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Symbiotic Interactions, Law of Purposive Association and the +/+ Nature of all Co-evolution

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Abstract

Objectives: To investigate all symbiotic interactions and the resulting specific and diffuse co-evolutions to bring out the +/+ nature of all of them. **Methods:** Analysis of all symbiotic interactions in light of law of purposive association and competition as the fundamental factor behind all of them. **Findings:** All symbiotic interactions are driven by competition at the fundamental level ultimately leading to +/+ co-evolution. All competition, including that involved in mimicry and endosymbiosis, finally ends up in cooperation for gainful evolution. Speciation and diversification depend not only on competition strength and the intensity of the driving instinct for perpetuation. Evolution is all-pervading force acting continuously in and through all organisms towards their perpetuation and up-gradation to higher evolutionary strata through purposive association, even though the organisms themselves don't precisely know or decisively undertake the exercise of such progressive evolution. A holistic vision of the organic wholeness of all life as giant self-evolving organism that includes all life-forms as its mutually interacting components emerges in the final analysis which can be extended to include biotic factors as well. **Applications/Improvements:** Meta-evolutionary analysis of symbiotic interactions based on law of purposive association for gainful evolution of species through competition.

Keywords: Competition, Co-evolution, Exclusion Principle, Mimicry, Mutualism, Symbiosis

1. Introduction

All organisms in an ecosystem interact among themselves irrespective of whether they are phylogenetically close or distant. The interactions may be long term i.e. seasonal or perennial leading to co-evolution or short term i.e. accidental with very little or no apparent consequence for co-evolution or evolution. They may be over large distances (as in case of migratory species of birds and fishes) or in close proximity in the same habitat. They may be intra-specific (within the species) and inter-specific (among species). All such biotic interactions have been grouped under the broad name Symbiosis, which originally means, and was used, only for +/+ interactions i.e. in which both parties gain[1]. But, it is now redefined to include all interactions or associations irrespective of whether favorable or unfavorable to one or both or may even be neutral to the interacting populations[1]. All these interactions form the biotic factors in evolution. However, we have recently proposed *a law of purposive association* which states that all interactions are definitely gainful in the long run, though they may look like being harmful in small time scales, the reason being in the operations of an evolutionary urge in and through all organisms[2, 3].

Darwin noted the interactions between insects and as determining their mutual evolution[4]. The term co-evolution was coined to denote such interactions while describing the relationship between caterpillars and the host food plants[5]. It has recently been observed that co-evolution can and does influence the structural make

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up and functioning of ecological communities and also transmission of infectious diseases[6].

Co-evolution is a type of community evolution where the evolutionary relationships that occur between two or more species in response to the evolutionary pressures they exert on each other have either minimum or no genetic information exchange[5].

Co-evolutionary relationships can be mutualistic where one cannot survive without the other; can be antagonistic where one species has a harmful effect on the other as in case of Prey-Predator Relationships (PPR) or Host-Parasite Relationships (HPR). Such antagonistic relationships lead to a phenomenon called arms race, meaning the counteracting characteristic that one species develops to negate the deleterious effect of the other species. The characters that evolve can be chemicals in forms of poisons or antitoxins or they may be mechanical such as stronger claws or spines. A pair-wise co-evolution involves step by step change in two species and such species need to be ecologically very closely associated in the same community for a span of time that allows such evolution to occur. They evolve in response to the each other's requirement. One species evolves certain specific characteristics and the other species then evolves compatible characteristics in response to this and vice versa. Examples of such specific co-evolution include: butterfly caterpillars and their host plants, bees and the plants they pollinate and ants and the acacia trees they reside in. Guild co-evolution or diffuse co-evolution involves more than a pair of species*e.g.*mammalian grazers and grassland plants, relationships of multiple predators and their prey species.

2. Biotic Interactions and Co-Evolution

Though the nomenclature and the manifest nature of the biotic interactions are different, there is but a single process going on through all these different forms of associations and that is competition. Co-evolution involves competitive interaction among the different species or the same species for their instinctive purposes.

