



Current Status of Parasite Infections in Indonesia: A Literature Review

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Abstract: Indonesia and South Korea have become inseparable in various respects since the 2 countries established diplomatic relation in 1973. Indonesia is a tropical region that stretches across the equator, comprised of 5 main islands (Java, Kalimantan, Sumatra, Sulawesi, and Papua) and 4 archipelagoes (Riau, Bangka Belitung, Nusa Tenggara, and Maluku). As most population of Eastern Indonesia (Sulawesi, Papua and Nusa Tenggara & Maluku) live in poor areas, it is expected that there will be many parasites. Nevertheless, little is known about the status of parasites in Indonesia. This study examines the prevalences of malaria and lymphatic filaria, which are prevalent in Indonesia, as well as those of soil-transmitted-helminths (STH). As a result, the *Plasmodium falciparum* and *P. vivax* case loads are almost equal. The current prevalence of *P. vivax* is uniformly low (<5%) in all age groups and annual parasite incidence (API) showed decreasing tendency as 0.84 per 1,000 population in 2016. However, more than 65 million people still live in malaria epidemic regions. Lymphatic filariasis remains an important public health problem and 236 cities were classified as endemic areas in 514 cities/districts in 2017. It is difficult to ascertain the current prevalence rate of STH in Indonesia, although West Sumba and Southwest Sumba in East Nusa Tenggara reported prevalence rate of more than 20%. The study also considers the (sero) prevalences of other parasites identified in Indonesia. This report should be useful not only to parasitologists but also to travelers and people with business in Indonesia.

Key words: Indonesia, parasite, prevalence, malaria, filaria, soil-transmitted helminths

INTRODUCTION

The Republic of Indonesia (hereafter Indonesia) is the largest archipelago nation in the world. It consists of 16,056 islands covering a land area of 1,916,862.20 km². Its population was estimated at approximately 261,890,900 in 2017 [1].

It comprises 5 main islands and four archipelagoes, namely, the islands of Java, Kalimantan, Sumatra, Sulawesi and Papua, and the archipelagoes of Riau, Bangka Belitung, Nusa Tenggara and Maluku (Fig. 1). The Wallace line separates Western Indonesia (Java, Kalimantan, Sumatra and Riau & Bangka Belitung) and Eastern Indonesia (Sulawesi, Papua and Nusa Tenggara & Maluku). As most of population of Eastern Indonesia live in poor areas, it is expected that there will be many parasites.

Nevertheless, little is known about the status of parasites in Indonesia.

Indonesia has the largest economy in Southeast Asia, and is the only member of the G20 in the Association of Southeast Asian Nations (ASEAN). In recent years the country has become increasingly important to South Korea because of the “New Southern Policy” promoted by the government of South Korea. The relationship between Indonesia and South Korea has become inseparable in various respects since the 2 countries established diplomatic relations in 1973, and especially since the creation of the special strategic partnership in 2017. For instance, 31,091 citizens of South Korea live in Indonesia and 45,328 citizens of Indonesia live in South Korea [2,3]. In addition, South Korea was the fifth largest trading partner of Indonesia, and Indonesia the 10th investment partner of South Korea in 2016. Furthermore, on average of 350,000 citizens of South Korea visit Indonesia and 250,000 citizens of Indonesia visit South Korea each year.

In spite of its close relationship, Indonesia is still regarded as an unfamiliar country by the people of South Korea, espe-

