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A note on scale morphology in Collembola

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Many Collembola (e.g. Entomobryidae: Tomoceridae) are characterised by a 'clothing' (*sensu* Salmon 1941) of scales. These scales confer a metallic-silver colour, which, when the scales catch the light, renders an iridescence to the surface of these hexapods. The functional significance of these scales is incompletely understood, although there is some evidence that they contribute to predator evasion (Bauer & Pfeiffer 1991). Their presence or absence is a fundamental taxonomic character for many genera, while more specifically, their morphology has been widely used as a species-specific character since the first studies in Collembola systematics (Beck 1873; Salmon 1941). From an evolutionary perspective, scales represent a derivation of cuticular setae (André 1988) that has been adopted independently by different taxa. For example, a study by Zhang *et al.* (2014) has recently demonstrated the independent origin of scales at least five times in the family Entomobryidae. This note briefly draws attention to previously unrecognised complexity in scale presence and architecture in Collembola at the level of individual species. An informed recognition of this complexity is recommended for future taxonomy.

Scanning electron and light microscopy were carried out on the springtail *Lepidophorella australis* Carpenter, 1925 from New Zealand. Micrographs of the surface scales of a normal adult show a dense clothing of paddle-shaped corrugated scales (Fig. 1a)—a scenario familiar to the SEM literature on Collembola (Eisenbeis & Wichard 1987). However, micrographs of the cuticle of an individual just before ecdysis, when scale coverage is partial, reveal a much more structurally complex condition. The scales are of different shapes and sizes and are layered on top of each other with a base layer of very small scales (Figs 1b-d). These differences, although made more visually conspicuous by the moult cycle, are not just reflective of allometric changes in scale morphology during regeneration. When scales from an active adult are brushed with a fine paintbrush onto microscope slides and examined, the extent of morphological variation becomes readily apparent. In addition to the primary or surface covering of scales (Fig. 2a), a variety of other scale types are evident. The most prominent scale morphologies observed in brushings were: (1) broad-paddle primary cover scales, (2) thin-paddle scales, (3) fan scales, (4) orbicular base scales and (5) asymmetric 'wing'-shaped scales (Figs 2a–f). A few brushings also revealed isolated, aberrant forms, which we take to be examples of scales captured mid-ontogeny (Fig. 2f). Further work will be needed to determine other potential aspects of ontogeny such as allometric scaling, growth regions and the dynamics of scale replacement. Obviously, the observations here simplify a complex phenomenon, however they make it clear that within many, if not all, scaled species, scales are not monotypic, but morphologically diverse. Layering and diversity facilitate complete coverage of the integument as well as ensuring the animal's clothing is compensated when it suffers partial scale loss. Perhaps the best illustrative analogy to the 'design principle' observed is to the different types of feathers employed by birds in their wings.

It is recognised that a complete description of scale types, sizes, and integumental stratification for individual species may be surplus to most diagnostic requirements. However, this correspondence does reveal the potential for such work—we note, for example, the work done on phanerotaxy by André (1988). Nonetheless, some recognition of this morphological diversity is advisable. In particular, it should be emphasised that the presence and morphology of primary cover scales—the baseline diagnostic—should be specifically designated as such, rather than simply as 'scales'. Likewise, both collectors and taxonomists should be alert to both cuticular layering and scale ontogeny as a source of morphological variation and diversity.

