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3

Biological Control of Parasites

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1. Introduction

As a rule, all species of animals are regulated by other living organisms (antagonists) which are not under manipulation by man but they are naturally occurring in our surrounding environment. The process called natural biological control when man attempts to use naturally occurring antagonists to lower a pest population which would cause losses to plant or animals. Biological control is an ecological method designed by man for lower a pest or parasite population to keep these populations at a non harmful level. In practice, applied biological control has no direct application to internal animal parasites especially in their parasitic stages which may be indirectly regulated by intermediate, paratenic or transport vectors even free living larval stages. Many organisms such as viruses, bacteria, turbellarians, earthworms, tardigrades, fungi, spiders, ants, insects, rodents, birds, and other living things are found to contribute significantly toward limiting parasite populations such as arthropods, protozoans and helminthes of domesticated animals. Numerous pathogens and predator of parasites (arthropods) have been known for decades, but few biocontrol programs have been developed. Parasites are controlled almost exclusively by chemical acaricides. The development of resistance to acaricides and their harmful to the environment necessitate alternative control strategies such as habitat modification, use of pheromones and hormones, improvement of host resistance and biological control. Research on the potential use of pathogens, parasitoids, or predators for the biological control of animal parasites lags for behind for plant pests. Among the discouraging remarks are statements that natural enemies are not efficient for biological control, because the population of parasites is so large and that there is little potential for biological control (Cole., 1965). Because the fecundities of predators appear to be below the level required to respond to the explosive increase in example tick numbers which follow certain types of weather such statements may explain partly the longtime neglect of this field and similar arguments were also expressed during the first steps of plant pest biocontrol.

2. Pathogens and their potential in biological control

Most pathogens enter arthropods via contaminated food. This means of entry is however not efficient for introducing pathogens into sucking arthropods such as ticks. Even so, some entomopathogenic fungi, as well as nematodes can penetrate the host via the integument.

Most pathogens are effective against arthropods only at relatively high humidity. The efficiency of pathogens to invade an arthropod depends to a large extent on the arthropod density. However when an area is artificially over flooded with a pathogen, it may reduce a pest population nearly to zero.

2.1 Fungi

2.1.1 Entomopathogenic fungi

The kingdom fungi is a monophyletic assemblage which at present comprises four major phyla: A; Chytridiomycota, B; Zygomycota C; Basidiomycota and D; Ascomycota. (Berbee & Taylor., 1999). The chytridiomycota contains few entomopathogenic species, but includes two genera (Coelomomyces and coelomycidium that kill the larvae of haematophagous diptera and have been studied fot the biocontrol of mosquitoes and black flies (Tanada and Kaya., 1993). The entomophthorales (zygomycota) include some important obligate entomopathogens that cause natural epizootics in a range of agricultural pests , and contain some key species that can not be grown readily *in vitro.* (MacCoy et al., 1988). The most widely studiesd genera of entomophthoraleans fungi, associated with pest control , include Conidiobolus, Entomophthora, Erynia and neozygites. Also Basidiomycota include a limited number of entomopathogens (MacCoy et al ., 1988). The Ascomycota contains many of the major plant pathogens and, together with the mitosporic fungi they also constitute the majority of the entomopathogens. The laboulbeniales (Ascomycota) comprise a larg number of commensal species that are confined to the exoskeleton of insects. The mitosporic fungi include many species of most important entomopathogens and members of the mitosporic entomopathogens are the most widely used for biological pest control.

Important genera of fungi are reported to be major pathogens of some parasites (insects) (Hall and Papierok 1982) because of their wide dispersal, their wide spectrum of hosts and their ability to efficiently enter into the cuticle. Entomopathogenic fungi require high humidity for propagule germination and hyphal penetration. At low temperature and low humidity they may parasitize the ticks via the anus and the fungus hyphae invade the ticks via the genital pore. The most commonly investigated entomopathogenic fungi belonged to the genera *Metarhizium* and *Beauveria*, and to the less extend to *Verticillium* and *Paecilomyces*. We reported for the first time the pathogenic effects of *Lecanicillium psalliotae* against *Boophilus annulatus* (Pirali-Kheirabadi et al., 2007 a,b). Entomopathogenic fungi are used against terrestrial insects, because of their wide geographic spread and host range as well as their unique ability to germinate even at a relatively low humidity. Fungi can remain active on cattle ears for 1-3 weeks in field trial. (Kaaya et al., 1996). The effect of a lot numbers of entomopathogenic fungal species has not yet been tested on different acari or insects. Entomopathogenic fungi attack insects by fungal propagules and affect their host via mycelia as well as by mycotoxins. In a study, application of extracts from 158 fungal strains in 29 genera on engorged females of *Booophilus microplus* tick (Acari ixodidae) revealed that only *Aspergillus niger* was able to prevent egg laying (Connole., 1969). Fungi from the genera *Metarhizium* and *Beauveria* are used increasingly in commercial formulations against insects. Their value as commercial biocontrol agents has yet to be proven but their high genetic variability and possible alternative ways to improve their formulations can made them promising candidates for future use as commercial biocontrol agents. In a comprehensive study, the pathogenicity of 11 strains of fungi including *Metarhizium anisopliae* (3 strains),