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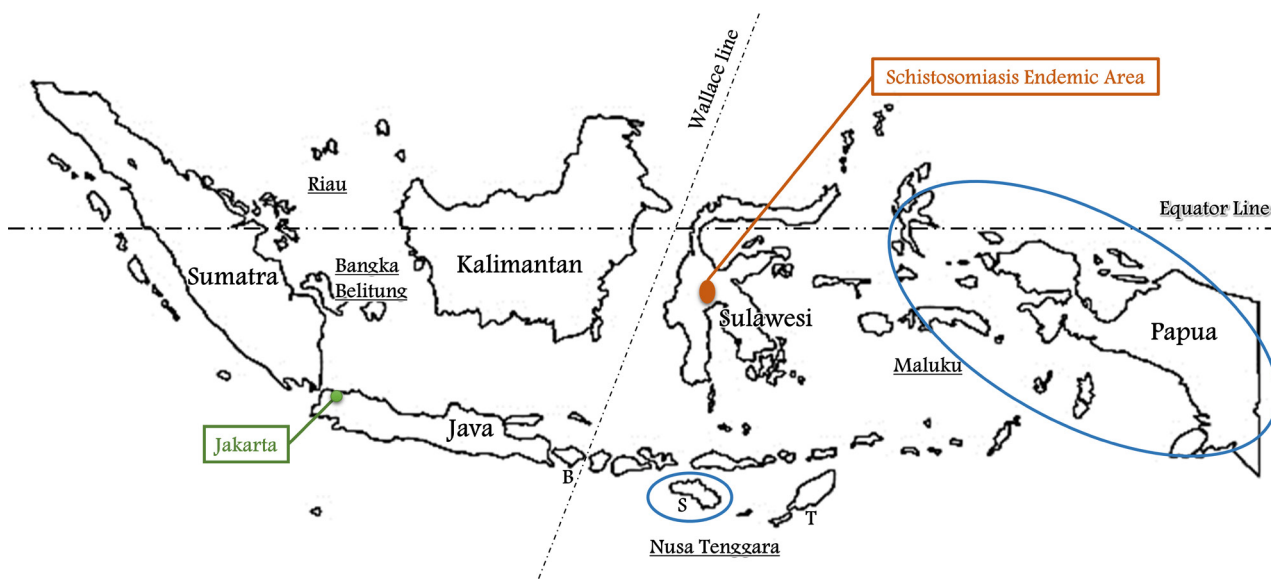


Fig. 1. Indonesia is comprised of five main islands, namely, Java, Kalimantan, Sumatra, Sulawesi, and Papua and four archipelagos, Riau, Bangka Belitung, Nusa Tenggara, and Maluku. The Wallace line separates Western and Eastern Indonesia. *Schistosoma japonicum* is found only in Central Sulawesi. The blue circle is the area with the highest annual parasite incidence (API) of malaria. B, Bali; S, Sumba; T, Timor.

cially in relation to the medical sector, and the parasites of Indonesia are not well known in South Korea. Given the prominence of parasites in Indonesia, it is important to investigate and summarize their impact in Indonesia to help Koreans become more familiar with them.

Below we describe the current status of prevalent parasites such as *Plasmodium* spp., lymphatic filaria, soil-transmitted helminths, cysticercosis/*Taenia* spp., *Schistosoma japonicum* and *Toxoplasma gondii*, all of which cause significant disease in Indonesia. Other parasites whose existence is known in Indonesia may be listed as follows: in protozoa; *Entamoeba histolytica*, *Giardia lamblia*, *Blastocystis hominis*, *Cryptosporidium* sp., *Cyclospora cayentanensis*, *Trichomonas vaginalis*; in Nematodes; *Trichinella spiralis*, *Capillaria philippinensis*, *Strongyloides stercoralis*, *Anisakis*, *Toxocara canis*; in Trematodes; *Fasciolopsis buski*, *Echinostoma* sp.; in Cestodes; sparganum, *Echinococcus granulosus*, *Hymenolepis nana*.

For this study, we identified published studies using automated data base searches of the National Library of Medicine's PubMed and further manual searching was done using Google Scholar. Also, the data from the Ministry of Foreign Affairs & Ministry of Justice in Republic of Korea, the Statistics Indonesia and the Ministry of Health Republic of Indonesia (MoH RI) were searched and utilized.

MALARIA

Malaria has received much attention from the public health sector in most tropical countries due to the difficulties in eliminating the disease, and the fluctuations in annual cases. In 2015-2016, malaria cases increased by 5 million, spread over 91 countries across the globe, and it was responsible for 445,000 deaths in 2016 [4]. It is one of the health problems given priority by the Ministry of Health Republic of Indonesia. Indonesia has many features that make it vulnerable to malaria: it is an equatorial country with malaria-receptive *Anopheles* mosquitoes; a large, dispersed population (>260 million and >5,000 inhabited islands); high internal migration; socioeconomic inequality; and decentralized governance [5,6].

