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▣ MINI-REVIEW

# Review of Zoonotic Parasites in Medical and Veterinary Fields in the Republic of Korea

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**Abstract:** Zoonotic parasites are animal parasites that can infect humans. The major zoonotic protozoa in the Republic of Korea are *Babesia bovis, Chilomastix mesnili, Cryptosporidium parvum, Endolimax nana, Entamoeba coli, Entamoeba hitolytica, Giardia lamblia, Iodamoeba bütschlii, Pneumocystis carinii, Sarcocystis cruzi,* and *Toxoplasma gondii.* The major zoonotic helminths in Korea include trematodes, cestodes, and nematodes. Trematodes are *Clonorchis sinensis, Echinostoma hortense, Echinostoma* spp., *Fasciola hepatica, Heterophyes nocens, Metagonimus yokogawai,* and *Paragonimus westermani.* Cestodes are *Diphyllobothrium latum, Dipylidium caninum, Echinococcus granulosus, Hymenolepis nana, Raillietina tetragona,* sparganum (*Spirometra* spp.), *Taenia saginata, T. solium,* and *T. asiatica.* Nematodes are *Ancylostoma caninum, Brugia malayi, Capillaria hepatica, Dirofilaria immitis, Gnathostoma dololesi, Gnathostoma spinigerum, Loa loa, Onchocerca gibsoni, Strongyloides stercoralis, Thelazia callipaeda, Trichinella spiralis, Trichostrongylus orientalis, Trichuris trichiura,* and *Trichuris vulpis.* The one arthropod is *Sarcoptes scabiei.* Many of these parasites have disappeared or were in decline after the 1990's. Since the late 1990's, the important zoonotic protozoa have been *C. parvum, E. nana, E. coli, E. hitolytica, G. lamblia, I. buetschlii, P. carinii* and *T. gondii.* The important zoonotic helminths have been *C. sinensis, H. nocens, M. yokogawai, P. westermani, D. latum, T. asiatica,* sparganum, *B. malayi, T. orientalis, T. callipaeda* and *T. spiralis.* However, outbreaks of these parasites are only in a few endemic areas. The outbreaks of *Enterobius vermicularis* and head lice, human parasites, have recently increased in the kindergartens and primary schools in the Republic of Korea.

Key words: zoonotic parasite, animal, human, protozoa, helminth

## WHAT ARE ZOONOTIC PARASITES?

Zoonotic parasites are separated into 4 categories, such as direct-zoonotic, meta-zoonotic, cyclo-zoonotic, and sapro-zoonotic parasites. Direct zoonotic parasites infect humans directly from animals, such as, *Entamoeba hitolytica, Cryptosporidium parvum, Toxoplasma gondii, Hymenolepis nana, Trichinella spiralis,* and *Sarcoptes scabiei.* Meta-zoonotic parasites can infect humans from invertebrate intermediate hosts, such as, *Babesia bovis, Babesia divergens, Plasmodium schwetzi, Clonorchis sinensis, Fasciola hepatica, Paragonimus westermani, Diphyllobothrium latum, Dipylidium caninum, Dirofilaria immitis, Brugia malayi, Onchocerca gibsoni,* and *Polymorphus boschadis.* Cyclo-zoonotic parasites have vertebrate intermediate hosts, such as, *Taenia multiceps, Echinococcus granulosus, Taenia saginata, Taenia solium,* sparganum (*Spirometra* spp.), *Porrocaecum crassum, Contracaecum osculatum, Capillaria hepatica,* and *Gnathostoma spinigerum.* Sapro-zoonotic parasites mean that parasites can be infected to humans from soil or water, such as, *Ancylostoma caninum, Ascaris suum, Capillaria hepatica, Strongyloides stercoralis, Trichuris vulpis,* and *Hypoderma bovis.* Many of carnivorous parasites are zoonotic parasites because dogs and cats have lived with humans for a long period of time. On the other hand, anthroponotic parasites mean that the parasites can be transmitted from humans to animals. Some examples of these are *E. histolytica, C. sinensis, D. latum,* and *Trichuris trichiura.*

## PREVALENCE OF ZOONOTIC PARASITES IN KOREA

### Major zoonotic protozoa

There are about 65,000 species of protozoan parasites in the world. Unicellular organisms, almost all protozoa, live by holozoic nutrition. Protozoa are divided into 5 phyla, Sarcomastigophora, Apicomplexa, Microspora, Myxozoa, and Ciliophora. Sarcomastigophora have flagella or pseudopodia for locomotive organs, reproduce by binary fission, and include *Trichomonas* spp., *Giardia* spp., and amoeba. Apicomplexa do not have special locomotive organs and reproduce by multiple fission and

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gamogony; the examples are coccidia, malaria, and piroplasma. Microspora are spore forming obligatory intracellular parasites and also reproduce by binary or multiple fissions, which include *Encephalitozoon* spp. and *Nosema* spp. Myxozoa have ameboid germinal elements (sporoplasms) and intracellular parasitism, and includes *Myxosoma* spp. Ciliophora have cilia as locomotive organs, reproduce by binary fission and conjugation, and include *Balantidium coli, Buxtonella sulcata,* and lumen ciliates [1].

