Kathleen Tait
Biology 501

EVOLUTION OF DRAGONFLIES

All life began from a common ancestor. According to most scientists, animal life is thought to have evolved from a flagellated protist. This protist evolved by a cellular membrane folding inward, which became the first digestive system in the Animalia kingdom (Campbell, Reece &, Mitchell, 1999). As time went on, the animalia kingdom became more diversified and the class Arthropoda arose. Arthropods had and still have several characteristics in common. Some of these characteristics include segmented bodies, jointed appendages, compound and/or median eyes, and an external skeleton. Arthropods may breathe through their gills, trachea, body surface or spiracles. Within the order of Arthropods there exits the largest class in the animal kingdom, Insecta. Insects share such common features as three pairs of legs, usually two pairs of wings, a pair of compound eyes, usually one pair of antennae, and a segmented body (head, thorax, abdomen). But from where in time did all of these insects evolve?

Wingless insects first appeared in the Devonian period approximately 380 million years ago following the development of the vascular seedless plants. Insects possibly evolved due to the first appearance of seedless vascular plants. These plants were a huge untapped source of food. According to fossil records, insects appeared quickly after plants in order to possibly fill in a new niche.

The evolution of insects occurred in four stages (Columbia University Press, 2003). The dragonfly appears in the second stage and therefore this paper will only cover the first two stages. The first stage is known as the Apterygote stage. These were the

simplest form of insects. They did not have wings, nor developed legs or body parts. Silverfish closely resemble those ancient insects. They do not have a metamorphosis; instead they have an ametabolous development. Ametabolous development means that the immature greatly resemble the adult except for the presence of genitalia and gonads. The fossils from this period (mid-Devonian period) already show the specialized features of the insect order.

The second stage, known as the Paleoptera stage, involves the formation of wings on the insects. This was a very important step in the evolutionary process of insects. Developing wings now allowed the insect the ability to do several things. Insects could now fly great distances and therefore disperse plant life, travel to locate new sources of food, easily find new mates and they also gave the insect the ability to escape predators. Along with the development of the wings came a new more complex type of metamorphosis, the hemimetabolous development. The hemimetabolous development is an incomplete metamorphosis, which means that some change will take place. In this process, the egg is deposited in the water where it develops into a nymph. The nymph resembles the adult, but there is not a pupa stage. However, the nymph will go through several molts before actually becoming an adult. Molting is not to be confused with metamorphosis; they are totally different processes. Many insects must molt in order to grow. The exoskeleton does not grow and therefore the insect must shed the old exoskeleton to form a new one and thereby allowing growth to take place.

Fossils of the first winged archaic insects date back to the late Carboniferous period about 300 million years ago. These insects were in the order Paleodictyoptera, which is the oldest group of winged insects. Paleodictyoptera were the precursors to the

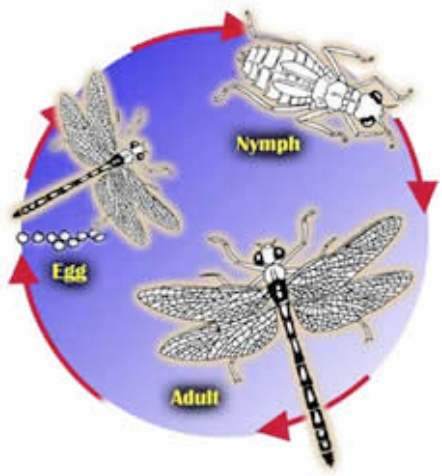
modern day Odonata. Dragonflies, which belong to the order Odonata, are one of the oldest insects still around today and they have not changed much from their ancestors. All Odonata share some similar characteristics in vision, life cycle, habitat, morphology flight, hunting prey and mating.

Compound eyes allow for keen eyesight in the dragonfly (Trueman et. al, 2001). Their eyes can be close together, almost touching to being totally separated. Each eye has 30,000 individual "eyes" called ommatidia, which can give up to a 360-degree field of vision. This gives the dragonfly a sensitive motion detector to hunt and capture prey.

http://www.teleological.org/Images/convergent%20evolution_files/Dragonfly_eye.jpg

Dragonflies must live in moist areas or near bodies of water. Life cycle for all dragonflies begin as eggs. Some species of dragonflies lay their eggs on plants located above or below the water. In other species, the female dragonfly may not have a functional ovipositor, which is used to attach the egg to a surface and as a result may bury their eggs in the sand or mud or directly in the water. The egg can hatch anywhere from 7 to 9 days or up to several months, depending upon the species. Larvae (nymph) live totally in the water and are voracious hunters. All odonata share the characteristic of having a

grasping labium, which is used for capturing prey. Larvae spend all of their time beneath the surface of the water using gills to breathe, and feeding on other vertebrates. Larvae may go through up to 30 molts over a time period of 3 months to 10 years depending upon species. Dragonflies can live a long life as adults from 4 months to 10 years.