Beauveria bassiana (6 strains) and *Lecanicillium psalliotae* (2 strains) against various developmental stages of *Boophilus annulatus* was evaluated for the first time in Iran (Pirali-Kheirabadi et al., 2007.a). The authors introduced the fungus *L. psalliotae* as a novel biocontrol agent of *Boophilus annulatus*, *in vitro*. Fig. 1 shows detailed information about destructive effects of tested fungi on different developmental stages of *B. annulatus*. In another report, the susceptibility of different developmental stages of *R. (B.) annulatus* to the Iranian strains of Entomopathogenic fungi *B. bassiana* and *M. anisopliae* and *L. psalliotae* were studied (Pirali-Kheirabadi et al., 2007.b). These fungi have global distributions and can be mass produced readily. Over 15 mycopesticides formulated from these genera are now available commercially for the management of a reng of pests in the homoptera, Coleoptera, Lepidoptera , Diptera, and orthoptera (Shah & Goettel., 1999).

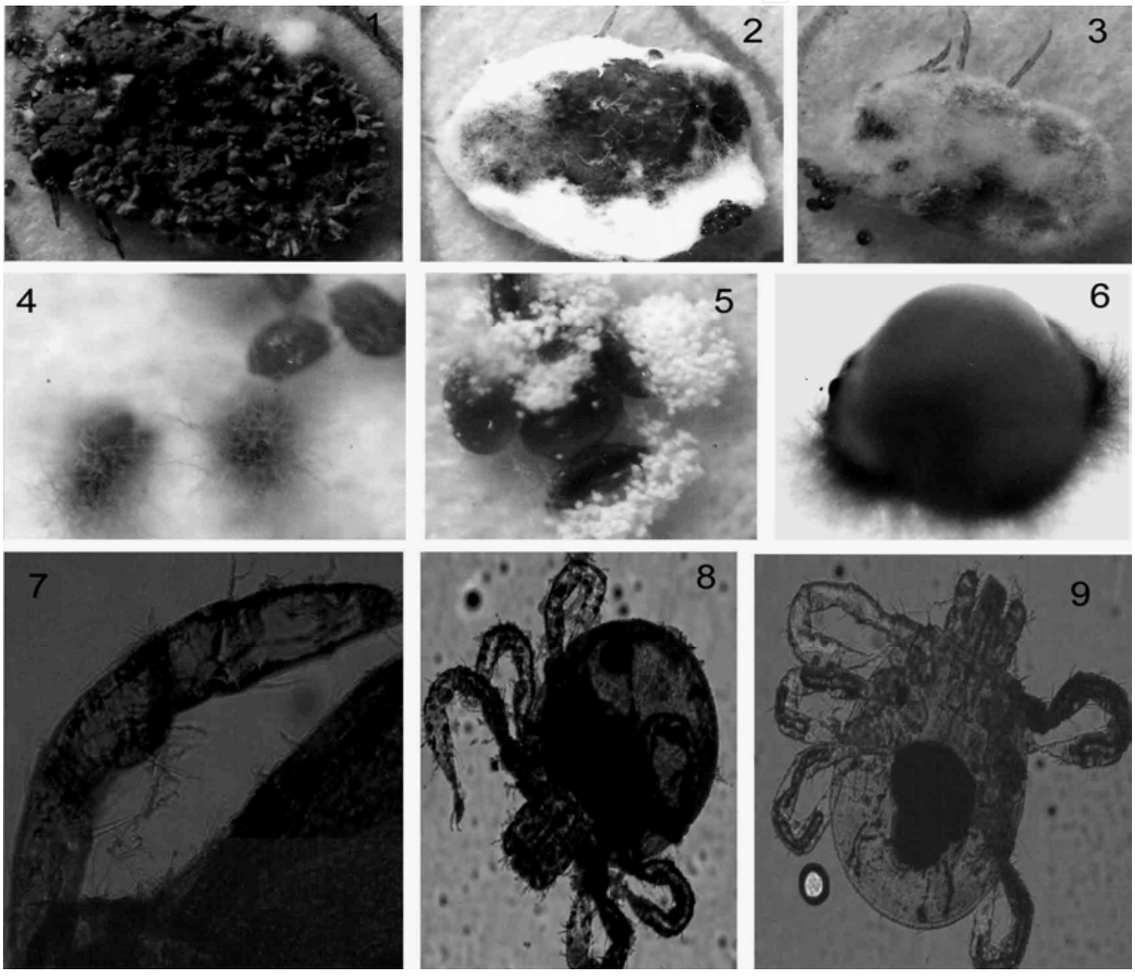


Fig. 1. Effect of fungal strains on engorged females (Figs. 1-1, 1-2 and 1-3), eggs (1-4, 1-5 and 1-6) and larvae (1-7, 1-8 and 1-9) of *Rhipicephalus annulatus*. *M. anisoplae* in Figs. 1-1, 1-4 and 1-7, *B. bassiana* in Figs. 1-2,1-5 and 1-8 and *L. psalliotae* in Figs. 1-3, 1-6 and 1-9.

A few entomopathogenic fungi have been tested against mosquitoes led to obtaining different results. However, only small-scale experiments have been carried out. The protective effect of two isolates of an entomopathogenic fungus, *Metarhizium anisopliae*

(DEMI 002 and Iran 437 C) on bee (*Apis mellifera*) colonies from the adult stage of *Varroa destructor* was evaluated in comparison with fluvalinate strips in the field by Pirali-Kheirabadi et al. (Unpublished data) and demonstrated that Isolate DEMI 002 can be considered as a possible non-chemical biocontrol agent for controlling bee infestation with *V. destructor* in the field.