Further, though the interaction is always spoken of as being at species level, but in reality each individual organism has to independently respond to the interactive pressure that builds up on it due to biotic as well as abiotic factors. Thus each individual is responsible for its evolution irrespective of its contribution to the evolution of its species or of other species. However, the individualistic response paradigm means also that species too respond individually to selection pressures and resources, irrespective of evolution of other species[6]. Some species might be controlled mainly by the climate and weather, others mainly by predation, and yet others mainly by competition[7]. Darwin sketched the outline for a process of mutual evolution between a plant and its pollinator and numerous studies have focused on identifying examples of such co-evolution, now formally defined as the reciprocal evolution of interacting species[8].

Organisms mutually interaction a goal directed way to evolve for fulfillment their needs. Through the process of competition the organisms interact and adapt to finally settle into a definite gainful mode, whether it is symbiosis, mimicry or otherwise, to acquire its niche[5].

In some cases the genetic mutations may be short-lived as per the pressure on the organism: for example, as seen in case of *Plasmodium falciparum*, the PFCRT gene mutation is very high during the high drug pressure of chloroquine. However its frequency decreased and even became zero after withdrawal of the chloroquine drug pressure[9]. When interactions among the organisms are very close and deep, it may lead to speciation in them through co-evolution.

In some other interactions, one species may find it difficult and tries to escape from the other as in case of herbivore-plant interaction or prey-predator interaction, where an adaptive radiation occurs from both sides as per the interactive pressure, the urge to escape and the strength of competition to fulfill their instinctive requirement for survival. Thus, it is a diffuse kind of co-evolution. The herbivorous insects have adapted themselves to feed on the toxic chemicals secreted by the affected plants by virtue of plant-insect co-evolution.

Since all biotic interactions are now called symbiotic, we delineate each of them with examples denoting them by ≦/≧ symbiosis i.e. in case there is inequality in survival or in other evolutionary advantage, it is put in the order *less/more* to have a uniform standard for such notations in keeping with the most used formats like Prey-predator, host-parasite, producer-consumer etc. in each of which the first species suffers lossor is at a disadvantage (apparently though). We show that in terms of individual organismic survival the symbioses may be different *i.e.* +/+ (Mutualism), 0/+ (Commensalism), -/0 (Amensalism), -/+ (Exploitation),0/0 (Neutralism) or -/- (Competition), but as far as species survival by adaptive evolution is concerned, all associations are purposive and are for +/+ or mutualistic co-evolution only.

3. Mutualism (+/+ Symbiosis)

It is an association of two different species for mutual benefit. The two species depend metabolically upon each other.

For example, Wood eating species like wood roaches and termites, which have no cellulose enzyme, have some flagellate protozoa in their gut which secret and hydrolyze cellulose to glucose and then ferment the glucose to acetic acid, CO_2 and hydrogen. These substances nourish the flagellates, and the acetic acid is used up in respiratory metabolism in the hosts. Similarly, protozoan ciliates which inhabit the rumen of ruminants such as cattle, Sheep and deer also perform the same function as flagellates do in the gut of termites.

Aquatic animals like hydra, sea anemones, jellyfish and corals have chlorophyllous dinoflagellates in their body which take up the carbon dioxide (respiratory byproduct of the animals) for photosynthesis and help their growth. Yet another example is of the Rhizobium bacteria that get protective residence and readymade food from the roots of the legumes providing the latter with fixed nitrogen to manufacture protein. Also, mycorrhizal association between tree roots and the associated endotrophic or exotrophic fungi is another example of mutualism. The fungi live on the roots of the trees and the latter in turn supply water and minerals.

Some algae and fungi join together to form another life form, called lichens. The fungi utilize the food manufactured by the phototrophic algae. The fungus protects the algae from drying up and both organisms together become lichens colonize tree barks, rocks and so on.

3.1 Mutualistic Co-Evolution

Janzen in 1966 was the first to describe the features of one-to-one co-evolution between acacia and ants *i.e.* the association between the ant species *Pseudomyrmex ferruginea* and the tree *Acacia cornigera*[10].

Acacia provides food by secreting nectars rich in proteins and lipids for the colony of ants. The workers attack the insects and other acacia-eating herbivores because the queen ant lays eggs in the swollen stipules at the leaf base. Acacia will be rendered leafless by the herbivorous insects and its survival will be at stake in the absence of ants. These acacias produce no poisonous chemicals for the grazers. Thus the presence of ant colony helps protect the plants. This association is profitable to them in the sense that instead of producing structurally and biochemically expensive protective mechanisms they can divert the energy for their growth. Besides, due to ants association, these acacias are able to compete more successfully in denser and wetter habitats than other acacias, which have not co-evolved with ants[11].

