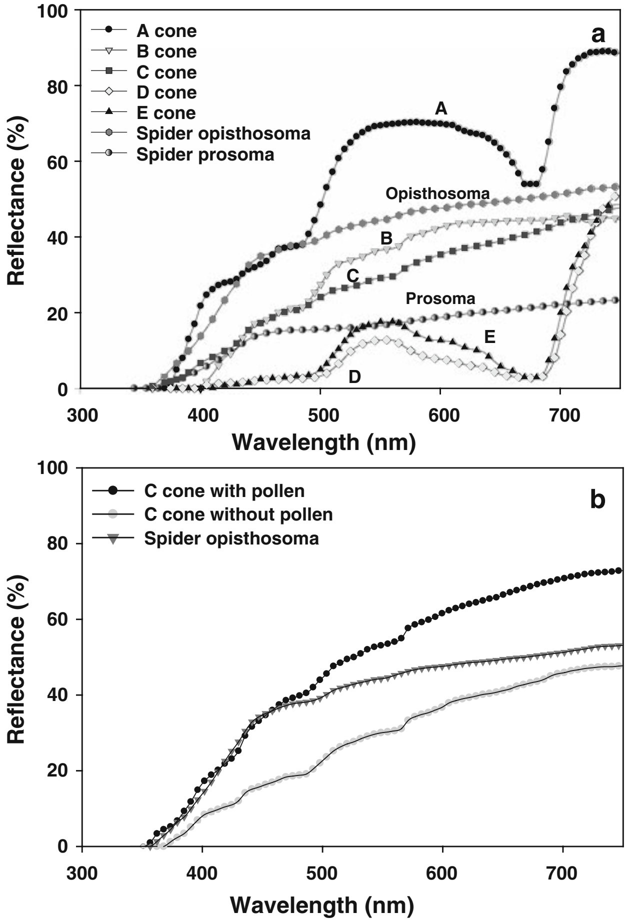


**Fig. 3** **a** Spectral reflectance curves of crab spiders (opisthosoma and prosoma) and cones of different phases of the *Spathiphyllum* plant. **b** Spectral reflectance of C cones with and without UV-reflecting pollen. Note the decrease in UV reflectance on the removal of pollen

the expected proportions of spiders on each phase were obtained from the availability of spathes in the different phases in the field at the time of the experiment; Fig. 2). Furthermore, binomial tests between the frequency of spiders present on spathes of different phases and their expected frequencies were significant only for A and B spathes ($P < 0.05$; Fig. 2), indicating that spiders over-utilised B cones and under-utilised A spathes, while spathes in C, D and E phases were used in proportion to their availability. We later show that this bias is likely to be a direct consequence of selection for high UV contrast by the adult crab spider.

## Prey's perception of spider and plant colour

The spectral reflectances of the spider opisthosoma were quite different from those of the prosoma (Fig. 3a). Reflectances of cones of D and E phases were similar, while that of the A phase cones was quite different. The B cones had lower UV reflectance than C cones (Fig. 3a). The C cone positions in the colour hexagon (Chittka 1992) were close to the spider opisthosoma positions, indicating that their receptor excitations were comparable (Fig. 4). However, the B cone positions in the colour hexagon did not overlap with those of the spider opisthosoma (Fig. 4). Furthermore, the overall chromatic contrast (Fig. 5a) between the spider opisthosoma and the B cone was found to be very high and was significantly different from the contrast for the C cone (Mann–Whitney $U$ test, $n = 10$ pairs, $U = 24$, $P < 0.05$). The presence of UV-reflecting pollen on the C cone (Fig. 3b) reduced the contrast of the spider on this phase. The calculated contrasts for the UV receptor (Fig. 5b) were found to be the highest for all the five phases. The comparison of individual receptor contrasts of the spider opisthosoma on the B and C cones showed that while the B cone contrast for all three receptors was significantly greater than that for the C cone, the difference was stark for the UV receptor (Table 1).