2.1.2 Nematopathogenic fungi

Nematopathogenic fungi commonly called nematode-destroying fungi are a widespread ecological group of more than 150 species of microfungi which are able to invade nematodes. They maybe divided in to three groups. Most species are found within the group of nematode trapping fungi. Species of this group produce nematode-trapping organs such as constricting (active) or non constricting (passive) rings, sticky hyphae, sticky knobs (as shown in Fig. 2 for *Arthrobotrys candida*), sticky branches or sticky networks (as shown in Fig. 3 for *A. oligospora*), at intervals along the length of a widely distributed vegetative hyphal system. The anchoring of the nematode to the traps is followed by hyphal penetration of the nematode cuticle. Inside the nematode host, trophic hyphae grow out and fill the body of the nematode and digest it. Another group, the endoparasitic fungi, infects nematodes by spores. Inside the host, they develop an infectious thallus which absorbs the body contents. Endoparasitic fungi have no extensive hyphal development outside the body of the host except fertile hyphae such as evacuation tubes or conidiophores that release the spores. A third group may be defined as fungal parasites of cyst and root-knot nematodes. They invade eggs or females by in growth of vegetative hyphae the last two groups should be called endopathogenic fungi and fungal pathogens of cyst and roar-knot nematodes, respectively.

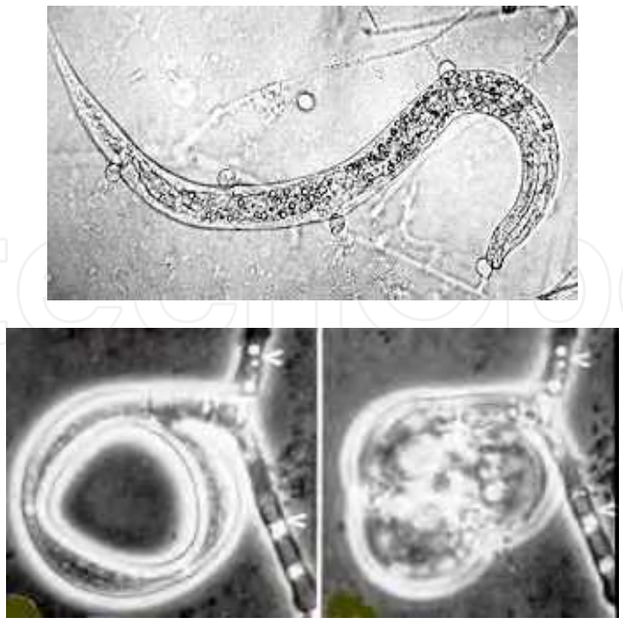


Fig. 2. Sticky knobs of *Arthrobotrys candida* and trapping fungi before and after constriction (Baron 1977).



Fig. 3. Sticky ring and branches of *Arthrobotrys oligospora* (Jaffee 1990).

In a survey, the effect of temperature, incubation time and in vivo gut passage on survival and nematophagous activity *Arthrobotrys oligospora* var. *oligospora* and *A. cladodes* var. *macroides* was studied in order to show the potential of these fungi in management of parasitic nematodes infections of ruminants in field condition (Ranjbar Bahadori et al., 2010).

2.2 Nematodes and earthworms

Numerous nematodes are either obligate or facultative parasites of insects. To date, hundreds of antagonistic organisms of nematodes have been described which are found within the group of viruses, bacteria, fungi, amoeba, earthworms, tardigrades, copepods, dang beetles and mites. Infection may take place by penetration of the cuticle, invasion through spiracles or anus or after ingestion by the host insect. Promising entomoparasitic nematodes are members of the genera Steinernema (Neoaplectana) and Heterorhabditis. Apparently, it is not the nematodes themselves, but the symbiotic bacteria they carry which are released in to the insect body that cause septicaemia and death. Mermitid nematodes can infected some ticks. For example among *Ixodes ricinus* ticks collected in denemark, 6% were infected. The length of juvenile nematodes was up to 20 mm and their exact taxonomic status is not known (Lipa, et al., 1997). Their fetal effect on their hosts is primarily due to a large hole left in the cuticle when they exist the host. With the success of mass cultivation, entomopathognic nematodes like Heterorhabditidae and Steinernematidae have been used commercially against various insects during the last decades. (Martin., 1997). Because their infective juveniles live in the upper layer of the soil, they are used mostly against insects living in this layes, e.g. ground-inhabiting stages of fleas. (Henderson et al., 1995). Engorged females of numerous other ticks species were killed by these nematodes. (El-Sadawy., 1994; Kocan., et al., 1998; Mauleon et al., 1993., Samish et al., 1996; Zhioua et al., 1995). The 50% lethal concentration values obtained with engorged *Boophilus annulatus* are similar to those achieved with nematode preparations against insect. *Steinernema* strain is active at 20-30 ^{o}C, but less infective at 15 ^{o}C, whereas a sub population of the some strain was efficient between 15-30 ^{o}C (Samish and Glazer., 1992, Zhioua et al., 1995). Soil-filled buckets with more silt, more manure or less moisture reduced the virulence of the nematodes (Samish et al., 1998). Nematodes may become a successful tool against ticks because many ticks drop off the host are highly susceptible to nematodes and most engorged ticks hide for days in dark and humid upper layers of the soil. Finally, nematodes could be readily applied either by irrigation or by spraying from the ground or air at low cost and they remain infective in

humid soil for long periods. (Martin., 1997) However nematode use may be limited to defined ecological niches because of the susceptibility of nematodes to low humidity, high manure or high silt concentration, the need for relatively high temperatures and the difference in susceptibility of tick stages and species to nematodes (Samish et al., 1998).

