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Popular Article

Host Manipulation by Parasite: An Insight

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Host manipulation by parasite can be defined as any alteration in host phenotype, induced by a parasite that has altimetry give the benefits to parasite. By altering the host behavior, it is very easy to facilitate the transmission or dispersal of the parasite leading to the completion of its life cycle. The phenotypic traits of a host will be modified either directly or indirectly through modulation in the genes in the parasite genome. Indeed, host manipulation by parasites has been proposed as one of the main concrete examples of extended phenotypes (Dawkins, 1982). These manipulative parasites in an animal population can shape host evolution, influences the ecology of other parasite species, alter the structure of the surrounding animal community etc. Generally, Nematomorpha or Acanthocephala has the ability to alter host behavior (Moore, 1984) and they target to modulate the physiological system, Immune System, and neural system (Lafferty *et al.*, 2013).

How parasites alter host behavior?

- Directly by interacting with the host's nervous system or muscle
- May secrete/excrete a neuro-active substance
- Can influences host development, intermediate metabolism and/or immunity
- Indirect effects on host behaviour by affecting host tissues other than neurons and muscles etc.

Adaptive manipulation

Adaptive manipulation refers to parasite-induced changes in host behaviour that benefit the parasite, often through enhanced transmission to the next host in the life cycle of the parasite. The parasite and its host must be at the right place at the right time to be transmitted to the next appropriate host. As a result, in some situations, natural selection has favoured parasites capable of manipulating their host's behaviour. In general, it is considered that behavioural changes observed in parasite-infected hosts could be explained by one of three phenomena: -

- ✓ The parasite itself does something specific and direct to the host, in order to alter behaviour to its own benefit
- ✓ The host changes its own behavior in order to eliminate or minimize the effect of infection.
- ✓ The change in host behaviour is the coincidental result of pathology or immune response.

Alterations in host

Parasites may use chemical secretions or other means to alter a variety of host behaviours in a way that benefits the parasites by increasing their chances of transmission to the next host. Changes in host phenotype, for new behaviours, and they provide strong evidence for the concept of the extended phenotype, i.e. genes in one organism having phenotypic expression in another organism (Dawkins, 1982).

Multiple parasites within manipulated hosts

When manipulation is costly and when both non-manipulative and manipulative parasites have a similar transmission agenda (i.e., they have the same intermediate and definitive hosts), non-manipulator parasites should increase their chance of transmission by preferentially infecting hosts that are already manipulated (hitch-hiking strategy) (Thomas et al., 1998).

Types of Manipulation

- ***Direct Method of manipulation***

Demonstrating that secretions/excretions from a parasite act directly on host neurons has proven difficult. Part of the problem lies with the complex interactions between immunity and the nervous system. When parasites invade any tissue, including the CNS, they typically envoke complex, but poorly understood, immune cascades Kristensoon *et al*., 2002) resulted in the release of neuroactive compounds and causes a variety of changes to the brain and behavior. Some parasites secrete chemicals identical to those secreted by the host's immune system. For example, the trematode *Schistosoma mansoni* secretes -endorphin and other opioid peptides and these substances affect both immune and neural function (Kavaliers *et al*.,1999).

- ***Indirect method of manipulation***

As example Trematode (*Trichobilharzia ocellata)* suppresses egg laying of IH snail, (*Lymnaeastagnalis)* similarly Parasitic excretion altered the snail's immune system and releases chistosomin with Gene expression in the snail's CNS, depressing egg laying in the snail.

- ***Predator -prey encounters***

As example three spined sticklebacks harbouring the larval cestode Schistocephalus solidus swim closer to the water surface and become less aware of the presence of predatory birds that serve as the parasite's definitive hosts (DHs). Rodents infested by the nematode Trichinella spiralis or the protozoan Sarcocystiscernae are less wary of predators, thus facilitating the parasites' transmission to DHs.

Examples of predator- prey encounter-

- ***Dicrocoelium dendriticum***

D. dendriticum is transmitted to ruminants, including domestic cattle and sheep, when they accidentally ingest infested ants along with their plant food**.**The parasite larva induces its insect host to climb to the tip of grass blades and remain there, anchored by its mandibles, awaiting ingestion by a grazing herbivore.

- ***Diplostomum spathaceum***

Complex three host life cycle including lymnaeid snails, fish and fish-eating birds, such as grebes and cormorants. Metacercariae induce cataracts due to mechanical destruction of the lens and metabolic products excreted by the parasites, thus reducing the host's vision (Karvonen *et al*., 2004).