## Spider choice of UV-reflecting surfaces

When given a choice of UV-reflecting and non-UV reflecting surfaces, the spiders chose non-UV reflecting surfaces to a significant extent (62.2% choices for non-UV compared to 34.8% choices for UV-reflecting surfaces, $\chi^2 = 4.26$, $df = 1, n = 46, P < 0.05$). In the control experiments, when a choice of only UV-reflecting surfaces or non-UV reflecting surfaces was provided, the spiders did not move preferentially to any one direction indicating lack of side bias in the experiment (for UV-reflecting surface: $\chi^2 = 0.3913$, $df = 1$, $P > 0.05$, $n = 23$; for non-UV reflecting surfaces: $\chi^2 = 0.0437, df = 1, P > 0.05, n = 23$). These results show that crab spiders are able to perceive UV and appear to prefer non-UV reflecting backgrounds in the absence of odour cues.

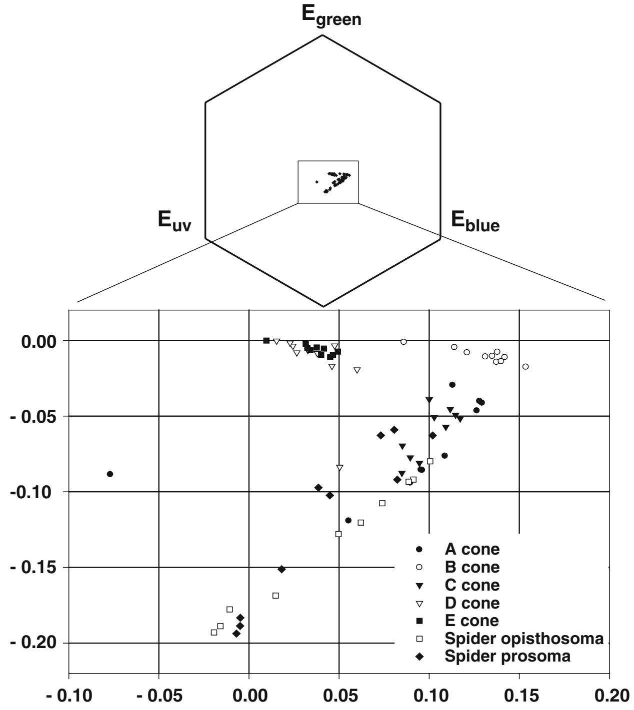


**Fig. 4** *x* and *y* coordinates of crab spider parts (prosoma and opisthosoma) and *Spathiphyllum* cones of various phases in honeybee perceptual space using the colour hexagon (Chittka 1992). Coordinates are calculated from receptor excitation (UV, blue, green) that ranges from 0 (no excitation) to 1 (maximal excitation). The B spathe's inner surface reflectance was used as the background in the calculations in place of the generic leaf spectrum