Nematodes from the families Heterorhabditidae and Steinernamatidae are used in commercial formulations but non field experiments to kill ticks and their value as commercial biocontrol against ticks has yet to be proven. According to Williams 1985, the entomoparasitic nematode, *Steinernema (Neoaplectana) carpocapsae* has shown some success against mosquitoes on an experimental level. A host specific entomoparasitic nematode, *Heterotylenchus autumnalis* parasitizes *Musca autumnalis* resulting in sterile female flies as nematode development occurs at the expense of egg production. Groups of predatory nematodes such as mononchids, dorylaimids, aphelenchids and diplogastrids are able to kill other nematodes by teeth, spears or stylets in their bucal cavity. The aphelenchids use a toxin to paralyze the prey during the battle. Their biology is unknown and it is open question if they may be of practical use in biocontrol in field conditions. Earthworm populations consume large volumes of soil and organic matter such as animal faeces. During feeding, they consume nematodes present in soil and faeces. The indirect beneficial effects of earthworms on the development of the free living stages by aerating deeper layers of the pats may be counterbalanced or even obliterated by more direct effects i.e. when earthworms start eating the dung. Dung beetles may significantly reduce infective larvae of gastrointestinal trichostrongyle nematodes when they erode cow pats, bury fresh dung in the soil and partially dispersevthe reminder. It must be concluded that in different parts of the world earthworms are responsible for natural biological control of trichostrongyle nematodes. Because of the beneficial effects of earthworms, it is important to protect these organisms in the areas where they live.

2.3 Bacteria

Strains of the entomopathogenic bacterium *Bacillus thuringiensis* are among the most widely used antagonists in biological control of insects. After ingestion, target insects are killed by a gut toxin which is released from crystal proteins in the bacterial spores. The first symptom is cessation of feeding, follow by a rapid breakdown of the gut epithelium. Because of the insect-killing abilities of *B. thuringiensis* depend to a large extent based on a toxin; the use of this bacterium is probably comparable in many ways to using pure toxin chemical compounds. Another bacterium, *Streptomyces avermitilis*, produces toxins collectively called "avermectins" which are highly effective against several invertebrates from the classes Insecta, Arachnida and Nematodes. Important anti-parasitic drugs, e.g. Ivermectin are produced by chemical modifications of the avermectins. Although according to our definition from biocontrol, use of avermectins is not in this category. In some countries, *B. thuringiensis* var. *israelensis* is available for control of mosquito larvae (Ravensberg 1994). The black fly *Simulium damnosum* which is an important vector of *Onchocerca volvulus*, causative agent of river blindness, is susceptible to *B. thuringiensis* var. *israelensis*. *Pasteuria (Bacillus) penetrans* is a well known nematopathogenic bacterium of plant parasitic root-knot nematodes. Bacteria spores adhere by adhesive microfibers to the cuticle of juvenile nematodes. As a consequence, the spores germinate and penetrate cuticle, filamentous microcolonies created inside the host body will destroy the reproductive capacity of the

infected female host. Eventually, thousands of endospores release to the soel from the dead decomposing nematodes. Based on present knowledge, it is doubtful if *P. penetrance* can be applied in biocontrol of nematodes of veterinary importance.

2.4 Rickettsiae

Most known species of rickettsiae family are parasites of warm-blooded animals, but some of them also parasitize arthropods (Hsiao and Hsiao., 1985). For example, ticks become adapted as vectors, reservoirs and/or propagation sites of rickettsiae (Raoult and Roux., 1997) and often harbor generalized asymptomatic infections. Reckettsial infection may lead to alterations in tick behavior, interfere with their development and cause pathological changes in salivary glands and in ovarian tissues. In sever cases, depending on the degree of infection and the rapidity of generalized infection and other circumstances, this infection may lead to death (Sidorov., 1979).

Rickettsiae like organisms are obligatory intracellular organisms confined in most cases to the malpighian tubes and ovaries of the host (Nodaet et al., 1997). Some parasites ingest bacteria with the blood of their hosts or become contaminated for their skin. High humidity and temperature increase bacterial contamination of the many pathogenic bacteria against insects. Some are also pathogenic to useful insects, men and domestic animals, but they do not usually share the same ecological niches.

2.5 Protozoa

Entomopathogenic protozoans have received little consideration as antagonists in biological control of insects. One problem is that most protozoans have a narrow host range combined with a low virulence, so it must be expected that they cannot be used alone. Some protozoa such as *Haemogregarina*, *Nosema*, *Babesia* and *Theileria* are pathogenic for some parasites like "ticks". Successful insect biocontrol pathogens have not been tested against insect and ticks. Biological control of ticks with *Babesia* or *Theileria* is not promising because of their pathogenic effects to vertebrates. Although there are no examples of effective direct biological control of protozoans in veterinary science, however indirectly, some protozoans, e.g. *Plasmodium* spp., may be controlled by their intermediate hosts or vectors. The predatory soil amoeba *Theratromyxa weberi* is capable of ingesting nematodes. It flows over the nematode body and assimilates it within 24h. This and other amoeba can be expected to have limited biocontrol capacities because they are slow-moving compared with nematodes. Also they are sensitive to low soil water potentials, conditions under which nematodes may thrive. One genus of ciliated turbellarians flatworms, *Adenoplea*, prey exclusively on living nematodes and it is unknown if they may be of potential use in biological control of parasites of domestic animals.

