First Blinding Cases of Horses Infected with Setaria Digitata (Nematoda: Filarioidea) in the Republic of Korea

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Abstract: Ocular setariases of cattle were reported but those of equine hosts have never been reported in the Republic of Korea (Korea). We found motile worms in the aqueous humor of 15 horses (Equus spp.) from 12 localities in southern parts of Korea between January 2004 and November 2017. After the affected animals were properly restrained under sedation and local anesthesia, 10 ml disposable syringe with a 16-gauge needle was inserted into the anterior chamber of the affected eye to successfully remove the parasites. The male worm that was found in 7 of the cases showed a pair of lateral appendages near the posterior terminal end of the body. The papillar arrangement was 3 pairs of precloacal, a pair of adcloacal, and 3 pairs of postcloacal papillae, plus a central papilla just in front of the cloaca. The female worms found in the eyes of 8 horses were characterized by the tapering posterior terminal end of the body with a smooth knob. Worms were all identified as Setaria digitata (von Linstow, 1906) by the morphologic characteristics using light and electron microscopic observations. This is the first blindness cases of 15 horses infected with S. digitata (Nematoda: Filarioidea) in Korea.

Key words: Setaria digitata, ocular setariasis, horse blindness, corneal opacification, Korea

Equine ocular setariasis caused by several species of Setaria, including S. equina, S. marshalli and S. digitata, has been reported in the eyes of donkeys and horses [12,14,15]. Among 242 horses with ocular disorders in India, 138 cases (57.0%) were diagnosed as ocular setariasis during 10 years from 2002 to 2011 [16]. We previously reported the first case of ocular setariasis of cattle in the Republic of Korea (Korea) in 2002 in which a 5-month-old female native Korean calf and a 2-year-old female Holstein cow were found to be unilaterally blind, and single S. digitata worm was isolated from the aqueous humor of each of the affected eye [13]. Since then, additional cases of ocular setariasis have not been reported until present in Korea. We report herein 15 cases of equine ocular setariasis caused by S. digitata (von Linstow, 1906), as identified by both light and scanning electron microscopies.

In January 2004, a 5-year-old male Jeju pony (Equus caballus) was found to have a left eye opaque at a local horse farm in Gyeongsan-si, Gyeongsangbuk-do, Korea. In contrast to the healthy and non-affected right eye, the cornea of the left eye was leukomatous to the extent that the affected eye did not respond to any movement on the left side of the face. An al-
most identical case was developed in a horse farm in Miryang-
si, Gyeongsangnam-do, Korea, at the same period. The right
eye of a 6-year-old Thoroughbred gelding was found to be
opaque, and a white worm was observed rapidly swimming
within the anterior chamber (Fig. 1). Additional 13 cases of
equine ocular setariasis were identified from October 2012 to
November 2017 (Table 1).

Worms were removed from the affected eye of each horse as
previously described by Shin et al. [13] by the needle puncture
aspiration (NPA) technique. Briefly, after the animal was prop-
erly restrained under sedation and local anesthesia, 10 ml dis-
posable syringe with a 16-gauge needle was inserted into the
anterior chamber of the affected eye at 6 o’clock position of
the cornea about 5 mm apart from the limbus. The entire par-
isite was successfully removed by pointing the tip of the nee-
dle near the one end of the worm and withdrawing the piston
to pull the worm into the syringe.

The average length of removed worms was $3.2 \pm 0.8$ cm in
length (mean $\pm$ SD), and 7 horses were infected with the worm
in the left eye and 8 on the right eye. Only 1 worm was found
in the affected eye from each horse. All worms were identified
as *S. digitata* by the morphologic characteristics under light
and electron microscopies using the identification keys pro-
vided by Thwaite [17], Shoho et al. [18], and Rhee et al. [2].
The anterior part of the worm had dorsal and ventral projec-
tions adjacent to the round lateral lips (Figs. 2, 3). The male
worm found in 4 of the cases showed a pair of lateral append-
ages near the posterior terminal end of the body (Fig. 4). The
papillar arrangement was 3 pairs of precloacal, a pair of adclo-
acal, and 3 pairs of postcloacal papillae, plus a central papilla
just in front of the cloaca. The female worm was characterized
by a tapering posterior terminal end of the body with a
smooth knob, a distinctively different feature compared to *S.
marshalli*, which is bulged and roughly furcated (Fig. 5).