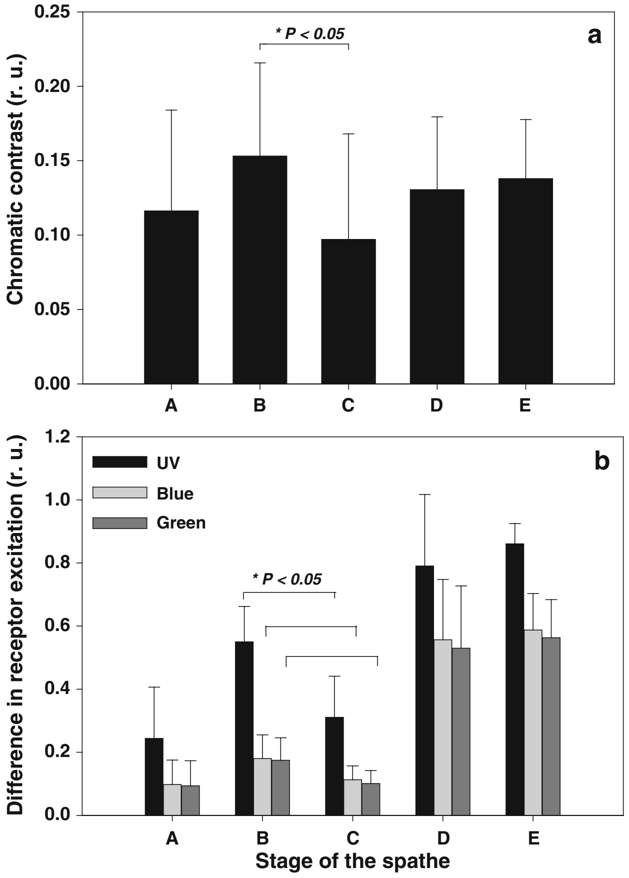


**Fig. 5** **a** Overall chromatic contrasts (Euclidean distance between two points in the colour hexagon) between the spider opisthosoma and cones of various phases. Contrast on the B cones was significantly higher than that on the C cones (Mann–Whitney *U* tests). **b** Receptor-wise difference in excitation between the spider opisthosoma and cones of various phases for a honeybee. B cones show a greater difference for all the three receptors when compared with the C cones (Mann–Whitney *U* tests). Chromatic contrasts and receptor-specific contrasts used methods and values of receptor excitation in Chittka (1992) and Chittka and Kevan (2005). *r.u.* relative units

**Table 1** Comparison of chromatic contrast for all receptors of spiders and cones for B and C cones (Mann–Whitney *U* tests)

| Receptor | Contrast on B cone | Contrast on C cone | *U* value | *P* value |
|---|---|---|---|---|
| UV | 148 | 62 | 7 | 0.001 |
| Blue | 135 | 75 | 20 | 0.023 |
| Green | 137 | 73 | 18 | 0.015 |

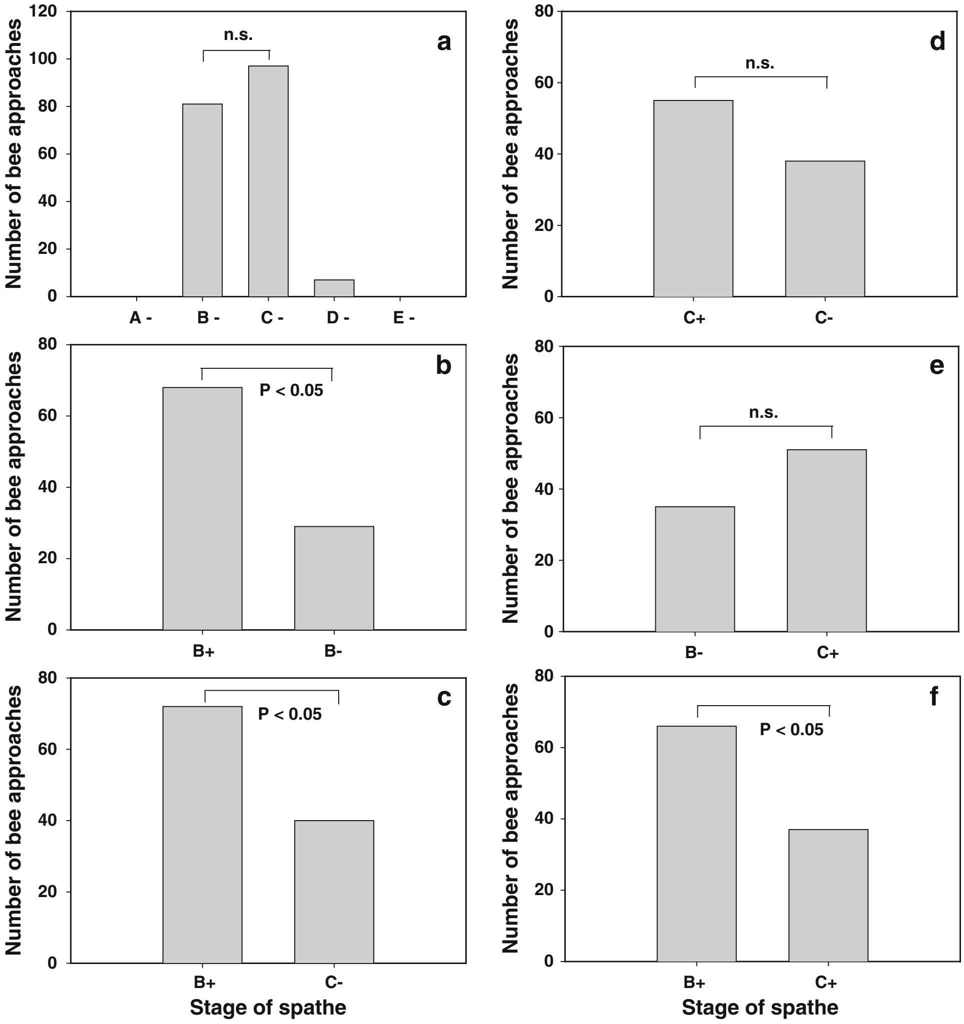
### Honeybee responses to cones with and without spiders