Five species of *Plasmodia* are present; *Plasmodium falciparum*, *P. vivax*, *P. malariae*, *P. ovale*, and *P. knowlesi*. The 25 known anopheline vectors transmitting malaria in Indonesia are found in plantations, aquaculture ponds and in villages. They are; *Anopheles aconitus*, *An. balabacensis*, *An. bancroftii*, *An. barbirostris*, *An. farauti*, *An. flavirostris*, *An. karwari*, *An. kochi*, *An. koliensis*, *An. leucosphyrus*, *An. maculatus*, *An. nigerrimus*, *An. parangensis*, *An. punctulatus*, *An. sinensis*, *An. subpictus*, *An. sundaicus*, *An. tessellatus*, *An. vagus*, *An. lebifer*, *An. ludlowi*, *An. minimus*, *An. umbrosus*, *An. peditaeniatus*, and *An. annularis* [7].

According to Elyazar et al. [8], the median prevalence rates of four *Plasmodium* spp. between 1900 and 2008 were: *P. falciparum* 5% (range: 0.03-82%); *P. vivax* 3% (range: 0.03-70%); *P. malariae* 2% (range: 0.05-53%) and *P. ovale* 0.2% (range: 0.07-4.9%). The prevalences of these four *Plasmodia* were higher in Eastern Indonesia than in the rest of the country. However, *P. knowlesi* was found in four out of 22 people living in Kalimantan [8,9].

Most Indonesian malarial infections (83%) occur in Papua, West Papua and East Nusa Tenggara [10], and the *Plasmodium falciparum* and *Plasmodium vivax* caseloads are almost equal. The current prevalence of *P. vivax* (in peripheral blood smears) is uniformly low (<5%) in all age groups; it increases somewhat during the seasonal rains, and probably at least several million Indonesians suffer acute vivax malarial infections each year [11]. In terms of rates of malaria by occupation, residential area and age group, the rate among farmers, fishermen and workers (7.8%) is higher than among civil servants (4.7%). Rural areas (7.1%) have a higher prevalence than cities (5.0%). Infection rates are similar at all ages; in 2013 the lowest infection rate in the age group between 65 and 74 was 4.8%, and the highest infection rate in the age group between 25 and 34 was 6.6% [12]. Malaria is known to cause severe maternal anemia, fetal loss and low birth weight. Nevertheless, about 6.4 million pregnancies are exposed to malaria annually in Indonesia [13].

In 2009 the Ministry of Health Republic of Indonesia announced a plan to reach the pre-elimination stage by 2020 and to be free of malaria transmission by 2030 [14]. Indonesia's rapid progress in the past decade has resulted in more than half of its districts being officially declared malaria-free [5,15]. Between 2007 and 2016, annual parasite incidence (API, along with the blood slide positivity rate) fell threefold, from 2.89 to 0.84 per 1,000 population [10]. API continuously decreased from 2011 (1.75) to 2016 (0.84) with APIs of 1.75, 1.69, 1.38, 0.99, 0.85, and 0.84. Nonetheless, the following provinces had high APIs: Papua (45.85), West Papua (6.79), East Nusa Tenggara (5.41), Maluku (3.95), and North Maluku (2.44) in 2016 (Fig. 1). In contrast, malaria infection was reduced by more than 80% in Jakarta, Bali, East Java, West Java, Central Java, West Sumatra and Yogyakarta. Malaria has been completely eliminated in Jakarta and Bali [16].

However, despite the government's efforts, 25 percent of the population (more than 65 million) still live in malaria endemic regions [17]. Obstacles faced in eliminating transmis-

sion of *P. vivax* include: the relapse behavior of *P. vivax* in Indonesia, which is generally believed to be the Southeast Asian/West Pacific pattern represented by the single strain designated Chesson [18]. The relapse behavior of that strain may be summarized as rapid and frequent, with most first relapses occurring at around day 21 post-patency of the primary parasitemia; 75% or more relapses before day 28, and up to 5 relapses over 2 years are the rule [19]. Another greatest impediment to the control of vivax malaria in Indonesia is primaquine toxicity in glucose-6-phosphate dehydrogenase-deficient (G6PDd) patients. This highly diverse X-linked disorder is prevalent among many of Indonesia's hundreds of ethnic groups. For this reason, the WHO recommends G6PD testing prior to administration of PQ for radical cure of *P. vivax* [20].

