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Some anomalies in the development of jumping spider eyes (Araneae: Salticidae)

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Here I document two different anomalies in the development of jumping spider (Salticidae) eyes, and one related anomaly observed in a wolf spider (Lycosidae) (Figures 1-2). One salticid anomaly (Figure 1.1) produced simple enlargement of the right primary eye (right AME). A second anomaly (Figures 1.2, 2.1-2.4) produced fusion of the the two primary eyes (or AME). In comparison, a similar anomaly observed in a lycosid spider (Figures 1.3, 2.5-2.6) produced fusion in *both* the primary eyes and the larger posterior medial eyes (PME).

Many related anomalies are known for various spiders, and these have been reviewed by Jiménez & Llinas (2002). The many ocular deformations that have been found in spiders include lack of certain eyes, or fusion (*conjoining*) of the primary eyes (e.g. Gabriel & Sherwood 2020).

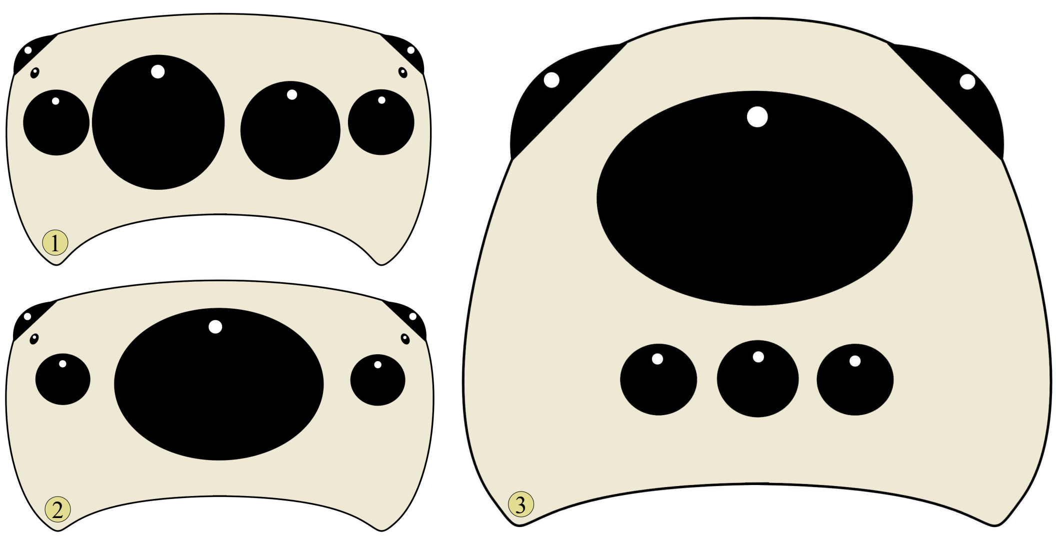

Figure 1. Some ocular deformations of salticids (1-2) and a lycosid (3). **1,** Deformation photographed by Weng Keong Liew for a tropical salticid from southeast Asia, perhaps *Cytaea*. **2,** Conjoining deformation of the primary eyes (AME) of a salticid photographed by Lowell Tyler in Mililani Mauka, Oahu, Hawaii (8 AUG 2017) This spider is also shown in Figure 2: 1-4. 3, Conjoining deformation of primary eyes (center, bottom row) and much larger medial secondary eyes (PME or MLE) of a lycosid spider photographed by the author (12 JUL 2013, Greenville County, South Carolina). This spider is also shown in Figure 2: 5-6.

Figure 2. Similar ocular anomalies in a salticid (1-4) and lycosid (5-6) spider. **1-4,** Salticid photographed in Mililani Mauka, Oahu, Hawaii (8 AUG 2017). **5-6,** Lycosid photographed by the author (12 JUL 2013, Greenville County, South Carolina). Photo credits: 1-4, © Lowell Tyler, used with permission.

In a study of the theridiid *Parasteatoda tepidariorum*, Schomberg et al. (2015) identified a non-neurogenic origin (*anlagen*) for each primary eye (AME), separate from the anlagen that divides to form the three secondary eyes on each side (ALE, PLE and PME). Schomberg et al. used the term MLE (or Middle Lateral Eye) instead of PME. This finding agrees with the anatomy of these eyes and their associated visual centers in the CNS, where we observe that the three lateral eyes share common neural pathways, quite separate from those of the AME (Hill 2022).

Thus the distinction between *primary eye* and *secondary eye* is well-supported by the development of these eyes. For salticids, it may be more appropriate to follow Schomberg et al, in use of the term MLE (instead of PME) with reference to the position of the eyes of the second row. Most often AME is interpreted as a reference to an anterior *median* position, rather than an anterior *medial* position, for the primary eyes. However this interpretation viotates the standard of medical terminology stated clearly by Gest (2000): *Medial* means toward the midline (or sagittal plane), *lateral* means away from that midline, and features that lie on the midline, like the trachea, are *median*. The cyclops-like primary eyes shown in Figures 1.2-1.3 and 2 are clearly median structures, but normally the position of these eyes, when separate, is medial.

The study of developmental pathways leading to these anomalies (when disrupted) is of interest. Chang et al. (2001) found that a lower level of Decapentaplegic (Dpp) signalling at the dorsal midline of developing *Drosophila* lead to a *cyclops* phenotype. They also identified similarities in the anterior brain/visual system partitioning of insects and vertebrates, suggesting conservative evolution of related developmental pathways that should extend to all arthropods as well. More recent studies have identified some differences between signalling related to eye positions in insects and spiders, but within the framework of a similar mechanism (Baudouin-Gonzalez et al. 2022; Janeschik et al. 2022). Mechanisms related to the wiring of neurons associated with vision in both arthropods and vertebrates may be similarly conservative (Malin & Desplan 2021).

The study of anomalies related to eye development in spiders does not require that one wait for that rare encounter in nature. For study purposes these anomalies can be produced through drastic environmental (e.g., temperature) changes during development of eggs in the laboratory (Napiórkowska et al. 2017). The study of behavioral changes associated with ocular anomalies might also produce some interesting results. Clearly these anomalies are not necessarily fatal to the spider.

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