3.2 Plant-Pollinator Mutualistic Co-Evolution

Many flowering plants are entomophilous i.e. they attract insect pollinators by producing flowers with nectar. The insects take nectar as food and in the process pollinate the flowers. The insect visit to the flower may be a function of amount of nectar, color and morphometry. The insect collects pollen on its body *unintentionally* while visiting the flower and rubs this pollen on the stigma of another flower it visits and if the flowers belong to the same species cross fertilization can occur. This relationship is complex and has co-evolved.

From energetic and cost benefit point of view, the plant should ensure pollination at the minimum cost producing as little pollen and nectar as possible. On the other hand the insect pollinator would maximize the visit to the flower by collecting more nectar per unit time and per visit. Thus theoretically different plants compete among themselves in inviting insect pollinators. They compete among themselves to be pollinated and to perpetuate their own species but they do not compete keeping in view their evolution by this process nor do they know that they are competing- plants by sensation and pollinators by instinct. Thus, the 'evolution' is an all-pervading mechanism which acts everywhere since the entire existence is for the ultimate purpose of evolution.

The pollination in Chinese gooseberries (*Actinidia chinensis*) or in tomato flower requires a special type pollination called buzz pollination. An insect visiting the flower buzzes loudly (produces sound) and the resulting vibration shakes off dry pollen from the male flower. The pollen falls on and sticks to the insect's body. Since honeybees cannot produce buzz sound, they cannot pollinate gooseberries or tomato plants. The large Bumble bee species (*Bombus* sp.) which produces buzz sound are ideal for bringing about pollination in these species.

Another specific mutualistic co-evolution is that of the fig and its pollinator, the fig-wasp. The latter lays its eggs inside the fig and in the process pollinates it. Thus both are benefited by the interaction. The honeybees collect and store pollen for use as food and also for specific use for producing royal jelly that they feed the larvae and the adult queens for their nutrition.

The question is: why at all such pollination mechanisms developed? Is it because of the insects' buzzing behavior that the plant developed such pollination mechanism or vice versa? Do the insects have a real interest to pollinate the flowers? Is there any subtle thing in the insects that is able to realize that the plants need pollination and that it must serve that purpose? Or, is it only because of an unconscious symbiotic mechanism which has somehow gripped the species without their knowledge and using them as its instruments? If so, how the design of this symbiotic mechanism came about? Or, is it in some way other? Could it be that there is some subtle thing in the insect that was present in the core of the being of the plant itself previously in the evolutionary process, and thus had stored the information of the definite pollination mechanism as a specific urge for pollination by that specific type of insect?

It is to be noted that the fertilization is a chance occurrence neither determined by the plant nor by the insect. Therefore, a subtler mechanism definitely acts behind the process, of which the species know nothing. So co-evolution of both the species is neither known to the respective species nor are they interacting to work out evolution of each other. Thus, their association and interaction is purposive, though not decisive, the true purpose of evolution being determined by the cosmic evolutionary force. While the insect sees only food in the flower, the plant sees a possible pollinator. Since plants respond adaptively to availability of specific pollinators and accordingly are known to manifest petal color and nectar amount etc. to attract them, it seems more reasonable to assign a greater decisive role to the flowers rather than to the ignorant insects seeking only nectar in them. The instinct for food in insects has been thoroughly capitalized upon by the more powerful instinct for reproduction in plants. The reproductive urge thus proves itself to be the most powerful one here itself.

3.3 Co-Evolution of Birds and Ornithophilous Flowers

In regions of scares insect population plants have diverged from entomophily to ornithophily in order to achieve reproductive fitness by suitable evolution of nectar amount, petal color and shape[12-16]. In *Penstemon*, adaptations favoring bird pollination may have had less impact on the evolutionary changes in floral traits compared to those that discouraged bee-pollination, but ornithophilous and entomophilous adaptations can be simultaneous as well[16]. Flowers such as *Heliconia angusta* have been observed to be pollinated by *Trigona* stingless bees though they were ornithophilous earlier. These bees take pollen for storing as food, but in the process pollinate them[17].

3.4 Mutualistic Diffuse Co-Evolution

Many entomophilous flowers have their nectar at the base of a long tubular vase, which can co-evolve with a corresponding complementary trait in the many pollinating insect species *e.g.* a long proboscis. Many families of bees, flies, beetles and wasps pollinate them resulting in mutual diffuse coevolution[18-20].