In addition, the increase of drug-resistant malaria is impeding appropriate treatment. The Ministry of Health Republic of Indonesia recommends the ACT (artemisinin-combined therapy), DHA-PP (dihydroartemisinin-piperaquine), as first-line treatment for acute attacks because of the high prevalence of chloroquine-resistant *P. vivax*. Also, the guidelines offer a warning regarding the signs and symptoms of acute hemolytic anemia in patients receiving primaquine (and other drugs), and recommend a weekly dose of 0.75 mg/kg for 8-12 weeks [21]. There are 2 options for first-line treatment of uncomplicated falciparum malaria. The first is a combination of artesunate (AS) and amodiaquine (AQ) taken orally for 3 days, with a single dose of primaquine (PQ) as a gametocytocide on the first day (AS+AQ+PQ). The alternative first-line treatment is the combination of dihydroartemisinin (DHA) and piperaquine (PP) taken orally for 3 days, with a single dose of PQ given on the first day (DHA+PP+PQ) [8].

LYMPHATIC FILARIASIS

Lymphatic filariasis (LF) is an important public health problem facing low- and middle-income countries across the world. More than 120 million people worldwide are directly affected by the disease, and over a billion people are at risk of infection [22,23]. LF causes permanent malformation of several body parts and is one of the most important infectious causes of permanent limb disability worldwide. The disability-adjusted life year (DALY) of LF is the highest of all tropical diseases [24]. LF is also a major cause of poverty due to loss of productivity, and eventually becomes an economic burden on family and society [25].

In Indonesia, LF remains an important public health problem. The microfilaremia prevalence in 1980 in Indonesia was reported to be 19.5%, and it was reduced to 4.7% by 2014 due to the efforts of the Ministry of Health Republic of Indonesia [26].

Nonetheless, 236 cities were classified as endemic areas in 514 cities/districts. Mass Drug Administration (MDA) was still progressed in 152 cities in 2018. It was estimated that a population of about 62 million required MDA in 2016 [27,28]. The number of chronic filariasis was estimated at 12,677 in 2017. The provinces showing many chronic filariasis are as followings: Papua (3,047), East Nusa Tenggara (2,864), West Papua (1,244), West Java (907) and Aceh (591) in Sumatra. In contrast, North Kalimantan (11), West Nusa Tenggara (14) and Bali (18) showed small number of filariasis [27].

Indonesia is the only country in the world with 3 types of LF parasite: *Wuchereria bancrofti*, *Brugia malayi*, and *Brugia timori*. *B. malayi* is more widely distributed than *W. bancrofti* and *B. timori*, and has been found on Sumatra, Kalimantan, Sulawesi and Maluku. Furthermore, *W. bancrofti* and *B. malayi* each have several distinct ecotypes with different vector species and ecology. This variability leads to varied transmission dynamics and responses to intervention [28,29]. Nocturnal *B. malayi* is transmitted by *An. barbirostris*, which lives in paddy fields, and nocturnal subperiodic *B. malayi* is transmitted by *Mansonia* spp. Microfilaria in blood are mostly found in night. However, non-periodic *B. malayi* is transmitted by *Mansonia uniformis* and *M. bonnae*, and their microfilariae in blood are also found in day and night [26]. Nocturnal *Brugia timori* is found in limited areas of Eastern Indonesia such as Timor, Flores, Rote, the Alor islands and the small islands of East Nusa Tenggara and Southeast Maluku. The vector (transmitter) of *B. timori* is *An. barbirostris*. However, urban *Wuchereria bancrofti* is transmitted nocturnally by *Culex quinquefasciatus*, which lives in domestic waste water and has been found in urban areas such as Bekasi, Tangerang, Pekalongan and Lebak in Java. In contrast, rural *W. bancrofti* is found outside Java, particularly in Papua and East Nusa Tenggara, and is transmitted nocturnally by *Culex* sp. and *Anopheles* sp. (*An. gambiae*, *An. funestus*, *An. scapularis*) [26].

