Coevolution of Angiosperms with Animals

The role of animals in the evolution of angiosperms have clearly elucidated by studies on comparative morphology, pollination biology and biochemistry. It is suggested that Animal kingdom and Plant kingdom, particularly the Angiosperms have undergone a process of co-evolution, wherein the evolution of one has influenced the other. This has proceeded in various ways.

The earliest seed bearing plants (gymnosperms) were pollinated passively by wind. Ovules exuded drops of sticky, sugary sap from the micropyle to aid pollen capture - like the modern conifers. It is thought that the earliest pollinating insects were sap and resin feeding beetles which discovered the supply of protein-rich pollen and the sticky ovule exudate. Once they returned regularly to the sites of this newly found food supply they began to inadvertently carry pollen to the ovules. For some plants this pollination was more effective than wind pollination alone. The better pollination and increased seed set encouraged the selection towards showy flowers more attractive to insects, edible flower parts, protein rich pollen, nectaries and bisexual flowers so that same insect visit can both deposit the pollen and pick up for visit to another flower.

Increased visits by insects posed danger to the exposed seeds, unfortunately they also ate the ovules, this must have led to evolution of greater protection of the ovules through natural selection. This led in angiosperms to the enclosure and reduction of megasporophylls to produce carpels which protected the young ovules. Greater ovule protection may also be the selective pressure for the evolution of the inferior ovary. This protection also allowed other changes; there was no longer any need for special defence modifications, such as thickening of the integuments, and formation of thick sclerotic seed coats. As a result, the ovules became smaller and simpler - with an even more reduced gametophyte and were capable of much faster development. This speed of development would have been of great benefit in the seasonal climate that is thought to have existed. These changes were also accompanied by the differentiation of stigmatic region, and the distinct style to keep the stigma within the reach of insects. The stigma took over the function of catching pollen grains and simulating the growth of pollen tubes, (previously a function of the micropyle in gymnosperms).

Relatively little energy is used in the construction of the ovule and gametophyte. This is a major step towards the evolution of angiosperms.

To suite to the floral mechanisms the early beetles were slowly replaced by higher insects such as moths, butterflies, bees, wasps and flies, coinciding with the floral diversification of angiosperms.

Beetle pollinated flowers are typically dull or white with fruity odours, edible petals and heavily protected seeds. Bee pollinated flowers are brightly coloured (blue or yellow but not red) with honey guides and with lot of pollen and nectar. Butterfly pollinated flowers are red, blue or yellow. Moth pollinated flowers mostly open at night and have heavy fragrance to attract moths. Moth and Butterfly pollinated flowers generally have long corolla tubes with nectaries at the base. Bird
pollinated flowers are bright red or yellow, produce large amount of nectar, with little or no fragrance. Bat pollinated flowers are dull coloured, open at night and have fruity odour.

**Biochemical coevolution** - Plants and their insect predators are believed to have undergone adaptive radiation in stepwise manner, with the plant groups evolving new and highly effective chemical defenses against herbivores and the latter continually evolving means of overcoming these defenses. Mustard oils of Brassicaceae are toxic for many animals, yet they attract other herbivores such as cabbage worm, which uses the mustard oils to locate the cabbage plant for laying its eggs. The chemical hypericin in genus *Hypericum* repels almost all herbivores but the beetle genus *Chrysolina* can detoxify hypericin and use it to locate the plant.

Interestingly, the evolution of new chemical defense of plant has resulted in plants often acquiring the growth hormones found in insect larvae. Proper levels of juvenile hormone in insect larvae are essential for the hatching of insect larvae into normal sexual adults. Several species of plants such as *Ageratum* contain hormone **juvabione**, similar to the juvenile hormone of insects. Such plants if ingested by the insect larvae elevate the level of hormone, resulting in their development into abnormal asexual adults. The larvae as such, learn to avoid such plants.

Some plant products help insects against predators. Monarch butterfly, for example, ingests cardiac glucoside from milkweed *Asclepias*. Such butterflies if ingested by blue jays make latter violently sick. Blue jays learn to recognize the toxic brightly coloured monarch butterflies. The milkweed, thus helps to protect monarch butterfly from blue jay.

**Change in Symmetry** - From simple radially symmetrical actinomorphic flowers (primitive) developed zygomorphic flowers in various families to suit insect pollination. The size of corolla tube and orientation of corolla lobes changed according to the mouthparts of the pollinating insects, with striking specialization achieved in the turn-pipe mechanism of *Salvia* flowers (as shown below), and female wasp like flowers of orchid *Ophrys*. 

![Pollination in Salvia plicata: A & B. L.S. of flower showing immature pistil and movement of stamen when pressed in the direction of arrow, C. A bee becoming dusted with pollen, and D. A flower with mature stigma](image-url)
**Methods of illustrating evolutionary relationships**

Evolutionary relationships can show common ancestry for populations and species using molecular evidence. This can be in the form of comparing proteins, nuclear DNA or even organelle genetic material.

Biologists use cladograms and phylogenetic trees to illustrate relationships among organisms and evolutionary relationships for organisms with a shared common ancestor.

We can see a typical cladogram and phylogenetic tree here –

A cladogram (on left in the diagram above) looks like a tree that may have been derived from a common ancestor to arrange organisms on different branches. But those branches used aren’t representative of the relative amount of change or evolutionary time that has occurred between organisms. Plus, a cladogram doesn’t necessarily show exact relationships between ancestors and descendants.

On the other hand, the branches on a phylogenetic tree (on right in above diagram) can be proportional to the amount of change or evolutionary time. So, we can also track how species have changed over time. Species are still grouped according to similarities and physical or genetic characteristics - for example, the presence or absence of gills. But, a phylogenetic tree describes an evolutionary history by showing how ancestors are related to their descendants and how much those descendants have changed over time.

It must be pointed out, however, that considerable confusion still exists between application of the terms cladogram and phylogenetic tree.

Bessey also initiated the representation of evolutionary relationships through an evolutionary diagram, a phylogram with primitive groups at the base and the most advanced at the tips of branches (shown below). His diagram, resembling a cactus plant is better known as Besseyan cactus.
Besseyan cactus or Opuntia Besseyi showing the relationship of orders recognized by Bessey