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# **Comparative electroretinography of** *Peucetia gerhardi* and *Peucetia graminea* (Araneae: Oxyopidae)

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## Summary

Anatomical characteristics of the eyes of *Peucetia* species indicate that their spatial resolution is not as good as that of *Oxyopes lineatus*, but their sensitivity is slightly higher, most likely corresponding to a less illuminated microhabitat. ERGs from 15.00 to 16.00 h and from midnight to 02.00 h were studied to obtain diurnal and nocturnal functional patterns. In *P. gerhardi* (Nigeria), day and night ERG patterns were similar. A small difference between diurnal and nocturnal amplitudes indicates that eyes function during photophase as well as scotophase. Median eyes are predominantly diurnal, whereas lateral eyes are equally diurnal and nocturnal. In *P. graminea* (Thailand), ERGs in daytime and at night differed significantly. During the photophase, the curves did not show any irregularity; during the scotophase,  $\gamma$  and  $\delta$  waves were well marked. Nocturnal amplitudes were 10 to 15 times higher than diurnal ones. In *P. graminea*, the ERGs thus indicate a predominantly nocturnal functioning of the eyes. Interspecific variations of the physiological characteristics of the visual system of *Peucetia* species suggest a higher specialization of *P. gerhardi* with respect to well illuminated habitats, whereas *P. graminea* is better adapted to low light conditions.

#### Introduction

Lynx spiders (Oxyopidae) are hunters in vegetation. The development and structure of eyes are the only aspects of the visual system which have previously been studied in this family (Homann, 1950; Kovoor & Muñoz-Cuevas, 1995, 1997). Some characteristics of physiological optics are described in the most recent of the above publications. Electroretinograms (ERGs) of oxyopid spiders have not been studied so far. In *Peucetia* Thorell, 1869, four pairs of eyes are arranged in three rows (2-2-4) (Figs. 1–2). Anterior-median eyes (AM) are the smallest, and anterior-lateral ones (AL) the largest. Posterior eyes (PM and PL), almost equal in size, form a procurved row.

#### Material and methods

Two *Peucetia* species were reared in the laboratory (Zoologie–Arthropodes, MNHN, Paris) at 21±2 °C, under a 10/14 L/D cycle. Electroretinograms were recorded from adult males (2), females (2) and juveniles (3) of *Peucetia graminea* Pocock, 1900, from Thailand, and from two adult females of *Peucetia gerhardi* Van Niekerk & Dippenaar, 1994, from Nigeria. Stimulation originated from a few millisecond electronic flashes of white light (45,000 lx/s). Animals were placed in a Faraday cage, in complete darkness. The electrode was positioned with the help of a Prior micromanipulator. The electric response of the eyes was amplified and photographed directly





Figs. 1–2: Visual areas. **1** *Peucetia graminea*; **2** *P. gerhardi*. AME = anterior-median eye, ALE = anterior-lateral eye, PME = posterior-median eye, PLE = posterior-lateral eye. Scale lines =  $200 \ \mu$ m.

from the screen of the oscilloscope. Details of the technical procedures are given in Carricaburu & Muñoz-Cuevas (1985). ERG recordings were obtained from each type of eye after 1, 2, 5, 10, 20, 60 and 300 seconds of dark adaptation, in daytime and at night.

# Results

For arachnids, an ERG comprises four waves:  $\alpha$  positive,  $\beta$  and  $\gamma$  negative, and  $\delta$  positive (Carricaburu & Muñoz-Cuevas, 1981), which may not always be observed at the same time.

## Peucetia graminea

Profiles of electroretinograms recorded in daytime were very different from those recorded at night. During the photophase, traces of ERGs are simple, without irregularities. Nocturnal ERGs clearly showed  $\beta$ ,  $\gamma$  and  $\delta$  waves, particuposterior and larlv for AM eves (Figs. 11, 15, 17). Amplitudes for AM and AL eyes (Figs. 19, 21) ranged from 0.26 to 0.75 mV in daytime, and from 4.5 to 7 mV at night. ERGs of AL eyes showed the highest amplitude for 5 s dark adaptation (Fig. 21). Latencies ranged from 77 to 100 ms during the photophase for dark adaptation times longer than 10 s (Fig. 21). They increased strongly and regularly during the scotophase, from 46 to 140 ms for AM eyes for 20 s dark adaptation (Fig. 19). Longest latencies were recorded in AL eyes: 100 ms for 1 s dark adaptation, a plateau at 150 ms for dark adaptation times longer than 10s (Fig. 21). Nocturnal amplitudes were 10 to 20 times higher than diurnal ones (Figs. 3, 5, 11, 13).

For posterior eyes also amplitudes were very low (0.3–0.5 mV) in daytime (Fig. 7, 9). They increased significantly at night, reaching 3.5 or even 6 mV (Figs. 15, 17).  $\beta$ ,  $\gamma$  and  $\delta$  waves were well marked; the  $\delta$  wave sloped down very slowly from 5 s dark adaptation on (Fig. 17). As in anterior eyes, nocturnal latencies of posterior eyes were longer than the diurnal ones (Figs. 23, 25). The increase of PL eye latencies was remarkable: from 48 ms for 1 s dark adaptation, they reached a plateau at 125 ms for dark adaptation times longer than 5 s (Fig. 25).

