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SHORT COMMUNICATION

FIELDS OF VIEW OF THE EYES OF PRIMITIVE JUMPING SPIDERS

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Most spiders have eight simple eyes, of which one forward-pointing pair (the principal eyes) has a different structure from the other three pairs (the secondary eyes). The principal eyes are often movable, whereas the secondary eyes are fixed. In most jumping spiders (Salticidae) two of the secondary eyes, the postero-median pair, are so reduced that they seem to be vestigial, and their fields of view overlap those of the other secondary eyes (the antero- and postero-laterals) (Homann, 1928; Land, 1969*a*; Eakin & Brandenburger, 1971). However, in certain supposedly primitive Salticid sub-families the postero-median eyes are comparable in size with the other secondary eyes, and would appear to play a more equal part in the function of the secondary eye system, which is the detection of movement (Land, 1972). The origins of the Salticidae are something of a mystery, and it is therefore of considerable interest to see whether the fields of view of the eyes of these primitive sub-families give any clue that might indicate to which of the other spider families the Salticidae might be linked. The form of the fields of view appears to be a conservative feature in spider evolution (Land, 1985), just as does the layout of the eyes themselves. The anatomy and ultrastructure of these eyes have been described before (Blest, 1983, 1984, 1985; Blest & Sigmund, 1984) and the systematic position of the sub-family considered here, the Spartaeinae, is discussed by Wanless (1984).

Two species from the sub-family Spartaeinae were obtained. *Portia fimbriata*, originally from Queensland, Australia, were kindly supplied by Dr Robert Jackson of Christchurch, New Zealand. A single female of *Spartaeus spinimanus*, from Singapore, was collected by Dr David Blest of the Australian National University, Canberra. In addition, specimens of the 'advanced' salticid *Plexippus* sp. were obtained locally in Canberra. Live spiders were anaesthetized with CO_2, and a small stick was waxed to the back to serve as a mount. They were then placed in the apparatus shown in Fig. 1. This consists of a Cardan arm on which is mounted a small telescope, and a light source whose beam is concentric with the viewing beam. The telescope has an acceptance angle of about 2°, which limits the accuracy of the method. The telescope is focused on the spider, and a reflection from the retina of each eye can be seen provided the axis of the telescope is within the field of view of the eye. The Cardan arm is calibrated in latitude and longitude coordinates, and these are used

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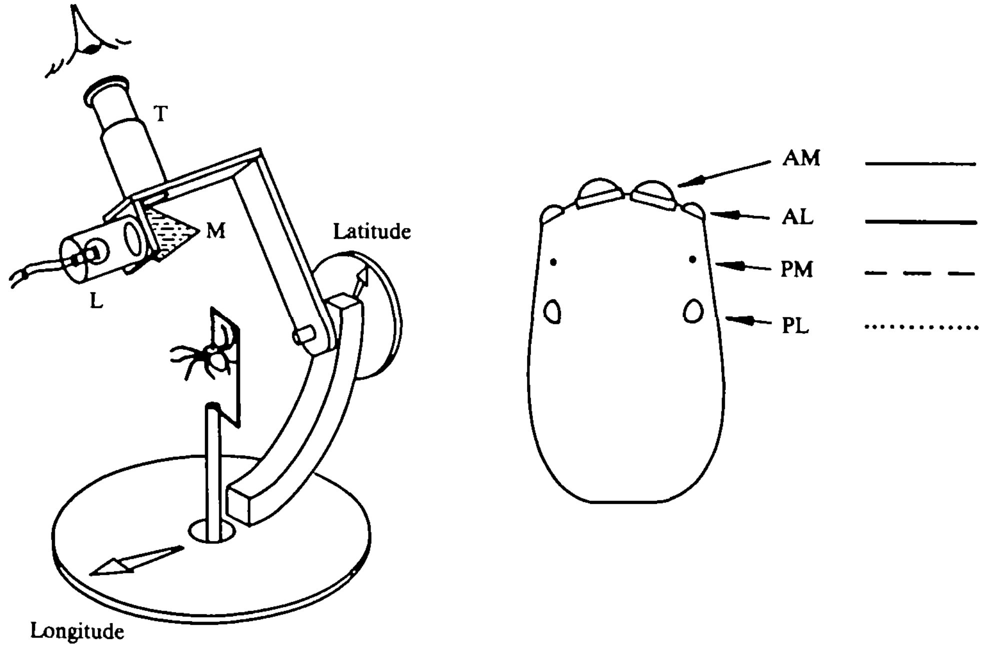

Fig. 1. Left: drawing of the apparatus used'to measure the fields of view. T is a small telescope, actually the inspection telescope from a phase-contrast microscope. L is a small light source with a collimating lens, and M is a half-silvered mirror. Right: sketch of the prosoma of an advanced jumping spider, from above, showing the locations of the four pairs of eyes. In *Portia* and *Spartaeus* the postero-median (PM) eyes are larger. The line types identify the different fields of view in Fig. 2. AM, antero-median; AL, antero-lateral; PL, postero-lateral.

to plot the locations of the edges of the fields of view of the secondary eyes (Fig. 2). The spider was aligned so that the equator of the coordinate system corresponded with the ventral rim of the prosoma carapace. Jumping spider eyes do not have tapeta, but the retinae contain screening pigment which causes them to appear slightly pink. Outside the retina this colour changes abruptly to grey. Additional ophthalmoscopic observations on the secondary retinae, and on the fields of view of the principal (antero-median) eyes were made using an ophthalmoscope described elsewhere (Land 1969*b*, 1984).