When honeybees were presented with an array of spathes of the different phases without the spiders, they made the greatest number of approaches to B and C phases (Fig. 6a); furthermore B− and C− cones (i.e. without spiders) were approached equally (Fig. 6a; $\chi^2 = 1.4382$, $df = 1$, $P = 0.23$, $n = 185$). In a choice between B+ and B− cones, bees made more approaches to B+ cones (with spiders) ($\chi^2 = 15.68$, $df = 1$, $P < 0.0001$, $n = 97$, Fig. 6b). In a choice between B+ and C− cones, bees made more approaches to B+ cones ($\chi^2 = 9.142$, $df = 1$, $P < 0.05$, $n = 112$, Fig. 6c). However, when bees were given a choice between C+ and C− cones, and between C+ and B− cones, they did not make a significantly greater number of approaches to the C cone with the spider (C+ versus C−: $\chi^2 = 3.1075$, $df = 1$, $P = 0.077$, $n = 93$, Fig. 6d; C+ versus B−: $\chi^2 = 2.976$, $df = 1$, $P = 0.08$, $n = 86$, Fig. 6e). Furthermore, bees made more approaches to B+ cones when given a choice between B+ and C+ cones ($\chi^2 = 8.165$, $df = 1$, $P < 0.01$, $n = 103$, Fig. 6f). These experiments clearly indicate that B cones bearing spiders are more attractive to bees than C cones with spiders. Thus the background on which the spider is presented to the bees influences bee behaviour.

## Discussion

Animals make foraging decisions in order to optimise their foraging success (Stephens and Krebs 1986). The selection

**Fig. 6** Honeybee (*A. cerana*) approaches to cones of different phases with and without spiders (*plus* indicates cones with a spider, *minus* indicates cones without a spider) in outdoor experiments ($\chi^2$ tests)



of suitable hunting sites for predatory animals such as crab spiders is crucial to their reproductive success (Morse and Fritz 1982; Fritz and Morse 1985). Crab spiders hunting on plants are dependent on prey such as pollinators and other floral visitors for their survival. Since they spend a considerable amount of time on a flower owing to their sit-and-wait life style, the selection of flowers for foraging is very important. Crab spiders choose hunting sites which either make them camouflaged (Théry and Casas 2002), or make them appear of high UV contrast to their insect prey (Heiling et al. 2003; Heiling and Herberstein 2004). High UV contrast creates a strong visual signal that is attractive to honeybees. These signals are perceived by hymenopterans and affect their floral visitation, and may thus be an example of sensory exploitation (Endler and Basolo 1998).

Crab spiders hunting on *Spathiphyllum* plants were preferentially found on B cones (Fig. 2) while C cones should be more attractive to honeybees because of the pollen rewards available in this phase. Spiders under-utilised A cones, and occurred in low frequency on D and E cones which are also unattractive to bees owing to the lack of rewards (Fig. 2). The presence of spiders on E phases can be explained based on the fact that adult female crab spiders lay egg masses on E spathes (personal observation). Since the selection pressure for the colouration of the spiders and the choice of hunting sites should be driven by the perceptual system of their principal prey, i.e. honeybees, we tested how spiders are perceived by honeybees in their colour space by using the colour hexagon (Fig. 4) and examining the chromatic contrast between the spider opisthosoma and cones. The positions of the B cones were separate from those of the spider opisthosoma, while those of the C cones overlapped with the colour positions of the spider opisthosoma. The overall chromatic contrast values for the spider opisthosoma on all phases was > 0.1 (Fig. 5a). Based on behavioural experiments, a colour contrast of 0.1 is seen by bees with a 70% discriminability (Chittka 1996). This indicates that bees can potentially differentiate between the spiders and cones when spiders are present on any of the phases. However, spiders preferentially occur on B cones, and bees approach B and C cones only even in the absence of the spiders (Fig. 6a). The primary contributor for the high overall chromatic contrast of the spider on the B cones can be assigned to high UV contrast (Fig. 5b). On the other hand, the UV contrast of the spider on C cones is dampened due to the UV reflectance of the pollen on C cones. This was evident from the fact that the reflectance of C cones in the UV region dropped when the pollen was brushed away (Fig. 3b). There was thus a natural increase in UV reflectance of the cones in transition from B to C phase due to pollen production. The production of UV-reflecting pollen is a strategy used by many plants to exploit the receptor bias of pollinators (Harder et al. 2001)