The cases contained herein are about ectopic parasitism of *S.
digitata* in the eyes of 15 horses from Korea. Although we pre-
viously reported 2 blindness cases of cattle due to the aberrant
migration of *S. digitata* into the aqueous humor [13], this is
the first blindness cases of horses infected with *S. digitata*

![Fig. 1. A motile *S. digitata* (arrow) in the aqueous humor of the
right eye of a Jeju pony from Miryang-si, Gyeongsangnam-do, Korea (Case 2).](image)

### Table 1. Summary of cases and results of worm recovery from the aqueous humor of the eye of 15 horses

| Case No. | Date     | Location in Korea | Breed                  | Horse gender | Horse age | Affected eye | Worm length (cm) | Worm number | Worm sex |
|----------|----------|-------------------|------------------------|--------------|-----------|--------------|-----------------|-------------|---------|
| 1        | Jan. 2004 | Gyeongsan-si, Gyeongbuk | Jeju pony (*Equus caballus*) | Female       | 5         | Left         | 4.5             | 1           | Female  |
| 2        | Jan. 2004 | Miryang-si, Gyeongnam | Thoroughbred           | Male         | 6         | Right        | 3.9             | 1           | Male    |
| 3        | Oct. 2012 | Muan-gun, Jeonnam   | Thoroughbred           | Male         | 6         | Left         | 3.1             | 1           | Male    |
| 4        | Oct. 2012 | Damyang-gun, Jeonnam | Thoroughbred           | Male         | 11        | Right        | 3.0             | 1           | Male    |
| 5        | Oct. 2013 | Yeongam-gun, Jeonnam | Thoroughbred           | Female       | 6         | Left         | 2.9             | 1           | Male    |
| 6        | Sept. 2014| Miryang-si, Gyeongnam| Warmblood              | Female       | 10        | Left         | NM              | 1           | Male    |
| 7        | Oct. 2014 | Gimhae-si, Gyeongnam | Halfinger              | Female       | 3         | Left         | 3.2             | 1           | Female  |
| 8        | Dec. 2014 | Tongyeong-si, Gyeongnam | Thoroughbred          | Female       | 6         | Right        | NM              | 1           | Female  |
| 9        | May-15   | Gwangju            | Thoroughbred           | Male         | 3         | Left         | 4.1             | 1           | Female  |
| 10       | May-15   | Yeongam-gun, Jeonnam | Thoroughbred           | Female       | 2         | Right        | 3.5             | 1           | Female  |
| 11       | Nov. 2015 | Chilgok-gun, Gyeongbuk | American quarter horse| Female       | 6         | Left         | 1.9             | 1           | Female  |
| 12       | Oct. 2015 | Changwon-si, Gyeongnam | Jeju pony (*Equus caballus*) | Female       | 5         | Right        | 2.7             | 1           | Male    |
| 13       | Sep. 2015 | Chilgok-si, Gyeongnam | Thoroughbred           | Male         | 4         | Right        | 2.1             | 1           | Male    |
| 14       | Nov. 2016 | Changwon-si, Gyeongnam | Thoroughbred           | Male         | 8         | Right        | 4.5             | 1           | Female  |
| 15       | Nov. 2017 | Hamyang-gun, Gyeongnam | Jeju pony (*Equus caballus*) | Female       | 2         | Right        | 2.5             | 1           | Female  |

NM: not measured.
(Nematoda: Filarioidea) in Korea. For removal of worms from the eye, we followed the NPA technique designed for removing *S. digitata* from the anterior chamber of cattle, as we first reported in 2002 [13]. The NPA technique was different from the other studies in which worms were removed from the aqueous humor by the surgical incision on the cornea [12,19,20]. Recent reports on the removal of ocular *Setaria* fol-
followed our protocol, which is easier and safer than previous
methods [14,21]. The NPA technique minimizes the damage
of the vital parts of the eye and does not need to put the horse
under general anesthesia. Several chemotherapeutic methods
are known for treating setariasis in animals. DEC (diethylcar-
bamazine) [3,16] or ivermectin [22,23] has been generally
used to treat setariasis in cattle and horses. However, chemo-
therapy of ocular setariasis is not recommended because the
dead body of the worm that remains in the aqueous humor of
the eye can exacerbate the development of opaqueness of the
affected eye.

Although we presented 15 cases of equine ocular setariasis
in this report, the annual incidence reported by local veterinari-
ans ranges from 10 to 15 cases alone in Gwangju and Jeon-
nam areas in Korea. This implies that quite a few horses are
annually infected with Setaria spp. without clinical symptoms.
So far, however, the epidemiological survey of equine setariasis
has not yet been available in Korea. While there have been
only a few cases of equine ocular setariasis caused by S. equina
around the world [14,15], many ocular setariasis by S. digitata
have been reported in Asia [4,12,15,21,24]. The reason for the
species variation of Setaria spp. in the development of ectopic
parasitism is unknown, but there is a possibility that each spe-
cies of Setaria elicits dissimilar immunological responses by
the hosts. In the case of S. digitata, a non-pathogenic parasite
of cattle, the worm is likely to elicit stronger host immune re-
sponses in horses than in cattle. On the other hand, S. equina
may cause relatively little pathogenic reaction to horses, its
permissive host.

The Korean government implemented 'The Horse Industry
Promotion Act' in 2011 in hopes of boosting rural economy.
Since then the number of horse-riding facilities, parks, training
schools, and academies have been rapidly increasing through-
out the nation [25]. As horse riding and sports activities are in-
creasing, however, the horse blindness by the nematode para-
site in Korea should also be alerted. Our report here on the
first blindness cases of horses due to S. digitata infection in Ko-
rea calls for a nationwide epidemiological survey of the para-
site infection as well as a strategic preventive medication pro-
gram against the detrimental disease in horses.

