Landmark Analysis of Dragonfly Hindwings: A 2-dimensional model for morphological evolution.

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Sympetrum costiferum. One of about 5 Sympetrum species found in Maine and 11 species in North America. Most males have a red abdomen but females are less distinctly colored and the individual species are difficult to distinguish. Males can be distinguished by their hamules.

Published shapes of male hamules of several Sympetrum species:

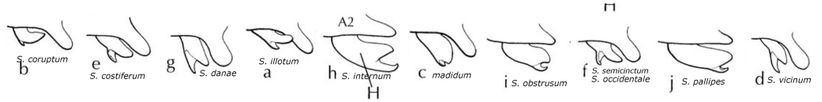
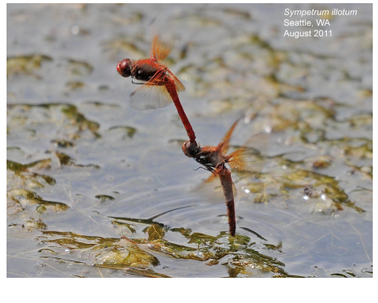


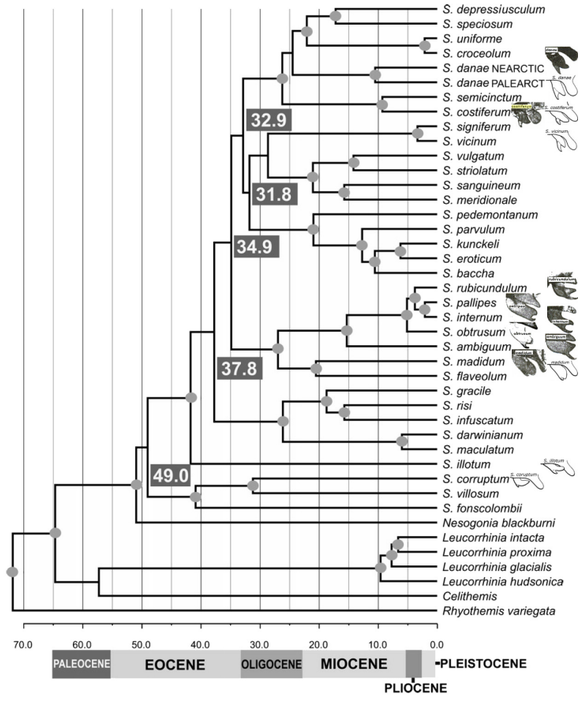
Figure 19. *Sympetrum*, male hamules, side view: a, *illotum*; b, *corruptum*; c, *madidum*; d, *vicinum*; e, *costiferum*; f, ~~*occidentale*~~ *semicinctum*; g, *danae*; h, *internum*; i, *obtrusum*; j, *pallipes*. A2 = abdominal segment 2; H = hamule.

Hamules from two species of Sympetrum collected in Scarborough ME.

The male hamules function to hold the female ovipositor when the partners are joined “in wheel”. They often fly in this configuration during mating and will stay partnered during oviposition.



The divergence and evolutionary relationships of current worldwide *Sympetrum* species have been recently determined using the DNA sequence of 6 genetic loci (Pilgrim & von Dohlen, 2012). The genus originated and has diverged since the 50 myrbp cataclysmic event. Specimens of *Sympetrum* species have been collected in Scarborough ME, in other USA states and from Czechland in Europe.

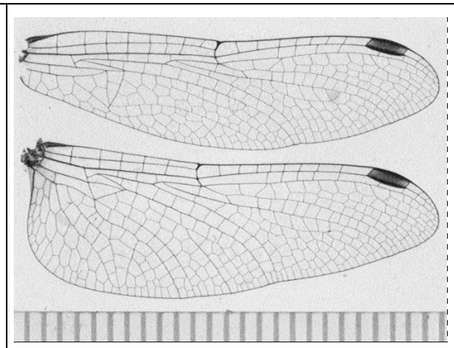


CONCLUSIONS

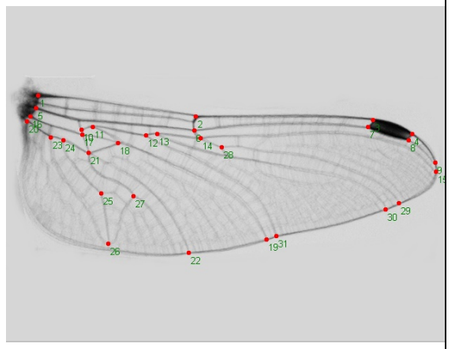
1.
2.
3.

REFERENCES

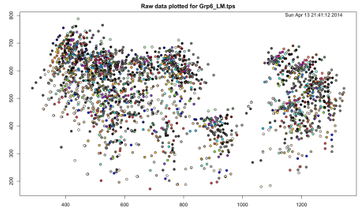
1. Pilgrim EM & CD von Dohlen. 2012. Phylogeny of the dragonfly genus Sympetrum (Odonata: Libellulidae). Org Divers Evol (2012) 12:281–295.
2. Zahiri R, A Sarafrazi, L Salehi and JG Kunkel. (2006) A geometric morphometric study on populations of Rice Stem Borer, *Chilo suppressalis* W. (Lep.: Crambidae) in northern Iran. Zoology in the Middle East 38: 73-84.
3. Kunkel JG and BR Bettencourt. (2011) *Transformer-2* Controls Subtle Sexually Dimorphic Features in *Drosophila melanogaster* wing development. http://bcrc.bio.umass.edu/flyclub/kunkel/kunkel_bettencourt/index.html



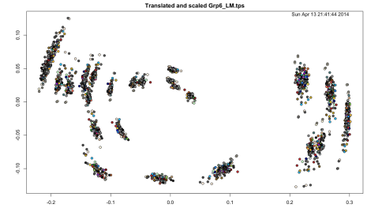
The process of Landmark Analysis uses homologous morphological points such as intersections of wing veins in the case of the dragonfly. A digital image of a wing is obtained. Points are chosen and data is collected using tpsDig software of F. James Rohlf of SUNY Stony Brook which works on digital images allowing landmarks to be chosen by mouse-clicks.



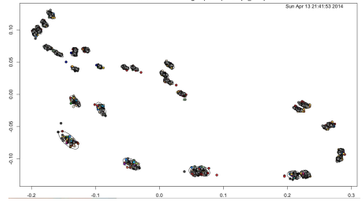
Averages of landmarks and images are made using other software in the tps-suite freely available from URL: http://life.bio.sunysb.edu/morph/
Here a grand average of 35 male and female wings images and the landmarks the average was based on is displayed:
Several packages of software are available for allowing comparison of shapes based on sex, species, populations or quantitative or factorial properties. Custom R-scripts as well as the R geomorph library were applied to 118 male and female wings of specimens collected in Scarborough ME.



The raw landmarks of all the specimens are shown at left. These landmarks are next centered and scaled to a common size below:



Finally, the scaled landmarks are rotated to



coincide best with one-another. In the cloud of individual landmarks at each homologous point there is seen variability that corresponds to sexual dimorphism as well as species differences that will be analyzed as this project goes forward.