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Strongylosis in equine: An overview

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Abstract
Strongylosis, caused by large and small strongyles, is considered as one of the most important internal parasitic disease entity caused by nematodes of family Strongylidae affecting >90% of equine population. Large strongyles like *Strongylus vulgaris, S. edentates* and *S. equinus* are generally recognized as the most important and pathogenic internal parasites in horses. Large strongyles show major pathogenesis that encompasses verminous arteritis, damage of visceral organs, embolism or thrombosis leading to death and is mainly attributed to migrating larvae of parasites. However, small strongyles (also called Cyathostomin) exhibit mild symptoms of diarrhea and loss of appetite and weight, poor hair coat, lethargy, peripheral oedema and disordered intestinal motility. Despite of adopting and implementing the latest diagnostic technique and treatment and control measures, still internal parasites remain one of the most important problems affecting the health and well-being of equines. Seasonal use of anthelmintic drugs and pasture management are the main strategic control to arrest the Strongyle infection and overcome anthelmintic resistance.

Keywords: Equine, gastrointestinal parasites, large strongyles, Cyathostomins

1. Introduction
The total estimated population of equines in India is 1.13 million comprising 0.62 million horses and ponies, 0.19 million mules and 0.32 million donkeys [4]. Equids (donkeys, mules and horses) play an important role as working animals in many parts of the world, including India and have been employed for packing, riding, carting and ploughing, while some are used in armed forces and sport events.

Equines suffer from a wide spectrum of disease causing pathogens of which gastrointestinal helminths (GIH) are very common and present a serious challenge to health and welfare issues of the equids worldwide [26]. Strongylosis, caused by large and small strongyles, is the most fascinating internal parasitic disease entity caused by nematodes of family Strongylidae. Large strongyles are generally recognized as the most important internal parasites in horses; major pathogenic species being *Strongylus vulgaris*, *S. edentatus* and *S. equinus*. The common name of *S. vulgaris* is double tooth strongyle, *S. edentatus* is known as toothless strongyle and *S. equinus* is called rippled toothed strongyle. *S. vulgaris* is smaller than the other two large strongyle species [27]. In brief, about the life cycle, after ingestion of infective third stage larvae (L_3) they travel through digestive system to large intestine. L_3 of *S. vulgaris* show an affinity towards anterior mesenteric artery and thus migrate there. It has been observed that L_3 of *S. edentatus* and *S. equinus* migrates towards liver or flank and liver as well as pancreas, respectively. Although the fourth (L_4) and fifth (L_5) larval stages of *S. edentatus* and *S. equinus* produce mainly haemorrhagic nodules in the liver, caecum and colon, it is L_4 and L_5 of *S. vulgaris* which are the root cause for arteritis, necrosis, and fibrosis right from aortic valves to the iliac arteries and majority surrounding the cranial mesenteric artery along with its branches [15, 24, 35]. As a result, there is formation of thrombi which on detachment acts as an emboli causing infarction and blockade of the major arteries (cranial mesenteric artery, brachiocephalic trunk etc.) ultimately leading to severe colic and death of horses [30].

The strongyle infections are usually diagnosed on the basis of clinical signs, faecal sample examination by floatation technique for detection of strongyle egg and per rectal examination reveals aneurysm of cranial mesenteric artery. In term of species differentiation, coproculture for larval cultivation is the most practical method to differentiate between large and small strongyles, based on the morphometry and morphology of the L_3 stage [5, 6]. Routine treatment with anthelminthic drugs is to eliminate strongyle infection and prevent pasture contamination with L_3.

2. Morphology

Large strongyles are classified under the kingdom animalia, phylum Nemathelminthes, class Nematoda, order strongylida, superfamily strongyloidae, family strongylidae and subfamily strongylinae [1]. The species of large strongyles, often red in colour and therefore, called red worms. Morphological identification of adult strongyles relies on size, presence or absence of teeth, shape of the teeth in base of buccal capsules, internal and external leaf crowns and its extra-chitinous support. The *S. vulgaris* has 1.5-2.5cm and two ear-shaped dorsal teeth; the *S. edentatus* has 2.5-4.5cm long, with out teeth and cup shaped buccal capsule; *S. equinus* has 2.5-5cm with pair of sub-ventral teeth and dorsal tooth which is bifid at the tip [44].