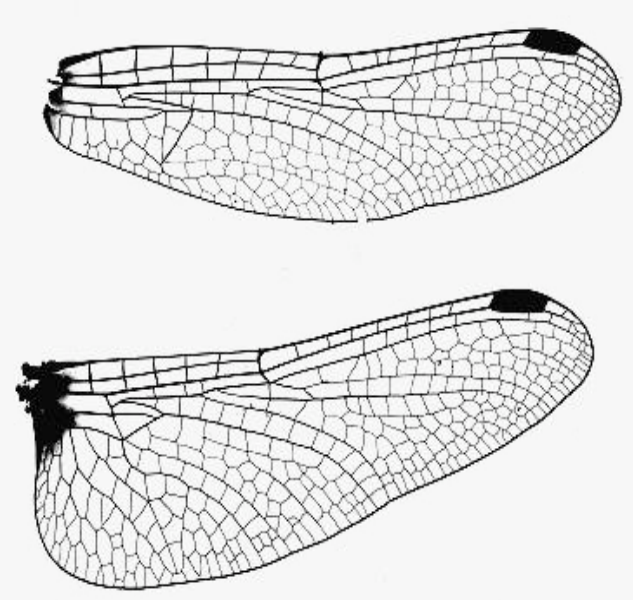
http://www.dragonfly-site.com/graphics/dragonfly_life_cycle.jpg

Adult dragonflies are adept at flying and at capturing their prey in flight. . Although their flight structure and method is ancient, it has not stopped them from being one of the best aerodynamic fliers in the insect world. Dragonflies can reach speeds of up to 97km/hr. Not only that, they are also able to fly backwards, sideways, hover and change directions in a flash. The wings of the order Odonata cannot be folded at rest and are fused to the flight muscle in the thorax. This means that when the muscle contracts, the wings beat (Ingram, 2000). Adults feed on bees, mosquitoes, butterflies and other insects.

The order Odonata is divided into three suborders based upon wing venetion (Tolfilski, 2004). One suborder is that of the Zygoptera, which includes damselflies, another suborder is Anisoptera, which includes dragonflies, and the last suborder is the

Anisozygoptera, which concerns the fossil remains found around the world. Venation is the arrangement of veins in the wing of an insect. These veins form pleats, which causes lift in the flight of the dragonfly. All adult Odonatas have two pairs of wings that are either equal or unequal in size or shape. In Anisoptera, the hind wing is broader than the forewing. There is a cross vein in both wings which divides the cell into a triangle and a super triangle. All Odonata contain a nodus and a stigma in each wing. The stigma is a shaded area located at the upper and outer edge of each wing and the nodus is located in between the tip and base on the forefront of the wing. The Zygoptera suborder has two pair of wings that are the same in size, shape and venation; however, there can be anywhere from a few cross veins to many cross veins.

The venation in Anisozygoptera is between the two suborders.



http://www.corzonneveld.nl/dragonflies/wings/s_sang.jpg
Anisoptera wing

A controversy has arisen within the order Odonata as to which suborder is monophyletic and which is paraphyletic. Monophyletic is a taxonomic group that contains all the descendents of a shared common ancestor. These organisms have similar characteristics. Paraphyletic is a taxonomic group that contains some of the descendents of a common ancestor but not all of them. This group is based on the shared physical characteristics not necessarily on evolutionary relationships. There are two convergent phylogeny theories that are at the center of the debate. One phylogeny theory was put forth by Handlirsch (Trueman et al. 2001) that states Anisozygoptera is a paraphyletic group from which the monophyletic groups of Anisoptera and Zygoptera were derived. Tillyard (Trueman et al. 2001) regards Zygoptera as the paraphyletic group from which the monophyletic groups of Anisoptera and Anisozygoptera were derived.

This debate has been ongoing for years and will likely continue until evidence from fossils or DNA reveal the true phylogeny. There is only agreement (Trueman et al. 2001) on the following:

-Odonata is a monophyletic group, which has been separated from Ephemeroptera, Neoptera, and the extinct Paleodictyopteroidea since at least the Lowermost Upper Carboniferous
-The three extant suborders are closely related
-Fossil suborder Archizygoptera is a subset of fossil suborder Protozygoptera
-Modern Anisoptera is monophyletic

As scientists conduct more research into the phylogeny of each suborder, more consensus may arise. Only time and evidence will tell, until then the debate will rage on.

Scientific Classification of Dragonflies

Kingdom: Animalia
Phylum: Arthropoda
Class: Insecta

Order: Odonata
Suborders: Zygoptera
Anisoptera
Anisozygoptera
Families: Aeshnidae
Austropetaliidae
Cordulegastridae
Corduliidae
Gomphidae
Libellulidae
Macromiidae
Neopetaliidae
Petaluridae

CITATIONS

Campbell , Reece, Mitchell, Neil, Jane B., Lawrence G (1999). *Biology:Concepts & Connections*. Boston, Massachusetts: Addison Wesley.

Evolution and Ancestors. Retrieved August 1, 2006, from Dragonflies - Living Fossils Web site: http://skurvits.tripod.com/dragonflieslivingfossils/index.html

Ingram, Jay (August 29, 2000). Dragonfly's evolution of flight. Retrieved August 1, 2006, from Discovery Channel Web site: http://www.exn.ca/Templates/printstory.asp?PageName=Discovery&story_id=2000081857

"Insect." The Columbia Electronic Encyclopedia, Sixth Edition. Columbia University Press. 2003. *Answers.com* 10 Aug. 2006. http://www.answers.com/topic/insect

Tofilski, Adam (2004).Draw Wing, a program for numerical description of insect wings. *Journal of Insect Science. 4:17*, 5 pp.

Trueman, John W. H. and Rowe, Richard J. 2001. Odonata. Dragonflies and damselflies. Version 01 January 2001. http://tolweb.org/Odonata/8266/2001.01.01 in The Tree of Life Web Project, http://tolweb.org

What's Up Doc. Retrieved August 4, 2006, from Horse-Stingers Understanding the Dragonfly Web site: http://www.pondoc.com/WhatsUpDoc/Wildlife/Horsestingers

Wikipedia. Retrieved August 1, 2006, from Dragonfly Web site: http://en.wikipedia.org/wiki/Dragonfly