In 2000, the Global Program to Eliminate LF (GPELF) was established by the World Health Organization, with the target of eliminating LF by 2020 [30]. GPELF uses a 2-pronged approach, combining MDA for all those eligible in at risk populations [22], with assistance for those with lymphedema and

elephantiasis to reduce LF morbidity and suffering [30]. The MDA uses a single dose of diethylcarbamazine citrate (DEC, 6 mg/kg body weight) and albendazole (fixed dose 400 mg). The aim of MDA is to decrease the microfilaria rate and the transmission rate of LF [31]. However, DEC does not kill adult worms, and, therefore, MDA must be implemented annually to the entire eligible population for 5 or more consecutive years, until the adult worms either die or stop producing microfilaria [32].

SOIL-TRANSMITTED HELMINTHS

Neglected tropical diseases (NTDs) mostly affect people who live in extreme poverty; these diseases are also known to increase poverty even further because of their chronic and debilitating effects [33,34]. The World Health Organization recognizes 17 major parasitic and related infections as NTDs [34,35]. Of these 17 NTDs 11 are parasitic diseases, namely the helminth diseases, cysticercosis/taeniasis, dracunculiasis (guinea-worm disease), echinococcosis, foodborne trematodiasis, lymphatic filariasis, onchocerciasis (river blindness), schistosomiasis and soil-transmitted helminthiasis (STH), and the protozoan diseases, Chagas disease, human African trypanosomiasis (sleeping sickness) and leishmaniasis.

There are 4 main species of STH: *Ascaris lumbricoides*, *Trichuris trichiura* and the hookworms (*Ancylostoma duodenale* and *Necator americanus*) [36]. Pullan et al. [37] estimated that in 2010, 438.9 million people globally were infected with hookworm, 819.0 million with *A. lumbricoides* and 464.6 million with *T. trichiura*. Southeast Asia (SEA) is the region with the highest reported prevalence of STH infection in recent decades [37]. Indonesia is the largest country and although it has the greatest economic power in SEA, it contains more than half of the 200 million poorest SEA citizens, with 43.3% of the population (about 109.8 million) living on less than US\$3.20 per day [34,38]. A national survey carried out in 2008 reported a regional prevalence of STH infection of up to 61% [39]. Hotez et al. [40] reported that Indonesia has the greatest number of cases of ascariasis and trichuriasis (more than 90 million cases of each) as well as of hookworm (60 million).

It is difficult to ascertain the current comprehensive prevalence rate of STH in Indonesia. It is known that the rate in children is higher than in adults due to poor personal hygiene. The average prevalence of STH infection in school age children between 2002 and 2009 was reported to be 31.8% [41], while

the rate of STH infection in children under 5 in Tegal City of Central Java Province in 2010 was about 12.3% [42]. Hotez et al. [34] reported numbers of estimated intestinal helminth infections of 16.9 million in pre-school age children and 43.5 million in school-age children in 2012 [34,43].

East Nusa Tenggara (Indonesian: Nusa Tenggara Timur, NTT) is the southernmost province of Indonesia and the third poorest province. It consists of more than 500 islands, the largest ones being Sumba, Flores, and the western part of Timor. The Ministry of Health Republic of Indonesia reported prevalence rate of more than 20% in West Sumba (in 2011) and Southwest Sumba (in 2013) [41,44]. Kalena Rongo village, the poorest village in Southwest Sumba had an even higher prevalence of STH: *A. lumbricoides* 65.8% (279/424), *T. trichiura* 60.4% (256/424), hookworms 53.5% (227/424) in 2014 [45].

However, Indonesia has implemented MDA for deworming, and provides albendazole treatment to school children biannually [46]. MDA has led to a significant reduction in prevalence of STH. Education is an important route to transforming participants' behavior, but behavioral changes are difficult to obtain in poor and remote areas, especially when the people are poorly educated. Therefore, WHO recommends mass treatment every 6 months for at least 5 years; in that way the worms could be controlled without altering the environment and behavior [47].