2.6 Virus and virus-like particles

More than thousands of entomopathogenic viruses active against insect have been described but still only very few are commercially available. Viruses either do not play an important role in reducing parasites populations or else our knowledge is too limited to determine their effects.

3. Predators and their potential in biological control

Predators can be vertebrates or invertebrates, some of which are arachnids, but deployment of insects is most common. The efficiency of predators in controlling populations of some parasites in different habitats varies and may reach up to 100% (Wilkinson., 1970 a,b). For example, predation is lower in tall grass areas than in short grass areas (Mwangi et al., 1991). Likewise, predation was two to eight times higher in open areas than in a ticked pasture area and none in intensive pasture or agricultural areas (Krivolutsky., 1963).

3.1 Arthropods

Occasionally, female arthropods are eaten by males. As an example, cannibalism of engorged females by males is reported mainly for argasid ticks (Oliver et al., 1986). In ticks all unfed stages may parasitize engorged nymphs or females. Cannibalism is often found during overcrowding on a host, in laboratory colonies when there is a lack of host animals. In ticks this behavior leaves typical scars in the integument. Biological control of insects may include predators (e.g. spider) parasites, parasitoids, (insect parasites of insects) or pathogens like viruses, bacteria, fungi, protozoans, and nematodes. Spiders have defined habitats. A change in the habitat, such as mulching may increase the spider population by as much as 60%. (Jackson and Pollard., 1996; Riechert and Bishop., 1990). Nine genera of spiders from six families were reported to pray on five hard tick and two soft ticks' genera. (Carroll., 1995; Krivolutsky., 1963; Mwangi et al., 1991; Spielman., 1988; Verissimo., 1995 and Wilkinson., 1970). Genus *Teutana triangulosa* spiders prefer *Rhipiocephalus sanguinus* to flies.

3.1.1 Mites

Some mites are nematode predators and the role as nematodes predators played by some micro- arthropods like mites has yet to be defined. Some mites are capable of consuming *Ascaris* eggs.

3.1.2 Flies (Diptera)

A breakthrough in the indoor control of the house fly has been the use of the predatory fly *Hydrotaea (Ophyra) aenescens*. In several countries of northern Europe *H. aenescens* is commercially available for biological control of *Musca domestica*. The predatory fly was introduced from America to Europe in this century**.** Wild predatory flies were observed in Denmark for the first time in 1972 and a commercial product was released to the market 20 years later. In 1994, *H. aenescens* was used for biological control in 5-6% of Danish pig farms.

3.1.3 Ants: (Hymenoptera) and beetles

Around 27 species of ants from 16 genera mainly *Aphaenogaster*, *Iridomyrmex*, *Monomorium*, *Pheidol* and *Solenopsis* are known to be tick predators. Ants are known to pray on most tick genera. Application of S*. invicta* in the United States markedly reduced the number of anaplasmosis in seropositive cattle in Louisiana (Jemal and Hugh-Jones., 1993). The predation in open areas was two to eight times higher than in woody ones. (Mwangi et al., 1991) Wild rabbits living in *Formica polyctena* infested plots had far fewer ticks than those in

ant-free plots and rabbits sprayed with formic acid were free of ticks for at least 5 days (Buttner., 1987).

Beetles (Coleoptera) pasture livestock flies breed primarily in cow pats. There have been many attempts to control these flies biologically by means of natural enemies and scavengers which consume and bury the dung. In this connection, dung beetles of the family Scarabaeidae (Scarabaeinae, Geotrupinae, and Aphodiinae) are relevant. Dung beetles such as *Onthophagus gazelle* and *Euoniticellus intermedius*, introduced from Africa to Australia are regarded as useful in biological control of *Musca vetustissima* and the buffalo fly *Haematobia exigua* pest flies. The African dung beetles are well adapted to cattle faeces and compete with fly larvae for food. The rapid burial of dung by the beetles reduces the breeding habitats for the flies. Dang beetles can play a role in natural biological control of bovine gastrointestinal nematodes (Trichostrongylidae).

Cattle infected with gastrointestinal trichostrongyle nematodes excrete parasite eggs in their faeces. After hatching, free living larvae develop in the cow pat to the infective stage which is spread to the surrounding herbage. In many tropical and subtropical areas, dung beetles of the family Scarabaeidae are the most important organisms responsible for the disappearance of fresh cow pats. They produce tunnels and break up the pats, thereby enhancing the drying-up of the dung. The result may be an increased mortality among the free living stage of trichostrongyle parasites, especially during dry spells. In this way at least some animals attracted to cattle dung may indirectly be involved in natural biological control of trichostrongylosis of cattle.

3.2 Amphibians and fishes

The water-tortoise *Pelomedusa subrufa* was reported to able to remove ticks from black rhinos in a streambed (Mwangi et al., 1991). Also in some areas the mosquito larvae may be controlled biologically by predatory fish such as *Gambusia affinis* and the *Guppy poecilia*. Snails are prey by fishes as well.