The prevalence of amoebae (including *Endolimax nana, Entamoeba coli, E. histolytica,* and *Iodamoeba bütschlii*), *Giardia lamblia,* and *Trichomonas hominis* in the Republic of Korea (= Korea) declined overall from the 1960s to 1990s, and became 0% nowadays, but those of handicapped people were very high. However, these are not the most severe zoonotic protozoans in Korea. The most important zoonotic protozoa recently are *T. gondii, C. parvum,* and *Pneumocystis carinii* [2-4] (Table 1).

Among the residents of Chorwon-gun, Kangwon-do, 9 (1.9%) of the 461 fecal samples were positive for *C. parvum* oocysts in 2001 [5]. The oocyst positive rate was 7.9% (248/3,146) in 1995, but the rate was remarkably different between Seoul and Chollanam-do, 0.5% (4/853) and 10.6% (244/2,293), respectively [3]. Re-surveying the same village of Hwasun-gun in 1995, 44 (35.2%) of 125 villagers and 14 (93.3%) of 15 cattle examined were positive for *C. parvum* oocysts [3]. The prevalence of *C. parvum* infection and its seasonality were studied in a small rural village occupied predominantly by aged people in Hwasun-gun, Chollanam-do, Korea [6]. Fecal samples were collected monthly from November 1996 to October 1997 and examined for enteric parasites. To detect oocysts of *C. parvum*, the modified acid-fast stain was applied. To determine effects of climatic factors, local weather reports were collected. The overall oocyst prevalence during 1 year from November 1996 to October 1997 was 57.0% (77 of 135), and significantly higher prevalence was noted among those aged 50-59 years (80.0%) and 60-69 years (69.0%) than in younger groups [6].

With respect to toxplasmosis, 19 out of 1,019 (1.9%) cases in general patients, 11 out of 1,030 (1.07%) cases in asthma patients in Kangnam St. Mary's Hospital, and 45 out of 780 (5.77%) cases in Cheju patients showed positive indirect latex agglutination (ILA) test titers [7]. Several local surveys during the past 20-30 years have shown that the antibody positive rates of patients in general hospitals ranged from 1.9% to 7.2% [8]. When the sera were screened for antibodies against *Toxoplasma* by ILA test, 76 cases (3.8%) were positive. In the paired CSF samples, no positive reactions were observed.

When ELISA was performed using PBS extract of Percoll purified tachyzoites as the antigen, the cut-off absorbance was determined as 0.40 and 0.27 for serum and CSF tests, respectively [9]. The antibody positive rates by ELISA were 7.0% in serum and 5.6% in CSF [9]. Thirty-nine cases (4.3%) among 899 sera from pregnant women and 4 out of 218 sera from middle school students had a positive reaction (1.8%) by ELISA [10]. Two outbreaks of acute toxoplasmosis involving 8 adult patients were linked to eating uncooked pork [2]. A total of 542 children under 10 years of age, admitted to the Seoul National University Children's Hospital, were examined for antibody titers of *T. gondii* using ILA test [11]. Among them, 7.7% had positive titers higher than 1:32, without significant difference between males (7.3%) and females (8.5%). The sera of local students from 18 high schools (boys 2,110, girls 2,460) and those of adults (474 admitted to Cheju Chungang General Hospital) were collected and checked for IgG antibody titers against *T. gondii* [12]. Serum