Several hummingbird-pollinated flowers bloom at a time just following the breeding season of several species of hummingbirds in North America. The color and morphology of these flowers are specifically effective in luring the birds to them. The bill morphologies of the birds are exactly in complementary correspondence with that of the corresponding corolla tubes of the flowers that they pollinate. This adaptation forcing a particular orientation and positioning of the bird during nectar-extraction allows the plant to place pollen on a specific part of the bird, thus permitting many mutual morphological adaptations[15].

4. Commensalism (0/+ Symbiosis)

In this symbiosis, one species is benefited whereas the other is neither harmed nor benefited (*i.e.* remains neutral). The participating members are called commensals. The dependent commensal gets the support of the substrate directly or indirectly for its food, shelter, support, transport or protection.

In the hermit crab - sea anemone ecto-commenslism, the crab uses the gastropod (mollusk) shell as a portable shield with the anemone fixed to the crab or on the shell. The anemone eats the crab's leftover food and the crab gets protection due to the presence of the stinging cells of the sea anemone. In opalina-toad endo-commensalism, opalina residing within the toad presumably does no damage to the toad, but it is itself benefited. Similarly, Inquilinism is a special type of commensalism in which one organism, called the inquilines, shares the nest or burrow of the other without (presumably) causing any damage to it.

Epiphytism is another type of commensal biotic association. Epiphytes, growing on other plants, do not derive their food from them. They are common in tropical and subtropical humid climates and get their moisture and nutritional requirements from rain. Besides, they store water in their special root tissue called velamen. Plants belonging to the families Bromeliaceae, Dischidia and some species of Ficus orchids, Lichens and mosses are epiphytes. Lianas are woody plants which have roots in the ground but climb up with the support of other trees and reach the top of the canopy. They do not derive their nutrition from these trees, but require their support for climbing up.

4.1 Commensalistic Co-Evolution

In the hermit crab-sea anemone commensalism, the anemone has little ability of locomotion and thus would run short of food. By providing defense to the crab, it has food security in the form of the residual food of the crab which forages on the sea bed. Thus it is beneficial to both and hence it is mutualism rather than commensalism.

Similarly, in epiphytism, the epiphyte in using the plant as a support, can and does cut off part of the sun rays with its leaves and may eventually block all sunrays if its leaves ever covered the entire canopy of the support tree, thereby harming it. Also it definitely leads to some stunting of the upward growth of the plant's branches (if not the trunk) and thereby harms it. The relationship would then be parasitism rather than commensalism.

In every case that is presumed and declared as commensalism, a deeper analysis would certainly reveal a gain or loss for the substrate, in which case it becomes a +/+ or -/+ symbiosis. And whatever be the symbiosis, the co-evolution is always +/+ *i.e.* win-win interaction.

5. Exploitation (-/+ Symbiosis)

PPR, Parasitism or HPR and Producer-Consumer Relationships (PCR) are all -/+ symbiotic relations and can all be put under exploitation or generalized Prey-predator Relationships as proposed by us[2].

In PPR the prey is devoured by the predator as an essential food item as per their placement in the natural food chain and it is rather ubiquitous if properly viewed in a general sense[2].

5.1 Co-Evolution by PPR

It is observed in nature that poisonous and distasteful animals are very often brightly colored like bees, wasps etc. Thus predators learn not to kill them. For example, two poisonous butterflies of Amazon basin, viz Heliconius erato and Heliconius melpomene belonging to one geographical area have similar wing patterns. Because of the same wing patterns the birds learn not to kill them thus they kill fewer insects and hence the insects benefit. The birds also benefit in learning what to avoid and catch fewer poisonous insects and thus preserve their number.

5.2 PPR and Diffuse Co-Evolution

The tree-inhabiting class of mammals diversified after dinosaur-extinction to occupy aquatic and terrestrial as well as cave and aerial habitats. They were omnivorous and began to graze as the forests changed largely to grasslands. The problem of predation then became more intense and they could no longer avoid being spotted by the predators. This led to the necessity of developing great ability to run fast to survive. The predators correspondingly also changed their strategy from being solitary hunters to group hunters (pack hunters such as wild dogs, hyenas, wolves and lions) because many herbivore species also started to live in groups to increase survival against predation. Thus there were definite morphological changes in both herbivores as well as carnivores. The prey species have thus constantly engaged themselves in evolving strategies to escape from the predator and predators on their part have busied themselves with evolving new strategies to catch them! This is the co-evolutionary arms race[21, 22].