3.3 Reptilians

Some lizards can eat arthropods. The lizard stomachs may contain 2.4-15 ticks/stomach. However because there are few lizards near the bird nest, their effect on the tick population is limited. Insecticides suppress arthropods that prey on ticks. Thus using less insecticide that is more specific to the target and minimizing the area of its distribution to tick infested areas, would contribute to the preservation of these predators.

3.4 Avian and domestic fowl

Bird is generally thought to be the main predators of insects. This impression is based mainly on sporadic observations. Bird species pick the ticks off the host during flight or collected them from the ground. One of potential for biocontrol of trematodes is control of their intermediate hosts (snail). Domestic fowls and birds are predators of snails, although potential candidates for biological control of snails may be found among predators, parasites such as leeches, egg pathogenic fungi, and pathogenic bacteria.

The value of birds as suppressors of ticks' populations in nature is difficult to evaluate. It appears that the motionless insects are an easy and they prey too many birds, which thus help to reduce the insect populations. Scrub jays were observed to spend 89% of their time searching deer for ectoparasites (Isenhart and DeSante., 1985). In Africa, chickens are natural predators of ticks and actually pick ticks from the bodies of cattle as well as from the vegetation. Preliminary experiment has indicated that chickens may become viable biological control factors for tick control in Africa.

3.5 Rodents and mammals

Some mammals are insectivorous. As an example, *Sorex araneus* prey on ticks and at times preferred them to alternative foods. (Mwangi et al., 1991; Short and Norval., 1982). Shrews seem to locate hidden ticks by their smell. Mice and rats are often cited as preying on ticks. Also natural biological control of cestodes by destruction of cestode eggs when they are ingested by various animals may occur in nature. In this way vertebrates that are not suitable hosts may destroy cestode eggs, it is also possible that invertebrates like ants, earthworms and beetles may destroy eggs or take them down into the soil, like wise no practical or successful cases of biocontrol of cestodes are known.

4. Concluding remarks and future prospective

Few promising examples of biological control of insects and parasitic nematodes are found in veterinary science. This lack of success has left the industry skeptical and only few companies have been interested in developing biological control products. The lack of success may arise from lack of enough knowledge about complex natural biological systems and the antagonists which may be found in nature. So, research is essential for developing primary antagonists for biological control programs. However, the large number of potential antagonists that occur in nature presents a formidable interdisciplinary challenge to the scientists working on biological control. Moreover, they have to shown, in small-scale experimental models, that the selected antagonists are effective in biological control. It is estimated that to date only 15% of existing natural enemies of insects have been discovered. Yet for some insect species, over 100 enemies are known (De Bach and Rosen., 1991) In each case, they should be able to select one or more natural antagonists virulent to the different important pest organisms. Even less information exists about tick enemies than that of insect enemies. However to bring biological control candidates from experimental to commercial success, scientists obviously need practical supports from industry. We hope it will encourage scientists and policy makers to turn this neglected important field into an active branch of research and develop it as a component of integrated insect management. As yet only a few experimental data exist on the impact of parasite enemies under field condition, such studies are essential for the development of an effective biocontrol program. So it is necessary that industry be willing to develop technology and breeding media for large-scale industrial production of antagonists and mass production of the antagonists should be reasonably cheap. As antagonists often are used in huge amounts in biocontrol, it must be expected that selection for antagonists with high performance in production system is needed. The effect and the price of the biological control products should be similar to that of existing drugs. The handling and application of biological control products should fit in

with standard farm practice. Finally, as an alternative to chemical control, the final product should be safe to users and consumers, to treated animals and to the environment.

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6. References

Barron G.L, 1977. The nematode-destroying fungi. Canadian Biological Publications, Guelph, Ont., 140 pp.

Berbee M. Land Taylor, J.W. 1999. Fungal phylogeny in molecular fungal biology (Oliver,R.&Schweizer,M., Eds), Cambridge University Press, Cambridge,UK,pp.21-77

Buttner K. 1987. Studies on the effects of forest ants on tick infestation of mammals, especially rabbits. *Waldhygiene* 17:3–14.

Cole MM. 1965. Biological control of ticks by the use of hymenopterous parasites-a review. World Health Organ. Publ. WHO/ebl /43 65:1–12.

Connole MD. 1969. Effect of fungal extracts on the cattle tick, *Boophilus microplus*. *Aust. Vet. J.* 45:207.

Carroll JF. 1995. Laboratory evaluation of predatory capabilities of a common wolf spider (Araneae: Lycosidae) against two species of ticks (Acari: Ixodidae). *Proc. Entomol. Soc.* 97:746–49.

Campbell W.C. and Benz G.W. 1984. Ivermectine : A review of efficacy and safety. *J. Vet. Pharmacol Therap.* 7:1-16.

Chandler D., Davidson G., Pell J.K., Ball B.V., Shaw K and Sunderland KD. 2000. Fungal biocontrol of acari. *Biocont. Sci. Tech.* 10, 357- 384.

DeBach P. and Rosen D. 1991. Biological Control by Natural Enemies. New York: Cambridge Univ. Press. 440 pp.

Eslami A., Ranjbar-Bahadori Sh., Zare R. and Razzaghi-Abyaneh M. 2005. The predatory capability of *Arthrobotrys cladodes* var. *macroides* in the control of *Haemonchus contortus* infective larvae. *Vet. Parasitol.* 130:263-266.