CYSTICERCOSIS/TAENIASIS

Cysticercosis/Taeniasis is one of the 17 major NTDs identified by the WHO [35]. The majority of the population of Indonesia is Muslim (87.2%), whereas the remaining 12.8% consists of Christians, Buddhists, Hindus and others. Christian populations are the majority in certain districts in several Province of Indonesia such as East Nusa Tenggara, North Sulawesi, Papua and North Sumatra. By contrast, in Bali Province the majority of the inhabitants are Hindus (83.5%) [48]. Usually, taeniasis due to the ingestion of uncooked meat are in general rare in Indonesia, since Muslims usually do not eat uncooked meat. Nonetheless, three *Taenia* species affecting humans have been reported in Indonesia: *T. solium* mainly in Papua and Bali, *T. saginata* in Bali, and *T. asiatica* (a hybrid-derived descendant of *T. asiatica* and *T. saginata*) in Samosir Island and Simalungun District, North Sumatra [49,50]. *T. saginata* is rather common in Bali where local people consume uncooked beef dish (beef lawar) as a traditional local food [49].

Taeniasis and neurocysticercosis (NCC) have also been reported from Lampung, Jakarta, East Java, East Nusa Tenggara, West Kalimantan, East Kalimantan, North Sulawesi, South Sulawesi, and South East Sulawesi [49,52]. It is believed to be decreasing in Bali due to improvements in household sanitation and pig husbandry, following sustained public health education campaigns and economic progress [53]. Recently, Swastika et al. [54] reported 20 cases of *T. solium* and 39 cases of *T. saginata* in Karangasem and Gianyar town in Bali, respectively.

In Papua, taeniasis/cysticercosis cases due to *T. solium* were first reported from Paniai district in 1973. Movement of people from the endemic district (Paniai) to other districts appears to have spread the parasite to other districts in Papua. In 2009, Salim et al. [55] reported prevalence of cysticercosis in four central highland districts of Papua; the Jayawijaya (20.8%) and Paniai districts (29.2%) showed higher rate compared with 2% in the other 2 districts (Pegunungan Bintang and Puncak Jaya). Among 71 pigs in 5 villages from Jayawijaya, 50 pigs (70.4%) were seropositive [56]. Analysis of dog sera revealed 7 of 64 dogs (10.9%) were highly positive. The 2 seropositive dogs had cysticerci of *T. solium* in their brain and heart. Therefore, cysticercosis has been confirmed in humans, pigs and even dogs [57]. Survey in 2012 in Jayawijaya, revealed lower prevalence rate compared with those of 2009; 8.3% of humans and 19% of pigs [49]. Nonetheless, lifestyle, religion, and socioeconomic aspects were known to be important issues in the perpetuation and enhancing the endemicity of *T. solium* taeniasis and cysticercosis in Papua [58]. Therefore, it has been very difficult to control taeniasis/cysticercosis in Papua [49].

SCHISTOSOMA JAPONICUM

In Indonesia, schistosomiasis japonicum has been identified in 3 isolated areas of Central Sulawesi Province, namely Lindu, Napu, and Bada Valleys (Fig. 1). The disease has been a public health problem in the Lindu and Napu Valleys for more than 70 years, since the disease was first discovered in Indonesia [59]. Bada Valley has been identified as a new schistosomiasis endemic area in 2008 [60]. Lindu Valley is at an altitude of 950-1,100 m above sea level. Its total area is approximately 50 km² and consists of 7 villages. Napu Valley is located in the sub-district of North Lore, Poso, and is at the same altitude, but has a much larger endemic area (approximately 7,500 km²) comprising 17 endemic villages. The Bada Valley consists of 6 villages situated south of the Napu-Besoa Valley.

The initial field survey of *Schistosoma japonicum* infection, carried out in 1940, indicated a prevalence of 56% of schistosomiasis in 3 villages in Lindu Valley. A study of the epidemiology of the disease and ecology of the intermediate host, and pilot control trials, were conducted since 1971. These identified *Oncomelania hupensis lindoensis* as the intermediate snail host [61].