Table 1. The reported prevalence (%) of gastrointestinal zoonotic protozoa in Korea

| Years (No. of tested sample) / Species of zoonotic protozoa | 1962-1968 (2,414) | 1969 Jul.-1970 Dec. (2,250) | 1981 (4,116) | 1981 May-Jul. (2,735) | 1983 Aug.-1985 Dec. (2,643) | 1985 Jun.-1986 Jul. (5,251) | 1988 Feb.-May (1,011) | 1984-1992 (52,552) | 1991 Jan.-Oct. (743) | 1997 Aug. (112) |
|---|---|---|---|---|---|---|---|---|---|---|
| *Chilomastix mesnili* | | 0.5 | | | | | | | | |
| *Dientamoeba fragilis* | | 0.1 | | | | | | | | |
| *Endolimax nana* | | 10.0 | | 2.71 | 1.7 | | 0.8 | 0.8 | 0.3 | 21.4 |
| *Entamoeba coli* | 15.3 | 20.5 | 4.9 | 5.52 | 1.4 | | 3.3 | 1.1 | 0.7 | 25.0 |
| *Entamoeba histolytica* | 11.9 | 6.4 | 1.4 | 0.69 | 0.6 | 0.06 | 0.2 | 0.3 | 0.3 | 1.8 |
| *Enteromonas hominis* | | 0.7 | | | | | | | | |
| *Giardia lamblia* | | 5.1 | 1.9 | 2.23 | 0.9 | 0.13 | 1.5 | 0.3 | 0.3 | 0.9 |
| *Iodamoeba bütschlii* | | 0.6 | 0.4 | 0.18 | 0.04 | | | | 0.1 | 1.8 |
| *Trichomonas hominis* | | 1.1 | | | | | | 0.004 | | |
| Province (area, subjects) | Gyungpook | Korea | Chollanam | Gyeonggi & Chollabuk | Soldiers | Seoul | Chollanam | Seoul | Gumgang (Chungnam) | Handicapped |

samples collected from both the students and adults showed seropositive rate of 5.5% and 12.9%, respectively [12]. Among sera of 1,109 inhabitants of the rural area Okcheon-gun, Korea, 6.9% were seropositive to *T. gondii* by ELISA [13].

A total of 1,008 *Apodemus agrarius*, a dominant species of field rodents in Korea, were trapped at various locations around the country, and their serum antibody (IgG) levels to *T. gondii* were examined by ELISA. The mean absorbance was 0.11, and 15 samples (1.5%) showed positive titers from 0.18 to 0.59. The seropositive samples were analyzed by immunoblot, of which 5 had reactive bands to *T. gondii* water soluble antigens of 30, 35, and 43 kDa [14].

In the survey of *P. carinii* infection in Korea, 40.0% of the 145 sera from Korean children were positive with any of the antigenic protein bands of *P. carinii* [15]. Forty-four percent of 2,580 sera from Seoul National University Hospital patients were positive for *P. carinii* [16].

The epidemiological and clinical patterns of HIV infection/AIDS in Korea were investigated retrospectively by analyzing the medical records of 176 HIV-infected persons who visited 2 major referral hospitals of AIDS in Korea from 1985 to April 2000. The *P. carinii* pneumonia was 15.9% and among death cases, 25.7% [19]. The medical records of 173 HIV-infected patients were reviewed to determine the frequency and types of major opportunistic diseases in patients with HIV infection in South Korea. The patients were seen from 1985 to 1998 at a referral hospital for AIDS in South Korea and the positive rate of *P. carinii* pneumonia was 10% among 173 HIV-infected patients [18].

### Major zoonotic trematodes

There are 3 kinds of trematodes, such as monogenean, aspidogastrean, and digenean trematodes, with digenean being the only zoonotic trematodes. The characteristics of digenean trematodes are dorsoventrally flattened, unsegmented, and leaf-like worms and have 1 or 2 suckers (oral and ventral suckers), rarely armed with hooks or clamps. All digenean trematodes have 1 or 2 intermediate hosts and first intermediate hosts are molluscs. Almost all zoonotic trematodes have the 2nd intermediate hosts, such as cyprinoid freshwater fish or crustacea [1].

The prevalence of zoonotic trematodes was reduced below 0.1% in all Korean people after the 1990s, but in some riverside and coastal areas it was as high as 10.0%. There were 30.8% and 14.5% rates of *C. sinensis* and *Metagonimus yokogawai* infection in 1991 along the river side areas. *C. sinensis*, *M. yokogawai*, and *P. westermani* revealed very low infection rates (0.2, 0.9, and 0.4%, respectively) in 1970 because there were few riverside areas where the 1st and 2nd intermediate hosts lived (Table 2).

In a survey of heterophyid trematodes, *Heterophyopsis continua*, *Pygidiopsis summa*, and *Heterophyes nocens* have been shown to be infected in domestic cats in Korea [19]. It was reported the human infections with *Heterophyes heterophyes* and *H. dispar* have been imported from Saudi Arabia [20]. A highly endemic locus of human *H. nocens* infection was discovered in a small coastal village of Shinan-gun, Chollanam-do, for the first time in Korea. Fecal examinations by cellophane thick smear and formalin-ether sedimentation techniques revealed 42.9% out of 98 inhabitants were positive for heterophyid eggs [21]. Also, the egg positive rate of heterophyids was very high, 75.0%, whereas that of other parasites was comparatively lower, 0.9-3.7% by parasite species, among 108 inhabitants in a small coastal village of Muan-gun, Chollanam-do [22].