5.3 Host-Parasite Relationship (HPR)

In parasitic symbiosis the parasite is benefited by drawing its nutritional requirements from the host which is often harmed in the process. The well-adapted parasite of course devours just enough of the host's body or resources to meet its requirements, since killing the host would ultimately endanger its own survival. Bed bugs, fleas and mosquitoes are *ectoparasites* living outside the hosts, while the malaria parasite (*Plasmodium*), round worm, tape worm, etc. are endoparasites that live within the hosts. Facultative parasites such as certain flies of genus Chrysomya and Calliphoracan live as parasite and also as free living organisms outside the host in decomposing organic matter. Obligate parasites cannot live without the parasitic association. Parasitic relationships can also be between plants and plants, plants and fungi. Common angiospermic parasites are Cuscuta, Orobanche, Balanophora and striga.

5.4 Co-Evolution by HPR

In HPR both the host species and the parasite evolve together as exemplified in the Red Queen hypothesis[23-25].This coevolution is supposed to have resulted in a tilt in favor of the prevalence of sexual reproduction in higher species which were host to multiple parasite species. It generated genetic diversity and polymorphism and histocompatibility[26-28].

5.5 Diffuse Co-Evolution by HPR

The collections of large number of bacteria in the guts of humans and of the ancestral great apes have co-evolved with their respective host species since millions of years[29]. The bacterial flora is collectively called the microbiota. They have co-evolved with their hosts so much that they can determine moods and feelings[30]. Not all of them must have been beneficial when they entered the gut as parasites but over millions of years of coevolution has rendered them all to stay permanently in a mutualistic symbiosis with their hosts so much so that their number is far more than that of the cells composing the average human body and human evolution may have been influenced by their presence as much as their evolution in turn has also been affected[31]. This gives us an example of the transition from initial HPR (-/+) to mutualistic (+/+) symbiosis by diffuse co-evolution.

5.6 Producer Consumer Relationship (PCR)

The symbiosis between animals and plants constitutes producer consumer relationship and it is the primary trophic-level interaction across species. Herbivory is the most prevalent natural food-chain link apart from carnivory.

In grasslands and forests, grazing by cattle and wild herbivores has a significant effect on the constitution of the vegetation. Heavy grazing reduces photosynthetic parts more rapidly than the rate of replacement and hence severely affects plant composition. Some plants are resistant to grazing or are not preferred by grazers while some others are consumed more.

5.7 Co-Evolution by PCR

As an example of herbivore plant coevolution we note that the crossbills and red squirrels in Rocky Mountains compete to eat the seeds of lodgepoles. If squirrels are present in a locality the lodgepoles have heavier cones with thinner scales and fewer seeds which are disadvantageous for the squirrels. Conversely, if only crossbills are there and no squirrels, then cones are seen to be lighter, having thick scales which make it seeds inaccessible to the crossbills.

5.8 PCR and Diffuse Co-Evolution

Grazing involves the large scale consumption of seeds due to their high nutritive value, which results in poor successive crops, unless the plants adapt to vegetative propagation. Rats selectively remove seeds from grasses and store them in their burrows in large quantities. They might be the reason of co-evolution of vegetative propagation along with sexual reproduction in grasses[32].

Herbivores graze a variety of plants and in general plants have developed mechanisms like development of thorns, tough leaves distasteful chemicals and toxins to reduce or avoid herbivore grazing pressure. Herbivorous insect species feeding on many plants might have to evolve tolerance to a number of different food sources and the plants may produce different chemicals to ward off the insects. Diffuse co-evolution, as in pair-wise co-evolution, can be mutualistic or antagonistic[32].

Most seed plants depend upon butterflies, wasps, moths, beetles etc. for the transfer of their pollen to the stigma. All higher animals including humans also help in the dispersal of seeds by carrying the fruits over long distances or by eating the fleshy parts and throwing the seeds, thereby helping in the dispersal. Seeds or fruits of Xanthium, Achyranthes etc. bear hooks which get attached to the body of grazing mammals and thus get dispersed. This must be the result of a kind of commensalistic diffuse co-evolution of such plants with the grazers, since the latter don't seem to gain anything from the former.