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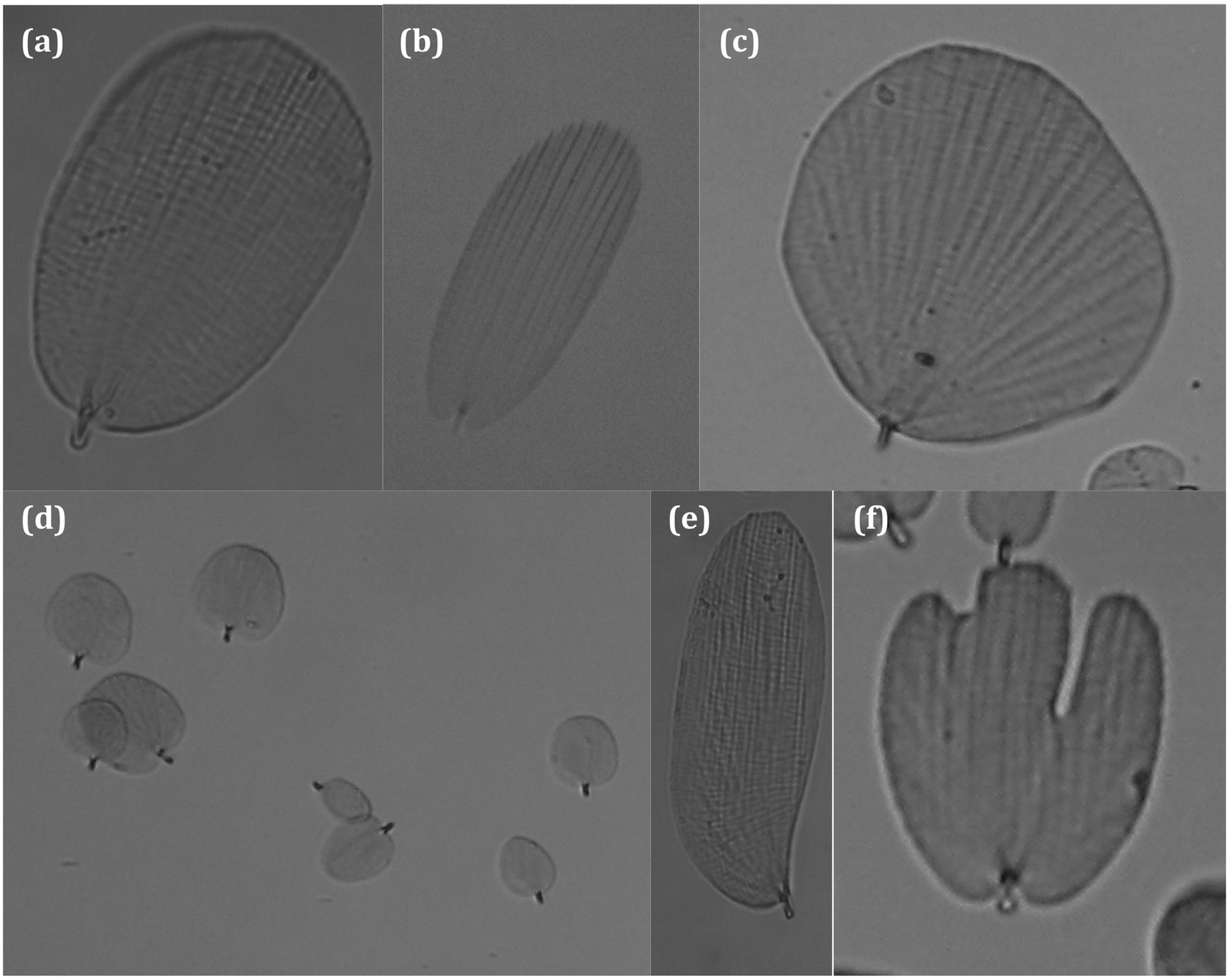

FIGURE 2a–f. Light microscopy pictures of principal scale types of *Lepidophorella australis*: a, primary paddle-shaped cover scale; b, thin-paddle scale; c, fan-shaped scale; d, orbicular base scales; e, asymmetric 'wing'-shaped scale; f, irregular-shaped scale captured during growth (note: margins of indentations are not serrated or rough as would be the case if these indentations represented fractures).

References

André, M. (1988) The phanerotaxy of the genus *Xenylla* (Collembola, Hypogastruridae), with the description of a new species from Ethiopia. *Journal of African Zoology*, 102, 503–527.

Bauer, T. & Pfeiffer, M. (1991) 'Shooting' springtails with a sticky rod: the flexible hunting behaviour of *Stenus comma* (Coleoptera; Staphylinidae) and the counterstrategies of its prey. *Animal Behaviour*, 41, 819–828. http://dx.doi.org/10.1016/S0003-3472(05)80349-5

Beck, J. (1873) Essay on the scales of the Collembola and Thysanura. *In*: Lubbock, J. (Ed.), *Monograph of the Collembola and Thysanura*. J. Ray Society, London, pp. 249–254.

Eisenbeis, G. & Wichard, W. (1987) *Atlas on the Biology of Soil Arthropods.* Springer-Verlag, New York, 437 pp.

Salmon, J.T. (1941) The Collembolan Fauna of New Zealand, including a Discussion of Its Distribution and Affinities, *Transactions and Proceedings of the Royal Society of New Zealand*, 70, 282–431.

Zhang, F., Chen, Z., Dong, R.-R., Deharveng, L., Stevens, M.I., Huang, Y.-H. & Zhu, C.-D. (2014) Molecular phylogeny reveals independent origins of body scales in Entomobryidae (Hexapoda: Collembola). *Molecular Phylogenetics and Evolution*, 70, 231–239. http://dx.doi.org/10.1016/j.ympev.2013.09.024