Chai and Lee [23] reviewed a total of 19 species of food-borne intestinal trematodes in humans in Korea in their review paper. They include 12 species of the Heterophyidae, *M. yokogawai*, *M. takahashii*, *M. miyatai*, *H. nocens*, *H. heterophyes* (imported), *H.*

Table 2. The reported prevalence (%) of zoonotic trematodes in Korea

| Years (No. of tested samples) / Species of trematodes | 1962-1968 (2,414) | 1969 Jul.-1970 Dec. (2,250) | 1970 Jul. (3,169) | 1983 Aug.-1985 Dec. (2,643) | 1985 Jun.-1986 Jul. (5,251) | 1984-1992 (52,552) | 1991 Jan.-Oct. (743) | 1992 (113) | 1993 (233) |
|---|---|---|---|---|---|---|---|---|---|
| *Clonorchis sinensis* | 29.8 | 12.1 | 0.2 | 7.6 | 1.43 | 3.2 | 30.8 | 6.2 | 0.4 |
| *Echinostoma hortense* | | | | 0.04 | | | | | 0.4 |
| *Echinostoma* spp. | | | | | | 0.03 | | | |
| Fasciolidae | | 0.04 | | | | | 0.7 | | |
| *Neodiplostomum seoulense* | | | | 0.9 | | | | | 0.4 |
| *Metagonimus yokogawai* | | 0.04 | 0.9 | 1.1 | 0.13 | 1.2 | 14.5 | | 0.9 |
| *Metagonimus* sp. | | | | | | | | 2.7 | |
| *Paragonimus westermani* | | 1/2,250 | 0.4 | 0.08 | | 0.02 | | | |
| Province (area, subjects) | Gyungpook | Korea | Cheju | Soldiers | Seoul | Seoul | Gumgang | Soldiers | Soldiers |

*dispar* (imported), *H. continua, P. summa, Stellantchasmus falcatus, Centrocestus armatus, Stictodora fuscata,* and *S. lari*; 4 species of the Echinostomatidae, *Echinostoma hortense, Echinostoma cinetorchis, Echinochasmus japonicus,* and *Acanthoparyphium tyosenense*; and 1 species each of the Neodiplostomidae, *Neodiplostomum seoulense*, Plagiorchiidae, *Plagiorchis muris,* and *Gymnophallidae, Gymnophalloides seoi* [23].

In a recent survey of metagonimiasis in Korea, the egg positive rate of *M. yokogawai* was 29.7%, showing a remarkable difference between males (46.6%) and females (16.3%) from 165 fecal samples around Osib stream, Gangwon-do (province) in an east-northern coastal area in Korea during 1997-1998 [24]. Similarly, the average infection rate of the inhabitants in several small streams of Gangwon-do was 7.8%; 11.4% in males and 3.2% in females [25]. Meanwhile, the eggs of *Metagonimus* spp. were detected from 15 (9.7%) out of 154 people examined in Umsong-gun, a side of the Namhan River [26].

During an investigation of intestinal flukes among house rats in Yangyang-gun, Gangwon-do, a total of 6 species of trematodes belonging to 3 families; the Echinostomatidae (*E. hortense, E. cinetorchis, E. revolutum* and *Echinoparyphium recurvatum*), the Neodiplostomidae (*N. seoulense*; under the name *Fibricola seoulensis*) and the Plagiorchiidae (*P. muris*), were recovered from 2 adult rats. *E. revolutum* and *E. recurvatum* were new trematode faunae of rats in Korea [27].

In Korea, there are no natural infections of *Schistosoma* spp., but an imported case of cerebral schistosomiasis caused by *Schistosoma mansoni* was reported in a 40-year-old man who had worked in Yemen [28].

### Major zoonotic cestodes

There are 2 kinds of cetodes, such as *Eucestoda* and *Cotyloda*. Cestodes are hermaphroditic and endoparasitic worms with an elongated flat body without a body cavity or alimentary canal. Their bodies are comprised of 3 parts, such as, scolex, neck, and strobila. *Eucestoda* have 1 intermediate host, but *Cotyloda* have 2 or more intermediate hosts [1].