If honey bees should primarily visit C cones for pollen, why should spiders prefer to hunt on B cones? Three explanations are possible. (1) B cones have some amount of UV reflectance, and could therefore be intrinsically attractive to the bees. Our experiments showed that honeybees (*A. cerana*) were equally attracted by B and C cones when they do not have spiders on them (i.e. B− and C− , Fig. 6a), giving credence to this hypothesis. In this experiment (Fig. 6a), since spiders were absent, we also recorded bee landings and found that the frequency of landings on the C phase was higher than that on the B phase ($\chi^2 = 4.2632$, $df = 1$, $P = 0.0389$, $n = 19$).

(2) B and C spathes occur in close juxtaposition to each other in the densely planted beds in the study site. Therefore, honeybees attracted to C cones by UV-reflecting pollen are likely to be additionally attracted by the high UV contrast spider on B cones at close range when bees actually use chromatic contrast (Heiling et al. 2005a). Our experiments have clearly shown that honeybees were more attracted to cones bearing spiders when the spider was on a B cone, while they were equally attracted to cones with and without spiders when the spiders were on a C cone. Furthermore bees, when given a choice between B and C cones bearing spiders, were more attracted to the B cone. These experiments show conclusively that the background on which the spider is present influences honeybee behaviour. This effect is likely mediated by chromatic contrast, especially UV contrast, which we have shown to be greatest when the spider is on a B cone. Thus spiders that preferentially hunt on B cones can, by their presence, increase the probability of bee visitation to the cones.

(3) When honeybees visit C cones for pollen, they could land on any part of the cone since the entire cone is UV-reflecting, and any part of the cone may yield reward. A sit-and-wait predatory spider hunting on such a cone, therefore, may not always be close enough to a bee to capture it, and thus may have reduced capture success per capture attempt. Such a spider on a B cone, however, constitutes a single high contrast attractive UV target for the bee on the cone. Bees are thus drawn in at close range to this highly attractive UV-reflecting spider on a B cone (personal observation) and this can constitute an extremely successful hunting strategy. Therefore, even in this system, as occurs in Australian crab spiders, *Thomisus* crab spiders seem to position themselves to maximise their attractiveness to their prey (Heiling et al. 2006) and do not use the alternative strategy of camouflage exhibited by *Thomisus* spiders in Europe (Théry and Casas 2002). Thus crab spiders in our study appear to be exploiting the sensory biases of bees.

The choice of B spathes over C spathes as hunting grounds by spiders may be due, however, not only to differences in visual cues of the two phases, since crab spiders are also known to be attracted to floral scents (Krell and Krämer 1998; Heiling et al. 2004). Therefore, to establish the direct role of UV contrast in the spider's choice of hunting site, we performed a choice experiment with visual cues alone. The use of two artificial surfaces differing only in their UV reflectance helped us to examine spider choice for different UV contrasts on a given background. The spiders preferred non-UV reflecting surfaces over UV-reflecting surfaces. This decision could be due to direct perception of UV light and a hard-wired preference for backgrounds with low UV reflectance, or a consequence of learning by hunting on cones of a given UV reflectance. Experiments with naïve versus experienced spiders would be needed to establish this difference. The choice experiment suggested that the spiders can perceive UV and may use this ability to choose appropriate hunting grounds to maximise their fitness. Since *Spathiphyllum* in India is an exotic, having been brought into the country as an ornamental plant, the presence of Indian *Thomisus* spiders hunting on them in the appropriate phase is indicative of active selection of appropriate hunting sites by the spiders. This study, therefore, shows that crab spiders are sensitive to the UV reflectance of potential hunting backgrounds and could use this information to make foraging decisions. Furthermore, *Thomisus* spiders in Australia, and now in India, appear to use different hunting strategies from those in Europe. Whether this finding is indicative of a more general biogeographic and phylogenetic pattern is an extremely interesting question and remains to be determined.

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