

Hopping in Palaeo-World – new proposal for migration routes of Lophopidae (Hemiptera: Fulgoromorpha)

Szwedo J.¹ & Soulier-Perkins A.²

¹ Museum and Institute of Zoology, Polish Academy of Sciences, 64, Wilcza Street, PL00-679 Warszawa, Poland; e-mail: szwedo@miiz.waw.pl,

² Origine, Structure et Evolution de la Biodiversité UMR 7205, Museum national d'Histoire Naturelle, 45, rue Buffon, F-75005, France; e-mail: soulier@mnhn.fr

The Lophopidae are placed in 'higher' Fulgoroidea. The representatives are found in tropical regions of South America, Africa, Australia, India and Southeast Asia. The family has generally been considered to be of a relatively basal lineage within the Fulgoromorpha. However, neither the known up to present fossil record nor recent phylogenetic studies supported an ancient origin of this family (Soulier-Perkins 1998, 2000). Three hypotheses were discussed by Soulier-Perkins (2000) to explain the biogeographic pattern of recent Lophopidae and the scenario dating the origin of the Lophopidae around the Palaeocene (65 million years) was preferred.

The findings of Lophopidae in the Paleocene deposits of Europe: Mid Palaeocene Menat Formation, France (ca. 61-60 Ma), Late Palaeocene Fur Formation, Denmark (55-54 Ma), Lowermost Eocene Oise amber, France (53 Ma) and Mid Eocene Messel Maar, Germany (49-47.5 Ma) give an indication to review these scenarios. It could be assumed that Lophopidae originated and initially diversified in the area of southern part of Asia very probably just after the Mid-Cretaceous biotic re-organisation ca. 100 Mya. Rapid differentiation could be related to diversification of their angiosperm host-plants and opening of new ecological niches. The ancestors of [Makota+, (Bisma+, Sarebasa+)] group differentiated somewhere along the western Pacific island arc system, and the second in Southeast Asia. Rapid Asia–Europe–North America geographic dispersal during the Paleocene–Eocene Thermal Maximum (PETM) is postulated for Lophopidae. This could be substantiated by the patterns observed in the other groups of plants and animals (Sanmartín *et al.* 2001; Smith *et al.* 2006; Cuenca *et al.* 2008). Dispersal from Europe to North America during PETM was possible through Thulean North-Atlantic bridge. Palaeogene European Lophopidae are quite differentiated, *Baninus thuringiorum* Szwedo et Wappler, 2006, from Messel Maar is a member of the Bisma+ group of genera, the fossils from Oise amber and Fur Formation are close each other and seems to be placed in Sarebasa+ generic group. Placement of supposed lophopids from Menat is not resolved yet. The taxonomic placement of the only fossil lophopid from North America, *Scoparidea nebulosa* Cockerell, 1920 is uncertain, as Shcherbakov (2006) transferred it to Issidae, and related to the recent genus *Colpoptera* Burmeister, 1835. The sole South American genus *Carriona* Muir, 1931 is believed to be a sister group of the other lophopids. Any lophopids were reported from the Miocene Dominican or Mexican ambers. The 'invasion' of lophopids to the Indian subcontinent probably took place since the earliest Eocene, since the Eocene Thermal Maximum (ETM2) and the subsequent Early Eocene Climatic Optimum (Zachos *et al.* 2008). These 'hothouse' conditions very probably affected the distributional pattern of insects. Anyway, the geologic events and plate tectonics for the area are still under discussions and controversies (Metcalf 2006; Aitchison *et al.* 2007; Ali and Aitchison 2008). The ancestors of [Makota+, (Bisma+, Sarebasa+)] group differentiated somewhere along the western Pacific island arc system and in Southeast Asia. This differentiation probably took place since the Mid Eocene, and was increased during the Neogene tectonic evolution of southeast Asia. Ancestral lophopids were dispersed onto the emerged land masses. When this arc became fragmented and drifted away from Southeast Asia, and islands were formed by flooding of land bridges, ancestors of Makota+ became isolated on islands in the west Pacific island arc, including Borneo. Ancestors of Bisma+ group very probably originated in the West Pacific islands arc. Eleven of the concerned genera are found in the terranes originating from this arc, however some taxa seems to have reached far to the west up to Europe. Sarebasa+ is the sister group of Bisma+ group, recently distributed mainly in southeast Asia and Australia, but with two genera known from Africa (Soulier-Perkins 2000). It was also present in the

Palaeogene of Europe. Therefore the origin of African genera, feeding on Poaceae and related to open savannah areas, expanded in Africa during Miocene aridization and cooling ca. 23 Mya, could be connected with European or Asian ancestors.

References

- Aitchison J.C., Ali J.R., Davis A.M. 2007. When and where did India and Asia collide? *J. Geophys. Res.* 112: B05423 [1–19]. doi:10.1029/2006JB004706, 2007
- Ali J.R., Aitchison J.C. 2008. Gondwana to Asia: Plate tectonics, paleogeography and the biological connectivity of the Indian sub-continent from the Middle Jurassic through latest Eocene (166–35 Ma). *Earth-Sci. Rev.* 88: 145–166. doi:10.1016/j.earscirev.2008.01.007
- Cuenca A, Asmussen-Lange CB, Borchsenius F. 2008. A dated phylogeny of the palm tribe Chamaedoreae supports Eocene dispersal between Africa, North and South America. *Mol Phylogenet Evol.* 2008 Feb;46(2):760-75.
- Kimsey, L.S., 1992. Biogeography of the Panamanian region from an insect perspective, in: *Insects of Panama and Mesoamerica*.
- Metcalfe, I., 1991. Late Palaeozoic and Mesozoic palaeogeography of southeast Asia. *Palaeogeogr. Palaeoclimatol. Palaeoecol.* 87, 211–221.
- Sanmartín I., Enghoff H., Ronquist F. 2001. Patterns of animal dispersal, vicariance and diversification in the Holarctic. *Biol. J. Linn. Soc.* 73: 345–390.
- Shcherbakov D.E. 2006. The earliest find of Tropiduchidae (Homoptera: Auchenorrhyncha), representing a new tribe, from the Eocene of Green River, USA, with notes on the fossil record of higher Fulgoroidea. *Russian Entomol. J.* 15(3): 315–322
- Smith T., Rose K.D., Gingerich P.D. 2006. Rapid Asia–Europe–North America geographic dispersal of earliest Eocene primate *Teilhardina* during the Paleocene–Eocene Thermal Maximum. *PNAS* 103(30): 11223–11227. doi: 10.1073/pnas.0511296103
- Soulier-Perkins, A. 1998. The Lophopidae (Hemiptera: Fulgoromorpha): Description of three new genera and key to the genera of the family. *European J. Entomol.* 95(4): 599–618.
- Soulier-Perkins, A. 2000. A phylogenetic and geotectonic scenario to explain the biogeography of the Lophopidae (Hemiptera, Fulgoromorpha). *Palaeogeogr., Palaeoclimatol., Palaeoecol.* 160: 239–254.
- Szwedo J., Wappler T. 2006. New planthoppers (Insecta: Hemiptera: Fulgoromorpha) from the Middle Eocene Messel Maar. *Ann. Zool.* 56(3): 555–566.
- Zachos, J.C., Dickens, G.R., Zeebe, R.E., 2008. An early Cenozoic perspective on greenhouse warming and carbon-cycle dynamics. *Nature*, 451 (17 January 2008): 279–283. doi:10.1038/nature06588