After zoonotic cestodes were reported by Matsumoto in 1915 in Taegu, Korea, many Japanese and Korean researchers reported cestodes in various places around Korea until 1943. After 1949, the incidences of cestodes reported were from 0% (0/147 and 0/5,251) in Gyeongsangnam-do [29] and Seoul [30] to 12.7% (402/3,169) in Cheju. Cheju was an endemic area of cestodes (10.2%, 452/4,449) in Korea at that time. However, the prevalence of cestodes in Cheju was reduced to 3.9% (50/1,280) in 1985. Cheju had the highest incidence of *Taenia* spp. infection out of different provinces in Korea. This is in accordance with the traditional habits and environments of Cheju. Many years ago, the pigsty was located below the toilet, so that pigs were raised to eat the stool and infected with the eggs of *Taenia* spp. Humans were habituated to eat raw pork products, especially the liver, so they became infected with the metacestodes of *Taenia* spp., *T. solium* and *Taenia asiatica*. Eom and Rim [31] reported the incidence of metacestodes (*Cysticercus*) to be 1.0% in pigs. Seong et al. [32] reported a 65.1% incidence of cestodes in Chunchon, *Taenia taeniaeformis metacestodes* surveyed in rats.

Zoonotic cestodes were important parasites in Korea until many years ago. But nowadays the prevalence of cestodes in humans is very low because the environment has changed very fast according to the change of the economic situation and education. Some zoonotic cestodes, such as, *D. latum*, a parasite with freshwater fish as the intermediate host, occasionally infect people who frequently eat raw freshwater fish.

During earlier years, the prevalences of cestodes in Pyeongbuk and Hamkyeong provinces (now located in North Korea) were reported by Japanese researchers until 1945. The prevalences of cestodes in Korea were 0.78% (3,285/419,942) from 1915 to 1998. The incidence of cestodes in Gyeonggi-do were higher (2.8%, 204/7,352) than any other provinces except Cheju. This was because the majority of the data (2.9%, 201/7,000) were those already reported many years ago by Mills in 1927. Patients with other zoonotic cestodes, such as, *E. granulosus, Hymenolepis diminuta* and *Hymenolepis nana*, have been reported. About 30 cases of hydatid diseases (due to *E. granulosus*) were reported, but all but 1 case were imported from other endemic countries [33] (Tables 3-5).

An imported case of hepatic unilocular hydatid disease was reported by Chai et al. [33]. A huge hepatic cyst was found by sonography and computerized tomography. Removing the cyst, an exploratory laparotomy was performed under the impression of hydatid disease. The cyst was successfully removed. This was the 16th case of hydatid disease reported in Korea [33]. The first human case of *Diplogonoporus balaenopterae* (Cestoda: Diphyllobothriidae) infection was reported in 1995 [34]. A part of cestode strobila was isolated from a 41-year-old male. The results of laboratory examinations were within normal limits except for slight eosinophilia (6%) and extraordinarily high serum IgE levels (10,182 IU/ml) [34]. Chung et al. [35] reported infection of *D. latum* in 3 men who had eaten the brackish water fish, *Liza*

Table 3. Prevalence of *Taenia* spp. infection through human coprological examinations in Korea from 1915 to 1998

| Province, area, or subjects | No. examined | No. positive | % |
|---|---|---|---|
| Korea | 186,197 | 1,694 | 0.9 |
| Soldier | 26,368 | 124 | 0.5 |
| Seoul | 81,233 | 148 | 0.2 |
| Kyeonggi | 7,352 | 204 | 2.8 |
| Kangwon | 2,975 | 54 | 1.8 |
| Chungbuk | 608 | 5 | 0.8 |
| Taegu | 4,905 | 56 | 1.1 |
| Kyeongbuk | 6,354 | 37 | 0.6 |
| Kyeongnam | 7,389 | 72 | 1.0 |
| Chonbuk | 5,818 | 177 | 3.0 |
| Chonnam | 84,996 | 245 | 0.3 |
| Cheju | 4,449 | 452 | 10.2 |
| Pyeongbuk | 698 | 7 | 1.0 |
| Hamkyeong | 600 | 10 | 1.7 |
| Total | 419,942 | 3,285 | 0.8 |

Table 4. Fluctuation in the prevalence of *Taenia* spp. infection in humans in Korea

| Periods | No. | | Prevalence (%) |
|---|---|---|---|
| | Examined | Positives | |
| 1910-1919 | 674 | 42 | 6.2 |
| 1920-1929 | 15,492 | 299 | 1.9 |
| 1930-1939 | 1,458 | 7 | 0.5 |
| 1940-1949 | 660 | 6 | 0.9 |
| 1950-1959 | 919 | 16 | 1.7 |
| 1960-1969 | 63,669 | 533 | 0.8 |
| 1970-1979 | 82,281 | 1,287 | 1.6 |
| 1980-1989 | 121,101 | 950 | 0.8 |
| 1990-Now | 133,688 | 145 | 0.1 |
| Total | 419,942 | 3,285 | 0.8 |
| 1992[a] | 25,552 | 256 | 1.0 |
| 1995[b] | 43 | 28 | 65.1 |

[a]The incidence of swine *Cysticercus* in pigs.
[b]The incidence of *T. taeniaformis* in rats in Chuncheon, Gangwon-do.