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CONFLICT OF INTEREST

We have no conflict of interest related to this work.

REFERENCES

1. Soulsby EJL. Helminths, Arthropods and Protozoa of Domesti-
cated Animals. Philadelphia, USA. Lea & Febiger, 1982, pp 316-
319.
2. Rhee JK, Choi EY, Park BK, Jang BG. Application of scanning
electron microscopy in assessing the prevalence of some Setaria
species in Korean cattle. Korean J Parasitol 1994; 32: 1-6.
3. Innes J, Shoho C. Nematodes, nervous disease, and neurotropic
virus infection. Br Med J 1952; 2: 366.
4. Yoshihara T, Oikawa M, Kanemaru T, Hasagawa M, Tomioka Y,
Kaneko M, Uehara N, Kyrui K. Two cases of cerebrospinal setari-
osis in the racehorses. Bull Equine Res Inst 1987; 24: 14-22.
5. Karhi K. A laboratory epidemiological outbreak investigation of
Kumri (Cerebrospinal nematodiasis) and use of diethylecarbam-
azin in treatment of goat in Banke dis-trict of Mid-Western Re-
gion of Nepal. Vet World 2008; 1: 168-170.
6. Lee CG, Lee CY, Kwag HS. Studies on the diseases of the Korean
native goat-a review. Korean J Vet Clin Med 2000; 17: 32-44.
7. Tung KC, Lai CH, Ooi HK, Yang CH, Wang JS. Cerebrospinal se-
tariosis with Setaria marshalli and Setaria digitata infection in cat-
tle. J Vet Med Sci 2003; 65: 977-983.
8. Yoshikawa T, Oyamada T, Yoshikawa M. Eosinophilic granulo-
mas caused by adult setarial worms in the bovine urinary blad-
der. Nihon Juigaku Zasshi 1976; 38: 105.
9. Fujita J, Imai S, Ishii T, Nunoya T, Takahashi K, Tomita T, Oikawa R. Heterotopic parasitism of Setaria digitata (Linstow, 1906) in the heart of a cattle. Nihon Juigaku Zasshi 1985; 47: 999-1002.
10. Okita N, Hanawa T, Yoshimoto M, Nakayama R. Heterotopic parasitism of Setaria digitata in the heart of eight cattle. J Japan Vet Med Assoc 1987; 40: 41-43.
11. Tamilmahan P, Zama M, Pathak R, Muneeswaran N, Karthik K. A retrospective study of ocular occurrence in domestic animals: 799 cases. Vet World 2013; 6: 274-276.
12. Jemelka E. Removal of Setaria digitata from the anterior chamber of the equine eye. Vet Med Small Anim Clin 1976; 71: 673-675.
13. Shin SS, Cho KO, Wei SH. Ocular infection of cattle with Setaria digitata. J Vet Med Sci 2002; 64: 7-10.
14. Marzok MA, Desouky AR. Ocular infection of donkeys (Equus asinus) with Setaria equina. Trop Anim Health Prod 2009; 41: 859-863.
15. Yadav A, Kumar A, Bhadwal MS, Khajuria JK, Gupta A. Ocular setariosis in horses: a case study. J Vet Parasitol 2006; 20: 183-184.
16. Tamilmahan P, Zama MMS, Pathak R, Muneeswaran NS, Karthik K. A retrospective study of ocular occurrences in domestic animals: 799 cases. Vetworld 2013; 6: 274-276.
17. Thwaite JW. The genus Setaria. Ann Trop Med Parasitol 1927; 21: 427-466.
18. Shoho C, Uni S. Scanning electron microscopy (SEM) of some Setaria species (Filarioidea, Nematoda). Z Parasitenkd 1977; 53: 93-104.
19. Ansari MM, Buchoo BA. Surgical technique for removal of intraocular parasite in horse. Intas Polivet 2005; 6.
20. Mohan K, Ananda KJ, Shridhar NB, Puttalakshamma GC, Placid EDS. Corneal opacity due to Setaria digitata in a Jersey crossbred cow and its surgical management. Vetworld 2009; 2: 69-70.
21. Jaiswal S, Singh S, Singh R, Singh H. Ocular setariosis in a horse. Intas Polivet 2006; 7: 67-68.
22. Klei TR, Torbert BJ, Ochoa R. Efficacy of ivermectin (22, 23-dihydroavermectin B1) against adult Setaria equina and microfilariae of Onchocerca cervicalis in ponies. J Parasitol 1980; 66: 859-861.
23. Shirasaka S, Suzuki M, Endou G, Adachi Y, Taira N. Efficacy of ivermectin against Setaria microfilariae in calves and cerebrospinal setariosis in sheep and goats. J Vet Med Sci 1994; 56: 1213-1214.
24. Bazargani T, Estami A, Gholami GR, Molai A, Ghafar-Charati J, Dawoodi J, Ashrafi J. Cerebrospinal nematodiasis of cattle, sheep and goats in Iran. Iran J Parasitol 2008; 3: 16-20.
25. Kim JY. The horse industry in Korea: its present condition and prospect. Adv Sci Technol Lett 2015; 99: 256-260.