6. Plant Carnivory: Unusual PPR

Plants like Utricularia, Drosera, Dionaea and Nepenthes are common insectivorous plants. They have specialized structures to trap insects. Small insects get entangled within structures and their soft parts get digested by the enzymes of the insectivorous plants[33].

6.1 Co-Evolution by Plant Carnivory

It is well known that carnivory in plants evolved independently in about 600 different species having convergent patterns of evolution and co-evolution of bacterial genomes of the microbiota associated with them depending on plant taxonomy, biogeography and trap types as well as digestive enzymes. *Nepenthes bicalcarata* found in Bornean peat swamp area has a nutritional mutualistic relationship with its ant symbiont *Camponotus schmitzi*. There is coevolution of fitness between those inhabited by ants and the ants themselves. Compared to the unoccupied plants, the inhabited plants produce broader leaves with higher nitrogen content. There is thus nearly a 200% increase in nitrogen availability for adult plants. The pitchers of *C. schmitzi*-occupied plants are bigger and are qualitatively different and the biomass content is also larger[34].

7. Amensalism (-/0 Symbiosis)

In this symbiosis, both species share the same habitat but one gets harmed while the other is neither harmed nor benefited. For example, grazers trample upon some species of grass that are not their food thereby harming the latter. Similarly while grazing; the grazers eat up lots of small creatures and their eggs etc. that are there in the grass. The latter are harmed while the grazers remain unaffected, unless by co-evolution, the symbiosis has upgraded itself to become either commensalistic or mutualistic[35].

8. Neutralism (0/0 Symbiosis)

In Neutralism, the species interact but don't affect each other. Here the effects on one another may be so insignificant that it is apt to presume that no effect is there. It can be taken to be there between non-interacting species. Still absolute non-interaction is impossible to obtain. Sooner or later the interaction if it exists will turn out to be causing gain or loss to at least one of the parties and then it will beany one of the other categories of symbiosis. If there is minimal or negligible niche overlap, then neutralism may occur between species. As the neutralism slides into any of the other modes of symbiosis it starts making contribution to co-evolution as per that mode[35,36].

9. Mimicry and Co-Evolution

Mimicry in the evolutionary adaptations may involve morphology, behavior or any other property corresponding to sensory signals which help the mimic gain advantage or avoid disadvantage in survival or perpetuation. Mimicry can be protective or defensive or can be aggressive or predatory or pseudo-predatory. In Batesian mimicry the harmless poses to be harmful, while in Mullerian mimicry, mutually harmless speciesmimic one another to pose themselves as harmful ones for a common predator or many predators. In Emsleyan or Mertensian mimicry the dangerous one poses to be less dangerous and in Vavilovian mimicry (Plant mimicry) weeds resemble the bonafide crop species and in this last category usually humans are the unintentional selecting agents[37].

Co-evolution results from the arms-race involving the mimic and the model (counterpart of the mimic), because the latter also can take recourse to different techniques for its own advantage by ensuring that the mimicry is either not attempted at all or is detected easily. The models themselves may also be mimics and there can be more than two species taking part in a mimicry ring and diffuse co-evolution will then be the result.

Egg mimicry of Passiflora is an example of Gilbertian mimicry. Female *Heliconius* do not lay eggs on those plants which are used up for laying, but the plant shows up false eggs on its leaves to avoid the *Heliconius*.

Mimicry thus involves co-evolutionary interactions. In Müllerian mimicry, there is reciprocal evolution between mutually distasteful models towards similar phenotypes. Therefore it is a +/+ mutualistic interaction in which all species benefit.

Batesian mimicry in the African mocker swallowtails is worth noting. The female of the species mimic region specific toxic models thereby looking different from both sexes of their species. On Madagascar, the island off Eastern African coast toxic models is not available and hence the females do not mimic and have the same appeared as the males.

Brood mimicry as in case of cokoo-crow relationship is also known as brood parasitism[38, 39]. A recent study has discovered that there is an element of mutualism involved in brood parasitism, since for some hosts, there is increasing evidence that the survival of host chick's increase by 40% if the cuckoo chick is present due to the immunity gained against the terror of foraging cat species owing to a chemical secreted by the cuckoo chick[40].

