Review

The Coexistence of Blastocystis spp. in Humans, Animals and Environmental Sources from 2010–2021 in Asia

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Simple Summary: Blastocystis spp. are unicellular parasites that infect the gastrointestinal tract of humans and animals. Their occurrence in the environment had been detected in water sources, thus causing contamination. The presence of the parasites in humans, animals and environmental sources in Asia were reviewed according to countries in Asia, different categories of human and animal populations, and environmental sources including water samples, food and ambient air. The coexistence of the parasites poses a public health concern as the parasites are commonly found in most studies. Hence, there is a growing interest in the study of Blastocystis spp. Due to the isolation of Blastocystis spp. from living and non-living sources, a collaborative, multi-sectoral and trans-disciplinary approach known as One Health is proposed for future study of Blastocystis spp. in order to achieve optimal health outcomes through the recognition of interconnection between people, animals and their shared environment.

Abstract: Blastocystis spp. are controversial unicellular protists that inhabit the gastrointestinal tract of humans and a wide range of animals worldwide. This review provides an overview of the prevalence and distribution of Blastocystis spp. and their subtypes throughout Asia. Research articles reporting on the presence of Blastocystis spp. in locations within Asia, between 1 January 2010, and 10 May 2021, were obtained from Scopus, PubMed, and Google Scholar. In 427 articles, the prevalence of Blastocystis spp. in 31 countries within the last decade was revealed. Isolates were found in humans, various mammals, birds, reptiles, insects, water sources, vegetables, and ambient air. Prevalence of Blastocystis spp. varied widely across host categories. Subtypes identified throughout Asia were STs 1–14, and ST18–22 (novel subtypes). ST1, ST2, ST3, ST4 were the most frequently isolated in humans; ST5 in pigs; ST10 and ST14 in goats, sheep, and cattle; and ST6 and ST17 in chickens. ST1 and ST3 were most common in water samples. ST1, ST2, ST3, ST4, ST5 and ST6 were shared by humans, animals, and water sources. There is a growing interest in the study of Blastocystis spp. and their subtypes in Asia. Due to the isolation of Blastocystis spp. from biotic and abiotic sources in Asia, the application of the One Health (OH) approach to the study of Blastocystis spp. is proposed for improved perception of this organism.

Keywords: Blastocystis; subtypes; epidemiology; one health; Asia

1. Introduction

Blastocystis spp. are anaerobic unicellular eukaryotes that are widespread among humans and animals around the world [1–3]. They reside in the gastrointestinal tract wherein their role in gut health and disease is unresolved [4]. Several attempts were made at the classification of Blastocystis spp. by means of physiological and morphological characteristics [5], however, its place as a member of the phylum stramenopiles was revealed by Silberman et al. [6] based on phylogenetic analysis of the small subunit ribosomal RNA (SSU rRNA) gene.
Blastocystis spp. exhibit morphological and genetic polymorphism [7]. The six morphological forms described in the literature are vacuolar, granular, amoeboid, cyst, multivacuolar and avacuolar [8]; each of these forms show substantial variations in size [9]. Discerning one Blastocystis spp. isolate from another by morphological means alone poses a big challenge as isolates from different hosts appear similar [1].

Differences in the nucleotide sequences of the SSU rRNA gene of Blastocystis spp. isolates demonstrate the organism’s substantial genetic heterogeneity [10,11]. According to a consensus on the terminology of Blastocystis spp. subtypes proposed by Stensvold et al. [10], Blastocystis spp. isolates are referred to as Blastocystis spp. ‘subtypes’ (STs). These designations are based on the differences among the SSU rRNA gene sequences; and by 2013, 17 different STs (ST1 to ST17) of Blastocystis spp. had been acknowledged [11]. Eleven additional STs (ST18 to ST28) have been proposed since then, although the validity of four of these STs (ST18 to ST20, and ST22) are being contested [12]. Infections with Blastocystis spp. ST1 to ST9 and ST12 have been reported in humans [13,14]. All Blastocystis spp. STs have, however, been widely isolated from non-human hosts, with the exception of ST9, whose first identification in a non-human host was by Noradilah et al. [15] in chickens reared by aborigines of rural Malaysian communities.