## Peucetia gerhardi

Nocturnal and diurnal ERGs of anterior eyes were similar (Figs. 4, 6, 12, 14). Their amplitudes ranged from 0.7 to 2 mV. For AM eyes,



Figs. 3–10: Diurnal ERGs for different times of dark adaptation. **3** AME, *P. graminea*; **4** AME, *P. gerhardi*; **5** ALE, *P. graminea*; **6** ALE, *P. gerhardi*; **7** PME, *P. graminea*; **8** PME, *P. gerhardi*; **9** PLE, *P. graminea*; **10** PLE, *P. gerhardi*. s = stimulus. Figs. 7 and 9, same scale; Figs. 8 and 10, same scale.



Figs. 11–14: Nocturnal ERGs of anterior eyes for different times of dark adaptation. **11** AME, *P. graminea*; **12** AME, *P. gerhardi*; **13** ALE, *P. graminea*; **14** ALE, *P. gerhardi*. s = stimulus. Figs. 11 and 13, same scale; Figs. 12 and 14, same scale.

they never exceeded 1 mV in daytime; nocturnal amplitudes of AM eyes were slightly higher, from 1.2 to 1.5 mV for dark adaptation times longer than 10 s. Latency curves were also similar: their values lay between 68 and 100 ms

for the longest dark adaptation time (Figs. 20, 22).

ERG wave-forms of posterior eyes were hardly distinguishable. For PM or PL eyes, amplitude values were comprised between 1 and

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Figs. 15–18: Nocturnal ERGs of posterior eyes for different times of dark adaptation. **15** PME, *P. graminea*; **16** PME, *P. gerhardi*; **17** PLE, *P. graminea*; **18** PLE, *P. gerhardi*. s = stimulus. Figs. 15 and 17, same scale; Figs. 16 and 18, same scale.

1.5 mV from 10 s in daytime as well as at night (Figs. 8, 10, 16, 18). The highest amplitude was recorded in PM eyes in daytime. Diurnal latencies of posterior eyes (77–100 ms) were clearly shorter than nocturnal ones (100–125 ms) (Figs. 24, 26).

# Discussion

Eye structure and optical characteristics of three *Peucetia* species and *Oxyopes lineatus* have been compared (Kovoor & Muñoz-Cuevas, 1997). Differences have been found in the visual area and the organization and fine structure of



Figs. 19-26: Diurnal and nocturnal amplitudes (mV) and latencies (ms) as a function of dark adaptation (s).

the retinae among *Peucetia* species themselves. For example, the visual area, in proportion to the size of the spiders, is smaller in *P. gerhardi* than in *P. graminea* which possess the largest lenses of all eyes; moreover, the rhabdoms of photoreceptors are higher in the latter than in *P. gerhardi*. An optical characteristic, the value of F-number, which is related to eye sensitivity, is nearly 1 in *P. graminea* and > 1 in *P. gerhardi* (posterior eyes): sensitivity of posterior eyes of

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Figs. 27–28: ALE retinae. **27** *P. graminea*; **28** *P. gerhardi*. P = pigment, Rh = rhabdom, T = tapetum. Scale line =  $20 \ \mu m$ .

*P. graminea* should be greater than that of *P. gerhardi*.

Differences between electroretinograms of the two species are obvious: low nocturnal as well as diurnal amplitudes of *P. gerhardi* ERGs contrast with high nocturnal amplitudes of *P. graminea* ERGs, the traces of which, furthermore, clearly show  $\beta$ ,  $\gamma$  and  $\delta$  waves. These data, together with a difference in the extent of the sheath of pigment covering the rhabdoms, which is limited to 38% of rhabdom height in *P. graminea* and reaches 50% in *P. gerhardi*, suggest that *P. graminea* is more active at night. Nyffeler *et al.* (1987, 1994), studying the predation ecology of *P. viridans*, observed that these spiders, though active day and night, prefer to feed during the night.

ERGs of Lycosa tarentula (Linnaeus, 1758) (Lycosidae), recorded earlier (Carricaburu et al., 1990) in similar conditions to those of Peucetia species, showed high amplitudes for the anterior eyes at night, and for posterior eyes, in daytime. These results are in agreement with the observation of a nocturnal activity of *L. tarentula* which was demonstrated as circadian (Ortega et al., 1992). Latencies of the electric responses of all eyes of *L. tarentula* were shorter than those of *Peucetia* in daytime. Nocturnal latencies were increased in both cases, but much more for *Peucetia* eyes, particularly for AL eyes of *P. graminea*. The ecological conditions of the

habitat of *L. tarentula* are however quite different from those of *Peucetia* species; but given the results of electroretinography and the observations by Nyffeler *et al.* (1987, 1990), it can be assumed that these oxyopid spiders exploit their microhabitat day and night; a nocturnal tendency would be accentuated in the case of *P. graminea*.

Further studies and observations are needed to elucidate the actual function of the visual system of oxyopid spiders living in different microhabitats. Members of the Senoculidae, the sister family of Oxyopidae (Griswold, 1993), would also be of great interest for comparison, although very little is known of their structure and behaviour (Homann, 1971).

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