Mimicry can be put under any type of symbiosis depending on whether there is gain or loss or neutrality of the species involved. The co-evolution however is ultimately for mutual benefit only and is thus +/+ in nature.

Masquerade (also called crypsis) can be a kind of defensive or aggressive camouflage to avoid getting detected by predator or prey by mimicking the appearance of inanimate objects such as sticks or stones or bird droppings[41]. It seems to be aimed specifically at avoiding bird-predation as they see from a distance to alight on the prey and thus require visual deception by such masquerade. However, all other forms of sensory deception by mimicking the other aspects (e.g. smell, taste etc.) of inanimate things may also be occurring in appropriate cases. The important point to note is that here the model is inanimate (abiotic). Is this the way the animals got at least some of their natural color, smell etc. - just to avoid predation? Thus mimicry somehow goes beyond the distinction between biotic and abiotic factors.

And, it can provide an understanding of the meta-evolutionary factor behind the phenomenon as being the evolutionary urge in the mimic for survival leading to epigenetic changes and the resulting mutations that bring it the genetically encoded successful imitation[2,3,42]. The intent and purpose in the psyche of the mimic to avoid, repel or attract are the most important factors that determine all forms of mimicry and masquerade. The urge to survive by not being detected, or if detected, the urge to be perceived as a threat (e.g. as a possible predator or as poison or at least as unpalatable food) to the approaching organism are the two dominating instinctive psychological modes that lead to the epigenetic encoding which gets accentuated as corresponding mutations in the mimic in course of evolution. In the meta-evolutionary paradigm, both predator diversity and environmental factors can be determinants of polymorphism in mimics.

10. Competition (-/- Symbiosis)

Competition is the fundamental mode of interaction where antagonism prevails in some form or the other because of common resources having to be shared among individuals or species e.g. cheetah and lions in the same habitat. It is assumed to be causing loss to both the interacting species and this is branded as a -/- symbiosis, which however is not correct. If competition were really -/- then we must expect that the weaker species will eventually become extinct, but on the contrary both species have co-existed since long. This does point to something deeper than what has so far been assumed to be driving force behind evolution: It is not competition but cooperation.

The species evolve progressively as a result of competition through biotic interactions and co-evolutionary effects on the organisms involved.

To appreciate the importance of competition and coevolution in bringing out species diversity it suffices to just state a few major recent research findings on divergence in systems such as Darwin's finches, spade foot toads, and Caribbean island lizards, three spine sticklebacks as also in many other limnetic and benthic species[43-56].

All these are the forms of competition among the organisms for their basic reproductive rate for which they need to avoid mortality by ensuring their survival through successful competition through purposive association to attain requirements such as space etc. according to the hierarchy of their survival, through successful competition by purposive association to attain requirements such as space, etc. according to the hierarchy of their instincts. Competition is the only interaction in nature which brings all evolutionary consequences[57-59].

10.1 Competitive Success and Evolution

The cosmic evolutionary force acts in every species and everywhere irrespective of the type of interaction whether biotic or abiotic[60]. The evolution process is always in progress irrespective of the nature of symbiosis. Though the reason ascribed for evolution may be competition, adaptation, variation, diversification and so on, competition is the fundamental process operating everywhere incessantly for the very existence of any organism on earth. Different modes of interaction are but the functional aspects of the cosmic evolutionary force that includes, but transcends the existence and survival of the organism.

Evolution is driven by both biotic and abiotic factors as also by competition[61]. However, the rate of evolution may vary as per the intensity of urge to win in the competition based on the primordial instinctive need through competitive stress tolerance by developing newer traits following different adaptive mechanisms[3]. As Stanley argues, mammals have higher rate of evolution than bivalves because of their higher degree of inter-specific competition[62].

Every interaction is a mechanism by which the organism tends to fulfill its basic instinctive urge for self perpetuation. The interactions of the organisms are the factors of evolution but the reasons for different rates of evolution by such interactions are not very clear[63,64]. The design of the biosphere is as a ubiquitous relationship of prey-predator only[2]. The whole system is always under a competition pressure. Through the competition the instinctive urges get manifested in order of their hierarchy. To fulfill the primordial instinct of "perpetuation", all organisms exert to quench the rest of the urges. Their position in the hierarchy finds meaning in their immediate success in the competition. The fundamental criterion for evolution is the 'Urge for self perpetuation' and the intensity of this urge is responsible for making an organism fittest one to win the competition[43].