- ***Hydatid disease***

Due to infestation with cysts (metacestodes) of the cestode parasite *Echinococcus* spp. Infested IHs may thus become more vulnerable to predators, including the DH of the parasite. Internal organs, including the lungs, are often among the first to be eaten by large carnivores, such as wolves. Therefore, it is possible that selection has favoured the location of parasite cysts at these sites to ensure rapid consumption by the DHs instead of transmission probability.

- ***Toxoplasma gondii***

Alterations in host behaviour by parasitic infection are sometimes exactly what we would expect to see if the host was to start acting in ways that benefit parasite transmission. In rodents, T. gondii causes increased levels of activity, along with decreases in neophobic (i.e.

fear of novelty) and anxiety behaviours, all of which could potentially enhance transmission to DHs.

- **Physiological manipulation-** it may occure due to different ways-
    - Parasite remodels the RBC infected to get nutrients
    - Parasite secretes hundreds of proteins that need to be transported from vacuole to interior of cell
    - Plasmodium translocon of exported proteins (PTEX), are essential for transporting materials to and from the vacuole.
- **Neuromodulatory manipulation**

Hosts infected with *T. gondii* exhibit changes in expression of dopaminergic and anxiogenic brain receptors, in levels of neurotransmitters, such as dopamine, and in concentrations of noradrenaline (norepinephrine) and testosterone.

- **Manipulation of habitat choice**

Parasites can also manipulate host habitat choice. As example digeneans such as Gynaecotylaadunca drive their molluscan first intermediate hosts toward beaches for the release of cercariae close to amphipods and crabs (second intermediate hosts). Hairworms (phylum Nematomorpha) and mermithid nematodes (phylum Nematoda) are parasitic in arthropods when juveniles, but they are free and aquatic when adults. Insects harboring mature nematomorphs seek water and jump into it, thereby allowing the parasitic worm to reach its reproductive habitat (Thomas *et al*., 2002).

- **Manipulation by vector borne parasites**

Leishmania/sand fly associations, infected flies exhibit increased probing behavior due to difficulties in ingesting the blood meal (Koella *et al*.,1996, 1998). Parasitized female mosquitoes make many attempts to feed and thus visit many different hosts, each time depositing parasites at the feeding site. Malaria sporozoites apparently reduce in salivary apyrase activity, an enzyme that counters host hemostasis. Reduced efficiency of blood meal location -*Rhodniusprolixus* (a blood feeding true bug, vector of Chagas disease in Latin America) infected with *Trypanosoma rangeli*, tsetse flies infected with *Trypanosoma* spp., and the rat flea *Xenopsyllacheopis* infected with the plague bacterium *Yersinia pestis*. Proximal reasons for changes in feeding behavior include physical blockage of the foregut by parasites (plague-infected fleas), obscured phagoreceptors (tsetse flies infected with trypanosomes), and reduced apyrase activity in the salivary glands (*Rhodniusprolixus* infected with *T. rangeli*) (Hurd H, 2003).

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Are humans manipulated by parasites?

The rabies virus (genus: Lyssavirus) -dogs exhibiting the encephalitic (furious) form of the disease show increased aggression and biting . Biting is the most effective means of transmitting rabies and therefore this change in host behavior will increase parasite transmission. Levels of dopamine, its precursor L-dopa, and serotonin decreased upon parasitization by the human blood fluke Schistosoma mansoni. In some cases, the change in host behavior (e.g., increased lethargy) could benefit both. Unfortunately, most parasite-induced changes in human behavior are identical to various aspects of "sickness behavior," that is, a host response to infection (Kristensson et al., 2002) making it difficult to determine whether the change benefits the host or parasite. Parasites that inhabit the central nervous system (CNS) are in a prime location to manipulate host behavior. In humans, Toxoplasma infections result in slight personality changes and reduced psychomotor performance (Webster, 2001). Pinworm Enterobius vermicularis lay their eggs around the anus - intense itching end up on fingers for transmission.

Cost of manipulation by parasites

As examples-

- ✓ Amphipods (Gammarus aequicauda) -immune response against manipulative trematode M. papillorobustus
- ✓ Encapsulation in host's cerebral region and melanization
- ✓ Higher risk of mortality for the parasite
- ✓ Manipulation is costly for parasites Individuals in larger infra populations suffered reduced size and fecundity etc.

Mafia like strategy for manipulation

- Parasites show collaborative behavior in their hosts by imposing extra fitness costs on recalcitrant hosts- **mafia-like strategy** (Soler *et al*.,1995).
- Cuckoos may force bird host to tolerate non-self-eggs by making rejection more damaging than acceptance (Zahavi *et al*.,1979).
- Ejector magpies suffer from nest predation as "punishment"
- Such retaliation favors an increase in "acceptor genes" relative to "rejector genes" in the host.

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