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The complex evolutionary history of the acquisition of morphological polymorphism in *Panorpodes paradoxus*

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The panorpodid scorpionfly *Panorpodes paradoxus* (Panorpodidae), which inhabits mountainous areas has many varied types of body color and wing spots pattern. In addition, it has known that female of *P. paradoxus*, which are living in the high altitude regions of the Central Japan and the several mountains of Tohoku (Aomori Prefecture), have short wings and these are called "short-winged type". Furthermore, the short-winged type has many morphological differences from "long-winged type"; (1) male's antenna is longer than that of long-winged one, (2) upper ridge of the hypandrium is rounder than long-winged one, (3) female's body color is dark brown (long-winged type's body color is generally pale yellowish brown), (4) female's wing spots pattern is characteristic and differ from long-winged one (there are many long-winged females which have not any wing spots, but short-winged female always has wing spots), (5) male of short-winged type has faint wing spots (appearance of wing spot is very rare in long-winged male), therefore, it is referred that "short-winged type" is an adaptation to high mountains, and suggested that "short-winged type" is a different species from "long-winged type" (Ichida, 1990).

So, in this study, we performed molecular phylogenetic analyses in order to confirm whether there are genetic differences between *P. paradoxus* of long- and short-winged types, together with this species having other varied morphological characteristics, or not. As a result, the long- and short-winged types did not separately compose monophyletic groups, and many varied types of body color and wing spots pattern did not related to the phylogenetic relationship. Furthermore, long-winged and short-winged populations occurring in the same mountain each composed monophyletic groups, but the two populations were never monophyletic.

Our phylogenetic analyses revealed that the many varied morphological types of *P. paradoxus* have complex evolutionary history. Although this species has varied wing length types, almost of mecopteran insects generally have long wings, consequently it is inferred that the short-winged type is the derivative character. The short-winged type differentiated in polyphyletic, and female of this type is darker in body color than long-winged type, and always has wing spots, and this derivative type is observed at high mountain regions. So it is possibly to refer that the short-winged type is the "ecomorph" in this species adapting to coldness, strong wind and ultraviolet radiation.