In addition, Carney et al. [62] found that the parasite infected not only humans but also 13 other mammalian species living in the surrounding areas, including wild rodents, wild pigs, wild deer, wild shrews, wild civet cats, cattle, water buffalo, horses and dogs in the endemic areas [62,63]. However, the role of livestock and wild animals in the epidemiology and transmission of schistosomiasis in Central Sulawesi remains unclear. Human, rat and snail surveys were conducted in 2008-2011. The data from human surveys showed that the prevalence of schistosomiasis fluctuated between 0.3% and 4.8% in Napu Valley, and between 0.8% and 3.6% in Lindu Valley. Rats are known to be good indicator animals for identifying schistosomiasis transmission [64]. During that period the percentage of infected rats fluctuated between 7.9% and 18.2% in Napu Valley and between 6.7% and 9.8% in Lindu Valley. The snail surveys showed that the percentages of infected snails fluctuated between 1.7% and 4.0% and between 1.8% and 3.6% in Napu Valley and Lindu Valley, respectively. The total rates in humans in Bada Valley were 0.8% (9/1,067) and 5.9% in 2008 & 2010, respectively [60]. Fortunately, *Schistosoma* infection has gradually decreased, and the rate has been low recently. Infection rates in Lindu Valley were 0.71% and 0.85% in 2013 and 2017, respectively, and in Napu Valley, 2.24% and 0.65%, respectively. Bada Valley had a rate of 0.97% in 2017 [65]. Thus, the infection rates in the 3 endemic valleys were less than 1% in 2017.

In order to maintain the low prevalence of schistosomiasis in endemic areas, a number of routine control activities were continued after the CSIADC (Central Sulawesi Integrated Area Development and Conservation) project of 1999-2005. These included human and animal stool examinations every 6 months, rat and snail surveys, selective human treatment with a single dose of praziquantel (60 mg/kg body weight), snail control and community health education, particularly for school children and farmers. This approach was able to slowly reduce environmental contamination, thereby lowering snail infection rates as well as curbing the disease cycle over time [60].

TOXOPLASMA GONDII

Toxoplasma gondii is one of the most common human zoonoses. The parasite can infect most genera of warm-blooded animals and is estimated to infect 30-50% of the human population globally [66]. The main factors associated with the great variability in the distribution of *T. gondii* infection are socioeconomic, environmental, and cultural, as well as living and eating habits [67].

Indonesia has a tropical climate, providing suitable conditions for gardening and farming, and thus increasing human contact with soil and livestock, as well as providing the possibility of contact with raw meat. Additionally, it is common to consume goat, sheep, beef, chicken, and rabbit satay, potentially as undercooked meat accompanied by raw vegetables [68].

The prevalence of *T. gondii* in Indonesia, one of the strongly affected countries, is estimated to be around 50% [69]. The seroprevalence of toxoplasmosis was 62.5% (394/630) and 67.7% (107/158) in Central Java and Yogyakarta, respectively [69,70]. In North Sulawesi there was also a high prevalence (58.5%; 501/856) in humans, and 2.3% in pigs [69]. Seroprevalence was 14.6% in pigs and 7.4% in cattle in West Java [71]. Clinically, of 64 HIV-infected patients, 21 (32.8%) gave positive results by PCR using CSF, although circulating toxoplasma IgG was present in 77.2% of patients in 1994 [72]. Also, Lestari et al. [73] reported that 26 (8.4%) of 311 HIV patients were diagnosed with toxoplasma chorioretinitis in 2013. More research and effort by governmental and nongovernmental authorities are required to minimize rates of infection.

OTHER PARASITES

We now list other parasites known to exist in Indonesia; in protozoa; *Entamoeba histolytica*, *Giardia lamblia*, *Blastocystis hominis*, *Cryptosporidium* sp., *Cyclospora cayetanensis*, *Trichomonas vaginalis*; in Nematodes; *Trichinella spiralis*, *Capillaria philippinensis*, *Strongyloides stercoralis*, *Anisakis*, *Toxocara* sp.; in Trematodes; *Fasciolopsis buski*, *Echinostoma* sp.; in Cestodes; sparganium, *Echinococcus granulosus* and *Hymenolepis nana*.