Competition builds a stress in the organism; the organism responds to stress through adaptation; adaptation influences its epigenome and develops epigenetic marks. More the instinct driven competition pressure, more the epigenetic marks the organism develops and accumulates and they influence the future generation too. The resulting population may be of a different genetic constitution[3]. The whole universe is a physical manifestation of the cosmic evolutionary force of the urges using the epigenome and consequently the genome only as the medium of its operation[65].

10.2 Competitive Exclusion Principle and Co-Evolution

Competitive exclusion principle states that to related species cannot occupy a single niche[66, 67]. If there will be no competitors for a species then the colony of the species will experience an ecological release as a result they will grow into a bigger population size. In such a situation, disruptive selection resulting in speciation may happen and when many species are involved they may undergo adaptive radiation as in case of Darwin's finches in Galapagos Islands and sticklebacks in Canada and also Salmonids from Noway and Ireland[67].

Gomez *et al* have observed diffuse coevolution of phytophagous insects with herbivores like *ungulates* in presence of *Timarchalugens*, beginning with competition for niche and then settling into either the modes of commensalism or exploitation as time progressed[68].

11. Adaptation, Ecological Release and Co-Evolution

Availability of a fresh niche to a species as the result of a new adaptation leads to ecological release. When the beetles adapted to large scale her bivory their clades multiply many fold compared to the other clades[69]. Similarly latex bearing plant species under went rapid speciation at a comparably greater rate than other taxa as the result of this new trait which is an adaptation against herbivores. The sudden expansion of diversity resulting from development of such new traits is termed as "escape and radiate" coevolution.

12. Primordial Co-Evolution of Cellular Components

It is currently an accepted fact that membrane bound organelles such as mitochondria and plastids in eukaryotic cells have resulted from endosymbiosis of certain bacteria in protoeukaryotic cells[70]. The similarity of alpha-proteo bacteria with mitochondria and cyanobacteria with chloroplasts lends credence to this proposal.

The examples of tightly bound mutualistic coevolution like that in case of fig and fig-wasp, and also between *Yucca* and Yucca moth (*Tegeticula*) have become so obligatory and specific that they are much like the primordial mutualism between mitochondria and chloroplasts with the archebacterial cells.. But can we think of the yucca and its moth or fig and fig-wasp as forming one organism living as part-plant and part-insect, in the same way as the cell with mitochondria and chloroplasts forms a whole living entity or as algae and fungi form lichens? Can endosymbiosis be more fundamental and ubiquitous than has been surmised so far? We wish to take up these important questions in a future publication.

13. Conclusion

We have argued that all symbiotic interactions are factors leading to evolutionary benefit for the species in the long run, though in certain initial phases of their existence they might have been detrimental to the individual organisms. Incessant competition among species for acquiring their respective biotic and abiotic niche is the rule and thus competition is never a -/- symbiosis as is usually presumed. In all forms of co-evolution it is competition alone that is the functional method of ever changing adaptive behavior. Without competition all life would simply perish. It is a different matter altogether that what appears to be competition at one stage is but a mode of cooperation for the higher more expanded life forms to thrive which is made possible by epigenetics and co-evolution of species.

The organism may not know the purpose of their interaction and its purpose may be different from its point of view or from ours, but every interaction is purposive and decisive by the cosmic law of evolution. Evolutionary force is an independent cosmic force which is acting in a goal-directed manner through seemingly diverse mechanisms towards a definite goal to be achieved through the intermediary of various visible and invisible forms that it operates through.

The visible interactions that have been studied among biotic factors are only the tip of the iceberg, so to say, because the entire spectrum of living organisms forms one giant living system of which the individual organisms are mere subsystems interacting mutually for survival and for evolution. The ant-acacia system for example is not just confined to the two co-evolving species only but extends beyond them to the other organisms that have various forms of interactions with them. For example, the termites population around, the flowering plants around with which the ants interact get affected by the ant-acacia coevolution. Similarly, the medicinal properties of acacia and the herbivores that depend on acacia do get affected by the ant-acacia co-evolution. There is thus always diffuse coevolution of the component life-forms that are interacting incessantly through the various symbiotic interactions. Thus, seen with a proper perspective and an expanded vision, the whole universe is one giant living, throbbing and evolving organism, with the various life-forms inhabiting it forming but its myriad organically related mutually interacting components.

14. References

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