Table 5. The reported prevalence (%) of zoonotic cestodes in Korea

| Years (No. of tested samples) / Species of cestodes | 1969 Jul.-1970 Dec.(2,250) | 1970 Jul. (3,169) | 1983 Aug.-1985 Dec.(2,643) | 1985 Jun.-1986 Jul. (5,251) | 1988 Feb.-May (1,011) | 1984-1992 (52,552) | 1991 Jan.-Oct. (743) |
|---|---|---|---|---|---|---|---|
| *Diphyllobothrium latum* | | | | 0.02 | | 0.004 | |
| *Hymenolepis diminuta* | | | 0.04 | | | | |
| *Hymenolepis nana* | 0.7 | 1.4 | 0.2 | 0.02 | 0.4 | 0.03 | |
| Province (area/subjects) | Korea | Cheju | Soldiers | Seoul | Chollanam | Seoul | Gumgang |

*haematocheila*. They were treated with praziquantel and an adult worm was collected from each of them. One had a 310 cm strobila with scolex, another had a 340 cm strobila with scolex, and the other had a 100 cm strobila without scolex [35]. Infections of pigs with *T. asiatica* metacestodes in their livers was surveyed among Korean domestic pigs [36,37]. A total of 256 livers (1.01%) of 25,358 pigs in Korea were found infected with 1-96 (mean 2.5 per pig) metacestodes. Most of the metacestodes were either calcified (87.1%) or highly degenerated (12.9%). Living metacestodes were present in only 0.015% (3/25,358) of the examined livers [36,37]. Out of 189 stool specimens, 2.6% were positive for *Taenia* spp. among inhabitants of 2 islands of Tongyeong-gun, Gyeongsangnam-do, examined by Kato's cellophane thick smear and formalin-ether sedimentation techniques [38]. Other reports on zoonotic cestode infections have been published [39-44].

Seven cases of *D. latum* infection were reported by Lee et al. [41]. A total of 12 worms (1-3 worms/patient) were isolated and identified by the morphology, such as, the worm size (85-423 cm in length), characteristic rosette-shape uterus in their gravid proglottids, egg size (61.0-65.3 × 41.7-46.1 $\mu$m), yellowish brown color of eggs, and ovoid to elliptical shape of eggs. This was reported as the 28th case of *D. latum* infection in Korea at that time. Min [42] reported a review paper on cestode infections in Korea, such as, the Pseudophyllidea, i.e., *D. latum*, *Diphyllobothrium yonagoense*, sparganum of *Spirometra erinacei*, and the Cyclophyllidea, i.e., *H. diminuta, H. nana, Mesocestoides lineatus, T. saginata, T. solium,* and *E. granulosus.* He reported that the plerocercoid larva of *Spirometra* spp. (= sparganum) infects humans through 16 kinds of animal hosts, such as, snakes, frogs, and so on.

In 52,552 out- and in-patients, 0.05% (28), 0.03% (18), and 0.004% (2) were reported to be infected with *Taenia* spp., *H. nana,* and *D. latum*, respectively, in the Seoul Paik Hospital (1984-1992) [43]. Two rare cases of human infections with the parvum (dwarf) type of *D. latum* [syn. *D. parvum* (Stephens, 1908)] were discovered by Lee et al. [43] in Korea. A complete strobila with a scolex, 120 cm in total length, was recovered from a woman treated with praziquantel [43]. A chain of tapeworm proglottids, 15 cm in length, was also collected from a 22-year-old medical student. They had eaten raw fish. Kim et al. [44] reported 112 cases of cysticercosis and 1 of sparganosis among 80,947 biop-

sied materials of humans from 1980 to 1989 in Gwangju and Chollanam-do.