3. Epidemiology and prevalence

Strongylosis is the most common and economically devastating disease of horses and causes deaths when control measures are neglected**.** Strongyles not only cause direct damages but also lower the immunity of the infected animals and predispose them to a wide array of diseases. In weakened, debilitated or immune-compromised horses, small numbers of parasites can lead to mortality. The important epidemiological risk factors for strongyle infection have been identified as season, age and managemental practices. The highest seasonal prevalence rate of GI infections has been recorded in rainy (monsoon) season could be because of optimal ambient temperature and high relative humidity conducive for the development of free living pre-parasitic stages of helminths [28, 40]. However, as cold and dry conditions are comparatively unfavourable for the development of parasitic stages, this leads to lower infection rates in these seasons. Age is important risk factor in regard to susceptibility to strongyle infection because infections in horses are more evident in young and under nourished horses. The older horses appear to gradually develop immunity against the GI parasites and are not severely affected by parasite related problems as compared to young horses [42]. The predisposing factors responsible for establishment of endoparasitic infection include pasture management, dietary nutrients deficiency, availability of fodder, host immunity to counter parasitic infection, seasonal variation, availability of intermediate host on pasture, grazing habits, the quantity of third stage larvae, poor reproductive performance, gastrointestinal inconvenience and prolonged emaciation [36]. These factors are greatly influenced by the managemental practices adopted in organised farms and have huge impact on prevalence of GI parasites as compared to the unorganised farms.

4. Life cycle

All species of equine strongyles have direct life cycles [14, 31]. Eggs are laid by adult female worms and passed in the faeces to the external environment where they hatch to the first stage larvae (L_1) at 26 ^{0}C which grows and molts to L_2 and then to the L_3 (infective stage) requiring approximately ten days to two weeks. Sheathed L_3 is the only larval stage that can infect a new host, therefore called the infective larva. Infection of host occurs by ingestion of (L_3), then they pass to the small intestine, remove outer sheath and initiate the further development. Exsheathment in the host gut is stimulated by certain physiological / biochemical conditions [21]. This triggers the larvae to release its exsheathing fluid hence disintegrating the larval sheath, thereby releasing the larvae either through an anterior cap (as in large strongyles) or via a longitudinal split in oesophageal region (in small strongyles) [24]. At this point, the life cycle of the various strongyles begin to differ. After ingestion of infective larvae (L_3) through contaminated feed and water, the L_3 travel through digestive system to large intestine and thereafter, those of *S. vulgaris* migrate towards anterior mesenteric artery and its branches; *S. edentatus* to liver or flank region and *S. equinus* to the liver and pancreas. The larvae come back into the lumen of caecum and colon and attain maturity. The pre-patent period in *S. vulgaris* is 6-7 months, *S. edentatus* is 10-12 months, *S. equinus* is 8-9 months [45]. Large and small strongyle larvae have different migratory patterns. While large strongyles larvae have a preference for extra-alimentary tissues [19], the small strongyles larvae have an affinity to reside inside the fibrous cysts in submucosal lining of the caecum and ventral colon [38].

5. Pathogenesis

Naturally infected horses usually carry a mixed load of large and small strongyles in the intestine [34]. Among the large strongyles, *S. vulgaris* is usually the cause of the most devastating internal parasitic disease. The migrating larvae of *S. vulgaris* are more harmful as they migrate towards cranial mesenteric artery and its branches and lead to the formation of thrombus, which results in interference of blood flow to the intestinal wall and can cause gangrenous enteritis; intestinal stasis, intussusception; and possibly rupture. The thrombi, detached, may block vital arteries like iliac artery, a temporary lameness may occur. The verminous aneurysms in the cranial mesenteric artery and its branches may cause colic by exerting pressure on the associated nerve plexus. Hematological and biochemical studies performed in equines infected with *S. vulgaris* infection showed a decrease in haemoglobin rates, total serum proteins and an increase in lymphocytic count [21]. The larvae of *S. equinus* may produce haemorrhagic tracts in the liver and pancreas. The larvae of *S. edentatus* may cause haemorrhagic nodules in the wall of peritoneum, caecum and colon. Adult large strongyles have large buccal capsules and are active blood feeders; they attach themselves, feed on mucosal plugs in the large intestine, suck blood producing anemia of a normochromic and normocytic type. *S. edentatus* and *S. equinus* adults are more harmful to the horse and suck more blood than *S. vulgaris* adults, but the larvae are not as dangerous [37].