Gronvold G, Henriksen S.A, Larsen M, Nansen P. and Wolstrup J. 1996. Biological control aspects of biological control with special reference to arthropods, protozoans and helminthes of domesticated animals. *Vet. Parasitol.* 64:47-64.

Hall RA. and Papierok B. 1982. Fungi as biological control agents of arthropods of agricultural and medical importance. *Parasitology* 84:205-240.

Hassan SM, Dipeolu O.O, Amoo A.O and Odhiambo T.R. 1991. Predation on livestock by chickens. *Vet. Parasitol*. 38: 199-204.

Hsiao C. and Hsiao TH. 1985. Rickettsia as the cause of cytoplasmic incompatibility in the alfalfa weevil, Hypera postica. *J. Invertbr. Pathol*. 45:244-246

Henderson G, Manweiler SA, Lawrence WJ, Templeman RJ. and Foil LD. 1995. The effects of *Steinernema carpocapsae* (Weiser) application to different life stages on adult emergence of the cat flea *Ctenocephalides felis* (Bouche). *Vet. Dermatol.* 6:159-163.

Henry J. E, 1981. Natural and applied control of Insects by protozoa. *Annu. Rev. Entomol.* 26: 49-73.

Hom A, 1994. Current status of entomopathogenic nematodes. *IPM Practitioner*, 16: 1-12.

Isenhart FR. and DeSante DF. 1985. Observations of scrub jays cleaning ectoparasites from black-tailed deer. *Condor* 87:145-147.

Jackson RR, Pollard SD. 1996. Predatory behavior of jumping spiders. *Annu. Rev. Entomol.* 41:287–308

Jemal A and Hugh-Jones M. 1993. A review of the red imported fire ant (*Solenopsis invicta* Buren) and its impacts on plant, animal, and human health. *Prev. Vet. Med.* 17:19–32.

Kaaya GP, Mwangi EN and Ouna EA. 1996. Prospects for biological control of livestock ticks, *Rhipicephalus appendiculatus and Amblyomma variegatum*, using the entomogenous fungi *Beauveria bassiana* and *Metarhizium anisopliae*. *J. Invertebr. Pathol.* 67:15–20.

Kocan KM, Pidherney MS, Blouin EF, Claypool PL, Samish M, et al. 1998. Interaction of entomopathogenic nematodes (Steinernematidae) with selected species of ixodid ticks (Acari: Ixodidae). *J. Med. Entomol.* 35:514-520.

Krivolutsky DA. 1963. Eradication of larvae and nymphs of the tick *Ixodes persulcatus* by predators. *Proc. Conf. Ticks Encephalitis Hemoragic Fever Viruses, Omsk, Dec.* pp. 187-188.

Lacey L.A, Frutos R, Kaya H.K and Vail P. 2001. Insect patliogem, as biological control agents: do they have a future? *Biological Control* 21: 210-248.

Lipa JJ, Eilenberg J, Bresciani J and Frandsen F. 1997. Some observations on a newly recorded mermitid parasite of *Ixodes ricinus* L. (Acarina: Ixodidae). *Acta Parasitol.* 42:109-114.

Luthy p, 1986. Insect pathogenic bacteria as pest control agents. *Fortschr. Zool.* 32: 201-216.

McCoy C.W., Samson R.A and Boucias D.G. 1988. Entomogenous fungi, in CRC Handbook of natural pesticides , volume V(Microbial insecticides,part A; Entomogenous protozoa and fungi_) (Ignoffo,C.M., Ed.), CRCPress , Florida, USA,pp.151-236.

Martin WRJ. 1997. Using entomopathogenic nematodes to control insects during stand establishment. *Hortic. Sci.* 32:196–200

Mwangi EN, Newson RM and Kaaya GP. 1991. Predation of free-living engorged female *Rhipicephalus appendiculatus*. *Exp. Appl. Acarol.* 12:153–162.

Mwangi EN, Dipeolu OO, Newson RM, Kaaya GP and Hassan SM. 1991. Predators, parasitoids and pathogens of ticks: a review. *Biocont. Sci. Tech.* 1:147-156.

Mwangi EN, Newson RM, Kaaya GP. 1991. Predation of free-living engorged female Rhipicephalus appendiculatus. *Exp. Appl. Acarol.* 12:153–162.

Noda H, Munderloh UG and Kurtti TJ. 1997. Endosymbionts of ticks and their relationship to *Wolbachia* spp. and tickborne pathogens of humans and animals. *Appl. Environ. Microbiol.* 63:3926–3932.

Oliver JHJ, McKeever S and Pound JM. 1986. Parasitism of larval Ixodid ticks by chigger mites and fed female *Ornithodoros* ticks by *Ornithodoros* males. *J. Parasitol.* 72:811–812.

Pirali-kheirabadi, K.H, Haddadzadeh, H.R., Razzaghi-Abyaneh, M., Zare, R., Ranjbar-Bahadori, SH., Rahbari, S., Nabian, S and Rezaeian, M. 2007. Priliminary study on virulence of some isolates of of entomopathogenic fungi in different developmental stage of *Boophilus annulatus* in Iran: *Iranian J. Vet. Res.* 62: 113-118.