The prevalence rates of the intestinal protozoa *Entamoeba histolytic*, *Giardia lamblia* and *Blastocystis hominis* (Bh) were 17.9% (76/424), 4.5% (19/424) and 34.4% (146/424), respectively, in a rural area of Southwest Sumba, East Nusa Tenggara Province, in 2014 [43]. Yoshikawa et al. [74] reported

that the prevalence of *Bh* infection in 2010-2012 was 29.9% (147/492) among children in Winyapu area, Southwest Sumba. In addition, a high prevalence of *Bh* was observed in Jakarta: 72.4% in 318 HIV patients (21-40 years) and 54.7% in immunocompromised children with persistent and/or recurrent diarrhea [75,76]. Therefore, *Bh* is thought to be a common parasite in Indonesia, although it is considered a rare parasite in Korea.

Among coccidian protozoa, *Cryptosporidium* spp. was found in HIV patients with chronic diarrhea in Jakarta; most of patients (28/36) were infected with *C. hominis* and two with multiple species (*C. meleagridis*, *C. felis*, and *C. parvum*) [77]. *Microsporidium* spp. such as *Encephalitozoon cuniculi* genotype II (7.0%), *Enterocytozoon bieneusi* (2.0%), and *Cryptosporidium* spp. (2.7%) including *C. parvum* and *C. muris*, have been detected in Orangutans (n=298) in Sumatra and Kalimantan [78]. Also, *Cyclospora cayetanensis* infection causing diarrhea has been reported among travelers returning from Indonesia. Cyclosporiasis infections have been recently reported in a Korean girl, fourteen Dutch scientists and three Polish business men who had been to Indonesia [79-81].

The prevalence rate of *Trichomonas vaginalis* as a sexually transmitted infection in female sex workers was 15.1% among 2,500 women from 9 provinces in 2010, and 22.6% among 217 women from Manado in Indonesia in 2011 [82,83].

Among Nematoda, 19.5% of 190 children and teenagers were seropositive for *Trichinella spiralis* in Bali in 1993 [84]. Two human cases of *Capillaria philippinensis* infection have been reported in Indonesia; a European tourist with travelling experience in Indonesia and a 2-year-old female in 1994 [85]. Another intestinal helminth, *Strongyloides stercoralis* had a low infection rate of 0.6% (4/646) in Nangapanda on Flores Island in 2015 [86]. Seropositivity for *Anisakis* was 11% in inhabitants of East Java in 1996, and the seroprevalence of *Toxocara canis* among 158 junior high school students was 65.8% in 2005 [87,88].

Among the Trematoda, *Fasciolopsis buski* infection was reported in an 11-year-old boy who had never left Indonesia [89]. A 27% of stool samples of 548 people in Sei Papuyu village in the Babirik sub-district was positive for *F. buski* egg in 1985, this high infection rate was dramatically reduced as 1% in the same sub-district in 2012 [90,91]. Two cases of echinostomiasis in 278 stools were reported in the highlands of Papua, Indonesia [92].

Among Cestoda, an average of 3.1% sparganosis was detect-

ed serologically in Papua (2.7%), North Sumatra (2.9%), and Bali (6.9%) [93]. Cystic echinococcosis (CE) caused by *Echinococcus granulosus*, is very rare in humans [94]. However, hydatid cysts have been identified in animals such as water buffalo, goats, sheep, pigs and Tonkean macaque monkeys. Alveolar echinococcosis (AE) caused by *Echinococcus multilocularis* has not been reported in Indonesia [95]. The intestinal helminth, *Hymenolepis nana*, had a prevalence of 0.5% (2/424) in Kalena Rongo village in Southwest Sumba [45].

The limitation of this paper is that it has not been able to provide the latest data since it was not sufficient to obtain data on the current situation of parasite infection in Indonesia. Nonetheless, this report should be useful not only to parasitologists but also to travelers and people with business in Indonesia.

CONFLICT OF INTEREST

The authors declare no conflict of interest related to this study.

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