6. Clinical signs

The intensity of clinical signs is directly proportional to the host age and the number of L_3 ingested while grazing [32]. Large strongyles are active blood feeders, all thanks to their large buccal capsule also helping them in digesting mucosal plugs, thereby causing anemia. Equine infected with strongyle infection is characterized by nonspecific signs such as weight loss, emaciation, poor growth, rough hair coat, compromised performance and diarrhoea. The principal clinical signs of *S. vulgaris* infection are directly associated with the migrating larval stages in the walls of cranial mesenteric arteries and its branches, cause interference in blood flow to the intestinal wall, leads to the formation of thrombosis. These thrombi are responsible for arterial blockade which at the time of necropsy is evidenced by infarction of intestinal walls. The infected horses develop clinical signs like pyrexia, anorexia and severe colic [1]. "Verminous aneurysm" is classic of this parasite [37]. The cyathostomins infections are generally mild with symptoms like anorexia, weight loss, poor hair coat,

digestive disturbances, lethargy, emaciation, oedema and decreased intestinal motility [21].

7. Diagnosis

Diagnosis is based primarily on the basis of grazing history, clinical signs, faecal sample examination by faecal floatation technique for detection of strongyle egg and per rectal examination reveals aneurysm of cranial mesenteric artery. Diagnosis of the large strongyle infections can be assumed if eggs are found in the feces. However, because of the prolonged pre patent period of all species in this group, eggs will not be present in the feces in animals less than 9-12 months old [39]. However, regarding strongylosis, diagnosis by faecal microscopy in terms of morphology of the strongyle eggs does not allow the species differentiation, especially in cases of mixed infections, which are common and frequent in field conditions, not even to the sub-family level [25]. For this reason, coproculture for larval cultivation is the most practical and readily available method to differentiate between large and small strongyles, based on the morphology of the L_3 stage [5, 6]. The larvae of large strongyles can be identified as per the keys of Manual of Veterinary Parasitological Laboratory Techniques, Ministry of Agriculture, Fisheries and Food [3] and similarly small strongyles (Cyathostomes) can be identified as per the instructions in published reports [22].

8. Treatment and Control

Treatment may be targeted against immature and adult large strongyle worms in the lumen of intestine, against migrating larval stages of strongyle, particularly *S. vulgaris* [37]. The most commonly used method for controlling GI parasites is the application of anthelminthic drugs [7]. Thiabendazole, a benzimidazole group member, has been widely used and several other anthelminthic drugs have been approved for use in equine, including tetrahydropyrimidines and organic phosphorus compounds [13, 41, 44]. In current scenario, mainly three broad spectrum group of anthelminthic are used, categorized by their mechanism of action: pro-benzimidazole/benzimidazoles (e.g. febantel, netobimin, thiabendazole, cambendazole, fenbendazole and Oxibendazole) imidazothiazoles/tetrahydropyrimidines (e.g. levamisole, tetramisole, pyrantel and morantel) and the macrocyclic lactones (e.g. avermectins and milbemycin [16]. The negative impact of anthelminthic drugs on the natural environment in addition to human and animal health is an issue of significant importance [12]. Now a days it is recommended to reduce the treatment intensity and follow alternative methods of controlling parasites significantly to holdup further development of anthelmintic resistance [20]. Integrated parasite management practices (IPM) can collectively help to control problem of internal parasites, particularly in pastures which are the main sources of transmission of GI nematode infections [8]. This can be achieved by performing mixed farming, pasture rotation, allowing young animals to graze first followed by adults, allowing two or more animal species to graze on the pasture simultaneously to break the parasitic life cycle [33]. Regular removal of animal dung and cleaning horse stables can help in reducing the density of infective larvae [18]. Besides decomposed animal faeces can be used as manure/compost and burning fuel in local households [23]. The physical control adds an additive effect along with chemical control methods in delaying the emergence of drug resistant Parasites [17]. Biological control strategies utilize plants enriched in tannins (acting as potent anthelmintic) *viz*. *Allium sativum* [10], *Cucurbia moschata* [29], *Artemisia absinthium*, *Juglans nigra*, *Cucurbita pepo*, *Artemisia vulgaris*, *Foeniculum vulgare*, *Hyssopus officinalis* and *Thymus vulgaris* [11], certain bacteria *viz*. *Bacillus thuringiensis*, nematophagous fungi *viz*. *Arthrobotrys oligospora* and *Duddingtonia flagrans* and birds parasitizing on different nematodal life stages [2]. The predatory nematophagous fungi *Duddingtonia flagrans* feeds on the parasitic nematodes using protein source to support their saprophytic lifestyle [9, 18].

9. Conflict of interests

All authors have no conflict of interest.

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