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THE TOP DOWN CONTROL IN TERRESTRIAL ECOSYSTEM: A REVIEW TO UNDERSTAND DOMINANT PREDATOR EFFECT ON SUB-ORDINATE PREDATOR.

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ABSTRACT:

Majority of papers address the top down control of predator in aquatic environment and effect on prey and vegetation in terrestrial habitat. Understanding the regulation of sub-ordinate predator by dominant predator in terrestrial environment is important to manage the ecosystem. The interaction in carnivore community is difficult to document in natural environment yet is an important aspect of carnivore conservation and management. The monitoring and maintenance of a) top predator prevent trophic cascade and mesopredator release, b) prey and habitat according to carrying capacity of carnivore guild helps in co-existence of sympatric carnivore, as well as in mitigating human-carnivore conflict. However, the studies oriented to understand relationship of top predator with sub-ordinate predator is limited and dominantly addressed in one of the three axis of niche partitioning (the diet, diel and habitat usage). The effect on mesopredator in abundance or absence of top predator is found to be patchily studied for major predator species across the world.

KEYWORDS: *top-down control, carnivore, terrestrial habitat.*

INTRODUCTION :

The importance of apex predatorfor regulation of an ecosystem in wildlife conservation ambit, was discussed more than half century ago (Leopold 1943,1949, Ripple et al 2005). The top down hypothesis or the cascading trophic interaction drew much of scientific community attention through 1940 to 1990s and in the context of three trophic (producer-herbivore-predator), elaborately in controlled lotic and lentic ecosystem (Hairston et al 1960, Carpenter et al 1985, Power 1992, Strong 1992). A review to understand the role of top predator on terrestrial ecosystem was done during these time (Terborgh et al 1999).The role of terrestrial top predator as umbrella species and effect on prey, vegetation and other communities like avi-faunawas also researched from late 1990s (McLaren & Peterson 1994, Rogers and Caro 1998, Crooks & Soule 1999,Terborgh et al 2001, Berger et al 2001, Rooney et al 2003, Ripple and Beschta, 2003, 2008).

In a Predator Prey system both Mesopredator release and Intra-guild predation occur (Palomere et al 1995) as in Top predator (limited by competition), mesopredator (limited by predation and competition) and prey (limited by predation); though the indirect effect on vegetation by top predator is a debated question (Polis et al 1999, Schmitz et al 2000). Also, the Optimal foraging theorydoesn't link top predator with small sized prey, however the research development in top down control contradicted the theory (Palomere et al 1995,Courchamp et al 1999,Letnic 2009, Brashares et al

2010).

Since studies to understand trophic cascade due to elimination, decimation, reintroduction of top predator requires long-term data in natural eco-system, it is considered difficult logistically and being ethically challenging (Trewby 2007). However,due to elimination of top predator in natural ecosystem like wolf, dingoes and African lion provided such opportunity (Glen et al 2007, Berger et al 2008, Sinclair et al 2011, Ripple et al 2013).Experimentally certain studies prove individual behavioral shift in sympatric sub-ordinate predator due to top predator (Watt et al 2010).

The present literature review investigated the following question in a terrestrial top down control:

The effect on the lower carnivore community with Increase /Decrease in abundance and elimination/reintroduction of top terrestrial predator.

The web search was done with keywords "predator", "predation", "intra-guild predation", "carnivore", "ecological meltdown", "trophic cascade", "meso-predator release", "trophic interaction", "tiger", "leopard", "wolf", "leopard"," lion", "dingoes", "reintroduction", "extinction", "terrestrial".

RESULT:

The literature search for terrestrial carnivore top down control synthesized into 28 research. Multiple research from similar area especially oriented to fox, coyote was eliminated. Terrestrial predator effect on only herbivore and involving invertebrate predator was further eliminated from the synthesis. The top predator whose effect and regulation on lower trophic carnivore is observed in natural environment is tiger, wolf, lion, dingoes, lynx, coyotes, puma, badger and feral cats. Hypothesis of few of the individual studies on sympatric carnivore did not include to understand top down control and inter-specific competition. The studies which concluded niche overlap but no direct effect on subordinate predator by dominant predator was excluded from the following synthesis.

Table1: Effect of top terrestrial predator on lower carnivore community

S.No.	References	Top predator status	Effect of Top-down control/ trophic cascade	Process
1	Morse 1974	Tiger presence	Reduction in niche breadth of leopard	Interspecific competition
2	Major et al 1987	Presence of Coyotes	spatial avoidance by red fox	Interference competition
3	Litvaitis et al 1989	Increase in abundance of Coyote	reduction in Bobcat population	Exploitative competition
4	Palomere et al 1995	Abundance of Iberian lynx	limitation to mongoose, Rabbit increase	Intra-guild predation
5	Palomere et al 1996	Iberian lynx home range	Egyptian mongoose and genet avoided lynx habitat	Intra-guild predation
6	Courchamp et al 1999	Feral cats	limit exotic mesopredator rodents, Increase in kakapo	Intra-guild predation
7	Crooks and Soule 1999	Presence of coyotes	Suppression of mesopredator and increase in scrub breeding birds	Intraguild predation and mesopredator control
8	Kitchen et al 1999	Presence of Coyotes	temporal, spatial overlap. Segregation on basis of diet. High mortality of swift fox by coyote	intraguild predation
9	Mitchell et al 2005	Presence of wild dog	temporal avoidance/ localized habitat shifts by fox	Intraguild predation
10	Helldin et al 2006	Presence of Lynx	Partial decrease in red fox population	Intraguild predation
11	Glen et al 2007	Reduction in dingoes and feral dogs	Increase in fox population	Intraguild predation
12	Berger et al 2008	Presence of wolf	Limitation to presence and abundance of coyotes	Intraguild predation
13	Letnic et al 2008	Presence of Dingoes	reduction of red fox, increase in rodents	intraguild predation