### Major zoonotic nematodes

Nematodes are characterized as free-living or parasitic, unsegmented, cylindrical, and elongated round worms with a body cavity and alimentary canal. Almost all nematodes are sex-separated and their life cycles are direct or indirect [1]. The major intestinal nematodes among Koreans were *Ascaris lumbricoides* (roundworm), *Enterobius vermicularis* (pinworm), hookworms, *Trichuris trichiura* (whipworm), *Trichostrongylus orientalis*, and *Strongyloides stercoralis*. The incidences of these nematodes were reduced to below 1.0% without special endemic areas after the middle of the 1980s. Almost all of these gastrointestinal nematodes disappeared in Korea after the 1990s, but *Enterobius vermicularis* has been recurrent [45-51] (Table 6).

Lymphatic filariasis due to *Brugia malayi* infection was endemic in several areas of South Korea; however, at present, it has been completely eradicated from Korea. In the 1960s, to determine the prevalence of filariasis in Korea, a night blood survey was carried out among inhabitants over 1 year in 15 villages throughout Cheju-do [52]. Blood films from 2,139 people were examined and 183 (8.6%) had microfilariae, with the incidences varying from 0.8 to 19.5% according to geographical sources [52]. Among 24,816 draftees from all over the country in the army recruitment camp, 155 (0.63%) were found to be infected with the microfilariae of *B. malayi* between 1964 and 1967. Cheju-do residents had the highest microfilaria rate (3.5%), followed by Gyongsangbuk-do (1.4%) and Chollanam-do (1.2%) [53]. The microfilaria positive rate among inhabitants of 5 villages in Yeongpung-gun, Gyeongsangbuk-do became 2.2% on average (male: 1.6%, female: 2.8%) among 370 persons examined in June 1980 [54].

To discover its recent situation, a small-scale survey was performed on the Heugsan Islands in September 2000 [55]. A total of 378 people, 151 males and 227 females, living in 8 villages (6 on Daeheugsan-do, 1 on Daejang-do, and 1 on Yeongsan-do) were subjected to a night blood survey for microfilaremia, and physical examination for elephantiasis in the extremities. There were 6 (1.6%) cases positive for microfilariae, and 3 patients with swollen legs were found [55]. Thereafter, microfilaremia has not been found even in previously endemic areas.

As imported zoonotic nematode infections, 2 loiasis cases due to *Loa loa* were reported [56,57]. As indigenous infections, there have been several human *Thelazia callipaeda* infections [58-65]. The reservoir hosts of *T. callipaeda* were examined. The eyes of 76 dogs reared at a farm, 78 military dogs (shepherds), 96 cattle, and 105 pigs were investigated for the presence of the eyeworm. Among them, 6 *T. callipaeda* worms were collected from 2 farm-raised dogs (2.7%) and 188 worms from 26 shepherd dogs (33.5%). No worms were recovered from the cattle or pigs. These results suggested that the dogs, especially the military dogs, serve as an important reservoir host of *T. callipaeda* in Korea [66]. Three cases of human infections with *Trichinella spiralis* were first confirmed by detecting encysted larvae in the biopsied muscle in December 1997 [67]. The patients were all men aged 35 years (1 man) and 39 years (2 men) residing in Gochang-gun, Gyongsangnam-do. They had a common past history of eating raw liver, spleen, blood, and muscle of a badger, *Meles meles melanogenys* [67]. *Dirofilaria immitis* infections are very popular among dogs in Korea; however, only 1 human *D. immitis* infection has been reported [68].

### Major zoonotic arthropods

*Sarcoptes scabiei*, causing scabies, is the most important zoonotic arthropod in Korea and around the world. The infestation rate of human scabies in Korea peaked in 1981-1982 and was prevalent (about 10%) among outpatients of the dermatologi-

Table 6. The reported prevalence (%) of zoonotic nematodes in Korea

| Years (No. of tested samples) / Species of nematodes | 1962-1968 (2,414) | 1969 Jul.7-1970 Dec. (2,250) | 1970 Jul. (3,169) | 1983 Aug.-1985 Dec. (2,643) | 1985 Jun.-1986 Jul. (5,251) | 1988 Feb.-May (1,011) | 1984-1992 (52,552) | 1991 Jan.-Oct. (743) | 1997 Aug. (112) |
|---|---|---|---|---|---|---|---|---|---|
| *Ascaris lumbricoides* | 40.9 | 46.0 | 44.3 | 2.0 | 0.02 | 17.4 | 0.2 | 0.4 | |
| *Enterobius vermicularis* | | 1.6 | | | | | 0.02 | 0.1 | 20.6 |
| Hookworms | 22.4 | 6.8 | 1.5 | 0.08 | 0.06 | 0.2 | 0.03 | 0.1 | |
| *Trichuris trichiura* | 83.6 | 46.8 | 65.6 | 13.0 | 0.7 | 27.5 | 2.0 | 1.6 | 0.28 |
| *Trichostrongylus orientalis* | 61.6 | 7.0 | 0.8 | 0.08 | | 0.2 | 0.1 | | |
| *Strongyloides stercoralis* (larvae) | | | | | | | 0.01 | | |
| Province (area/subjects) | Gyungpook | Korea | Cheju | Soldiers | Seoul | Chollanam | Seoul | Gumgang | Handicapped, Gangwon |

cal clinic, but decreased dramatically during the past ten years and has been below 1% since 1990. However, canine scabies tends to increase recently.