In Fig. 2 the fields of view of *Portia* and *Plexippus* are compared. In *Portia* there is a gap about 20° wide between the fields of view of the antero-lateral (AL) and postero-lateral (PL) eyes. This gap is filled by the strip-shaped field of the postero-median (PM) eye. In *Plexippus* there is no gap, and the fields of the AL and PL are contiguous in this region. It appears that the fields of both AL and PL eyes have expanded to fill the gap. In *Spartaeus* the field of view of the PM eye is very similar to that of *Portia* but is not so extensive vertically. It stretches from about 20° below the equator to 40° above (60° total) compared with 35° below to 60° above in *Portia*. The spacings of the receptors in the secondary retinae of *Portia* were examined ophthalmoscopically. In the AL eye the centre-to-centre separation varied from 0·55° in the acute region near the body axis, to 0·97° near the lateral edge. In the PL eye the separation was nearly uniform at approximately 1·49°. Interestingly, the separation in the PM eyes was intermediate, at almost exactly 1·0°, and uniform. This contrasts with other jumping spiders where estimates for the PM eye, to the extent

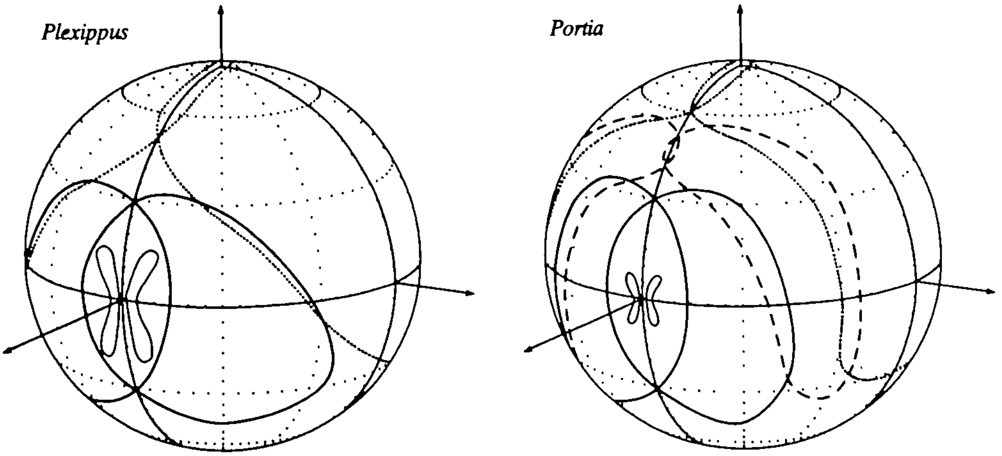

Fig. 2. Fields of view of an advanced salticid *Plexippus*, left, and the primitive salticid *Portia*, right. The main difference is the presence in *Portia* of a strip-like PM field, lying between the AL and PL fields. Principal (AM) fields were derived from ophthalmoscopy, and the data of Williams & McIntyre (1980) for *Portia*. In life, the AM eyes can move so that the centres of their fields of view can scan over most of the fields of the AL eyes. The visual fields are shown here projected onto a sphere around the animal (orthographic projection), viewed from 15 ° above the equator, and 30 ° to the animal's left. AL, antero-lateral;, AM, antero-median; PL, postero-lateral; PM, postero-median.

that they have any meaning, are around 10 °. Clearly in the Spartaeinae, the PL eyes are integrated into the overall function of the secondary eye system, whereas in most other salticids they are not.

Unfortunately, the location of the field of view of the PM eyes in *Portia* does not correspond particularly closely with the PM fields of any of the other hunting spider families that have so far been studied (for maps of these see Land, 1985). In the Lycosidae (wolf spiders) the PM eyes are the largest pair and their fields are also large, extending from directly above the animal to 50 ° below the equator, and from the front to about 70 ° lateral. In both the Sparassidae (huntsmen) and Thomisidae (crab spiders) the PM fields are more dorsal and less frontal than in the Lycosidae, but in all these families the region around the dorsal pole is occupied by the fields of the PM eyes, not the PL eyes as in the Spartaeinae. The PM fields in these other families are also much larger than they are in the Spartaeinae although – for what this is worth – they are smaller in the Thomisidae than in the Lycosidae or Sparassidae. The visual fields in the other hunting spider families (Clubionidae and Oxyopidae) have yet to be investigated. Possibly one should also look to the web-building families since *Portia*, unlike other salticids, does build a web (Jackson & Blest, 1982). However, the optical design of the eyes in most of the web-building families does not permit the accurate mapping of visual fields (Land, 1985). If *Portia* and *Spartaeus* are properly regarded as primitive, then we may conclude that the ancestors of the salticids had six functional secondary eyes, like most other spiders, but that the distribution of their fields of view was not like that in any other family that we have good information about at present.

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