14	Trewby et al 2008	culling Eurasian badgers	Increase in red fox	intraguild predation
15	Johnson et al 2009	Presence of Dingoes	Decrease in abundance of red fox	intraguild predation
16	Wang et al 2009	Tiger presence	leopard habitat usage did not overlap with tiger	Habitat preference
17	Hayward et al 2009	Lion and spotted hyena	temporal avoidance by wild dog and cheetah	Interference competition
18	Brashares et al 2010	Decimated lion and leopard	Primate mesopredator Olive baboon increase; reduction in ungulate population	Mesopredator release
19	Cupples et al 2011	Presence of dingoes	Suppression of fox population, increase in small prey	Intraguild predation and dietary competition
20	Harihar et al 2011	Increase in abundance of tiger	shift in habitat usage and diet in leopard	Intraguild predation
21	Viota et al 2012	Iberian lynx home range	shift in microhabitat use of Egyptian mongoose	Intra-guild predation avoidance
22	Mondol et al 2012	Reintroduction of tiger	Spatial and temporal avoidance by leopard	Intra-guild predation avoidance
23	Bhattarai et al 2012	Tiger presence	Leopard diet have more of small sized prey	resource partitioning
24	Swanson et al 2014	Increase in African lion population	local extinction of wild dog	Intraguild predation
25	Gordon et al 2015	Dingo presence	restriction to feral cats; abundance of rodents and its foraging efficiency	Intra-guild predation avoidance
26	Wang et al 2015	Puma occupancy	spatial and temporal segregation due to coyote activity which in turn by Puma activity	Intra-guild predation avoidance
27	Allen et al 2016	occurrence of Puma	subordinate fox uses dominant Puma scent to avoid Coyotes	behavioral cascade
28	Sugimoto et al 2016	Presence of Amur tiger	Leopard have wider niche breadth	Niche partitioning
29	Groom et al 2016	increase in Lion population	Reduction in pup to adult wild dog ratio, Shift in habitat usage	Intra-guild predation

DISCUSSION:

The literature synthesis established top down regulation by predator in terrestrial ecosystem. The diversity in predator level can affect the intensity of top-down effects by niche complementarity or intraguild predation and interference between predator species (Straub et al 2008, Stachowicz et al 2007). However, such intensity observation is difficult for terrestrial mammalian predator due to their cryptic behavior. The terrestrial mammalian community studies mainly focus on three axes to understand co-existence of sympatric carnivores; The diet partitioning, the diel partitioning and the habitat partitioning. The body size decides the social dominance amongst predator and hence the sub-ordinate carnivore avoid the dominant predator on one or more of the above-mentioned axes.Studying the overlap between sympatric carnivore on any one of the three axes fail to highlight the top down control due to body size by tiger (Wang 2009, Sevlan, 2013, Lovari 2015, Sugimoto et al 2016). Where top down control and biodiversity regulation is reported for wolf (Beschta and Ripple, 2007, Ripple and Beschta, 2008), Dingo (Letnic et al 2012, Dickman 2009), lion (Sinclair et al 2010), it was observed that such studies lacked for tiger. The avoidance of tiger by subordinate predator leopard and dhole is reported (Morse 1974,Harihar et al 2011, Mondol et al 2012). The co-existence amongst tiger, leopard and dhole is driven by principal prey (Ramesh et al 2012) or habitat heterogeneity (Karanth et al 2000), large size prey density (Seidensticker, 1976), contradictsthe theory of top-down control by tiger. The

co-existence of sympatric carnivore is said to be facilitated by expulsion rate of subordinate predator by dominant predator (Seidensticker, 1976).

Apart from few, diversity of carnivore studies proffers that top down control regulates the carnivore communities. The mesocarnivore whose distribution may widely be affected not only by habitat, anthropogenic effects but also by carnivore community interaction cannot be monitored over large scale due to logistic constraints and elusive nature of the species. However, certain management intervention has been undertaken which had been positive as well as negative in long run e.g controlling exotic rodents by feral cats to conserve endangered kakapo (Courchamp et al. 1999), persecution of dholes was undertaken to save livestock but it resulted in increase in wild boar hence more crop raiding and loss of agricultural fields (Wangchuk 2004). The management of ecosystem can benefit from understanding carnivore community.

The social impact of loss of top predator has also resulted spread of diseases and change in living condition of people apart from change in attitude e.g. reduction of lion and leopard resulted in olive baboon release , more crop raiding and spread of diseases in humans and also the children had to leave school to guard the agricultural fields (Brashares et al 2010). The estimation and monitoring of carrying capacity of various trophic carnivore and their prey can involve timely managerial intervention. This would prevent dispersal of sub-ordinate carnivores to fringe areas of forest causing human wildlife conflict.

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