Pirali-kheirabadi, K.H., Haddadzadeh, H.R., Razzaghi-Abyaneh, M. Bokaie, S., Zare, R., Quazavi, M., Shams-Ghahfarokhi, M. 2007. Biological control of Rhipicephalus (Boophilus) annulatus by different strains of *Metarhizium anisopliae* , *Beauveria bassiana* and *Lecanicillium psalliotae* fungi. *Parasitol. Res.* 100: 1297-1302.

Pirali-kheirabadi K.H, Teixeira da Silva J. A, Razzaghi-Abyaneh, M. Nazemnia M 2011. A Field Experiment to Assess the Pathogenicity of *Metarhizium anisopliae* to *Varroa destructor* (Acari: Mesostigmata) (Un published data).

Poinar G.O. 1986. Entomophagus nematodes. *Fortschr. Zool.* 32:95-121.

Ranjbar Bahadori SH, Razzaghi Abyaneh M, Bayat M, Eslami A, Pirali-Kheirabadi Kh, Shams – Ghahfarokhi M and Lotfollahzadeh S. 2010. Studies on the effect of temperature, incubation time and in vivo gut passage on survival and nematophagous activity *Arthrobotrys oligospora* var. *oligospora* and *A. cladodes* var. *macroides* .*Global Veterinaria* 4: 112-117.

Raoult D and Roux V. 1997. Rickettsioses as paradigms of newer emerging infectious diseases. *Clin. Microbiol. Rev.* 10:694-719.

Riechert SE, Bishop L. 1990. *Prey control by an assemblage of generalist predators: spiders in garden test systems. Ecology* 71:1441-1450.

Sayre R.M and Wergin W.P, 1979. The use of SEM to classify and evaluate the parasites and predators of pest nematodes. *Scan Electron Micros.* 3:89-96.

Sutherst RW, Wharton RH, UtechKBW. 1978. Guide to studies on the tick ecology. Div. Entomol. Tech. Pap. No. 14, Commonw. Sci. Ind. Res. Org., Aust., pp. 1–59

Sidorov VE. 1979. Some features of *Coxiella burnetii* interaction with argasid ticks (experimental morphological study). In *Razvitie Parazitologicheskoi Nauki v Turkmenistane*, ed. IM Grochovskaia, MA Melejaeva, pp. 112-128. Ashchabad: Yilim.

Samish M, Glazer I and Alekseev EA. 1996. The susceptibility of the development stages of ticks (Ixodidae) to entomopathogenic nematodes. Anonymous pp. 121-123. Columbus, Ohio: Ohio Biological Survey

Samish M and Glazer I. 1992. Infectivity of entomopathogenic nematodes (Steinernematidae and Heterorhabditidae) to female ticks of *Boophilus annulatus* (Arachnida: Ixodidae). *J. Med. Entomol.* 29:614–618.

Samish M, Alekseev EA and Glazer I. 1998. The effect of soil composition on antitick activity of entomopathogenic nematodes. *Ann. NY Acad. Sci.* 849:398–399.

Short NJ and Norval RAI. 1982. Tick predation by shrews in Zimbabwe. *J. Parasitol.* 68:1052.

Spielman A. 1988. Prospects for suppressing transmission of Lyme disease. *Ann. NY Acad. Sci.* 539: 212-220.

Sayre R.M., 1986. Pathogens for biological control of nematodes. *Crop. Prot.* 5: 268-279.

Tanada , Y. and kaaya ,H.K.(1993)Insect patology , Academic Press , San Diego ,USA, 666 PP.

Verissimo CJ. 1995. Natural enemies of the cattle tick. *Agropecu. Catarin.* 8: 35-37.

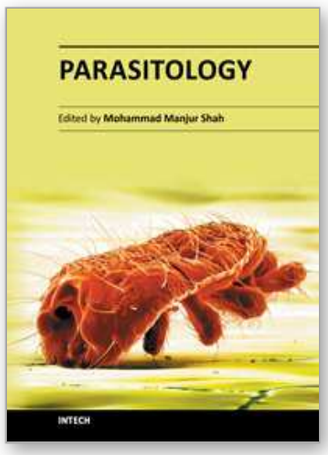
Wilkinson PR. 1970. A preliminary note on predation on free-living engorged female rocky mountainwood ticks. *J. Med. Entomol.* 7:493–496.

Wilkinson PR. 1970. Factors affecting the distribution and abundance of the cattle tick in Australia: observations and hypotheses. *Acarologia* 12: 492–507.

Zhioua E, Lebrun RA, Ginsberg HS, Aeschlimann A. 1995. Pathogenicity of *Steinernema carpocapsae* and *S. glaseri* (Nematoda: Steinernematidae) to *Ixodes scapularis* (Acari: Ixodidae). *J. Med. Entomol.* 32: 900–905.

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Parasitology is an established discipline that covers a wide area of subjects, ranging from the basics (study of life cycle, ecology, epidemiology, taxonomy, biodiversity, etc) to the advanced and applied aspects (human and animal related, although control aspect remains the most important task). There is a great scarcity in the amount of available literature that is freely accessible to anyone interested in the subject. This book was conceptualized with this in mind. The entire book is based on the findings of various studies performed by different authors, comprising reviews and original scientific papers. I hope this book will be helpful to diverse audiences like biologists, zoologists, nematologists, parasitologists, microbiologists, medical doctors, pathologists as well as the molecular biologists, by providing them with a better understanding of the subject.

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