### Prevalence of zoonotic parasites in animals

In an epidemiological study of zoonoses in Korea, Min [69] reported that out of 13,685 specimens of animals examined from July 1980 through August 1981, a total of 9,808 (71.7%) were positive for helminth parasites. The positive rate was 99.0% in cattle, 86.5% for sheep, 85.4% in pigs, 35.4% in dogs, and 15.1% in cats. Single infection cases showed the highest rate (60.0%), followed by double (27.5%), triple (8.1%), quadruple (2.8%), quintuple (1.5%) and hexad (0.1%) infections in the decreasing order of prevalence. In this study, 18 species of zoonotic helminths were found; 11 nematodes, 6 trematodes, and 1 cestode. In cattle, strongyles, *Neoascaris vitulorum, Trichuris ovis, Nematodirus* sp., *Srongyloides papillosus, Capillaria bovis, Paramphistomum* sp., *Fasciola hepatica,* and *Eurytrema pancreaticum* were reported with infection rates of 26.4%, 24.1%, 12.0%, 6.3%, 5.1%, 0.02%, 41.5%, 33.2%, and 29.7%, respectively. In sheep, 3 nematodes and 2 trematodes were reported, including strongyles (33.0%), *S. papillosus* (26.9%), *Nematodirus* sp. (14.6%), *F. hepatica* (31.7%), and *E. pancreaticum* (19.6%). In pigs, 5 nematodes and 2 trematodes were reported; strongyles (43.1%), *Ascaris suum* (29.0%), *Metastrongylus apri* (20.3%), *Trichuris suis* (14.0%), *Strongyloides ransomi* (12.1%), *Clonorchis sinensis* (1.4%), and *Paragonimus westermani* (0.9%). Four nematode species, 3 trematodes, and 1 cestode were reported in dogs. Those were *Toxocara canis* (14.4%), *Trichuris vulpis* (9.5%), *Ancylostoma caninum* (8.0%), *Toxascaris leonina* (4.0%), *C. sinensis* (2.4%), *M. yokogawai* (1.3%), *P. westermani* (0.8%), and *Spirometra* sp. (0.9%). Two nematode species, 3 trematodes, and 1 cestode were reported in cats. Those were *Toxocara cati* (7.7%), *Ancylostoma tubaeforme* (3.1%), *C. sinensis* (1.9%), *P. westermani* (1.4%), *M. yokogawai* (1.2%), and *Spirometra* sp. (0.7%) [69].

Out of 102 stray dogs examined in Ejungbu City of Gyonggido, Korea, 72 were infected with at least more than 1 species of helminthes [70]. The common helminths found were *Dipylidium caninum* (47%), *A. caninum* (26%), *T. leonina* (16%), and *Toxocara canis* (13%). Also, *Taenia pisiformis* (9%), *Echinostoma hortense* (4%), *E. cinetorchis* (2%), and *Spirometra mansoni* (2%) were found. One dog was incidentally found to be infected with *Clonorchis sinensis* [70]. In the feces of 245 dogs, 99 (40.4%) contained parasite eggs [73]. The infection rate of *A. caninum* was 17.1%, whereas *T. vulpis, T. canis, Isospora canis,* and *T. leonina,* were 16.7%, 8.2%, 3.3%, and 2.0%, respectively [71].

## CONCLUSION

Recently, direct-zoonotic parasites, such as, *C. parvum, T. gondii,* and *P. carinii* have been prevalent in endemic areas of the Republic of Korea. Meta-zoonotic parasites, like *C. sinensis, H. nocens, M. yokogawai, P. westermanii,* and sparganum (*Spirometra* spp.), are also prevalent among people who consume raw freshwater fish or crabs in endemic areas. Cyclo-zoonotic parasites, such as, *T. saginata, T. solium,* and *T. asiatica,* were prevalent in humans who consumed raw cattle or pig meat; however, these parasites are decreasing nowadays in Korea.

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