Blastocystis spp. are transmitted through the fecal-oral route via the ingestion of feces-contaminated food and water, with the cyst form as the only transmissible form [9,14,16]. Molecular epidemiological studies have revealed possible human-to-human, foodborne, waterborne and zoonotic transmission [17–27]. For example, Eroglu and Koltas [19] reported the isolation of Blastocystis spp. subtype 1 from Blastocystis spp. positive patients, their pets and the tap water they drank from. Likewise, the presence of Blastocystis spp. subtype 4 in humans, the animals they reared and the rivers they visited regularly were observed in a rural community in Nepal by Lee et al. [18]. It is also worth mentioning that Blastocystis spp. are included as waterborne pathogens in the World Health Organization’s publications on drinking water quality [28], implying possible public health concerns.

Globally, increasing interactions between humans and animals (domestic, livestock, wildlife) at close proximity cannot be overemphasized. The rapid growth perceived in areas of agriculture, urbanization, industrialization, and international travel and trade have all contributed greatly to these interactions [29,30]. A human-animal-environment interface has emerged from the dynamic relationships between humans and animals; a clear understanding of the risks at this interface would allow better public health outcomes [29]. This is the One Health (OH) holistic approach, which considers health in the context of human, animal and environmental relationships [31]. It urges the use of interdisciplinary collaborative effort to attain optimal health for humans, animals, plants, and the environment. Bearing in mind that the role of Blastocystis spp. in the host gut, whether as mutualists, commensals, or pathogens, has yet to be ascertained [32]; the study of this organism from an ecological standpoint is required.

Studies abound on the prevalence of Blastocystis spp. from around the world revealing the various host groups and geographic distribution of this intestinal protist. The growing use of polymerase chain reaction (PCR)-based approaches has, equally, broadened the understanding of genetic diversity and transmission of Blastocystis spp. Over the last decade, Blastocystis spp. research in Asia has noticeably intensified. Rauff-Adedotun et al. [33] observed an increase in the studies of Blastocystis spp. infection in animals in Southeast Asia over the last decade. This research direction is deemed timely considering the role of agriculture, industrialization and globalization on the rapid economic growth that is taking place in the Asian region; as well as the resulting large and growing human and livestock populations, high levels of interspecies interaction, and large-scale ecological change.

This article serves as a summary of the prevalence of Blastocystis spp. and the distribution of its subtypes in humans, animals, environmental, and food sources across Asia in the last decade.
2. Materials and Methods

Articles on Blastocystis spp. research carried out within the continent of Asia were searched for in three electronic databases: Scopus, PubMed, and Google Scholar. The search covered articles published between 1 January 2010, and 10 May 2021. Duplicate articles from the three databases were removed; experimental studies, case reports, review articles, articles that did not report a positivity percentage and articles with unclear/confusing information were also excluded. Articles on the prevalence/occurrence and/or subtypes of Blastocystis spp. in both life and non-life sources undertaken within Asia were selected. The information extracted from each article included country of study, method(s) of detection of Blastocystis spp., host(s) of study, number of samples examined, number of samples positive, subtypes identified with corresponding numbers of isolates, author(s) and publication dates. Studies were retrieved on Blastocystis spp. in humans, various animal hosts, water sources, vegetables, and ambient air.

A total of 427 manuscripts met inclusion criteria, these studies were for 31 Asian countries/regions (Bangladesh, Cambodia, China, India, Indonesia, Iran, Iraq, Israel, Japan, Jordan, Korea, Laos, Lebanon, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Qatar, Russia, Saudi Arabia, Singapore, Syria, Taiwan, Thailand, Turkey, Cyprus, United Arab Emirates, Uzbekistan, Vietnam, and Yemen). Blastocystis spp. have been identified in humans, different kinds of animals, leafy vegetables, water, and ambient air using conventional microscopy, in vitro cultivation, and molecular methods.

3. Blastocystis spp. Infection in Humans

Investigations on human Blastocystis spp. infections were on children, high school and college students, hospital patients/patients referred to medical laboratories for tests, patients with gastrointestinal disorder (GID) and other conditions, immunocompromised individuals, different categories of workers, and apparently healthy and general populations from urban and rural settings alike. Irrespective of these human host groups, Blastocystis spp. were the common organisms detected in studies describing gastrointestinal tract organisms in humans; and Blastocystis spp. ST1, ST2 and ST3 were the most frequently isolated.

The presence of Blastocystis spp. has been reported in infants, kindergarten, and school-aged children in Asia in the past ten years (Table 1). However, the participants were either asymptomatic or their clinical conditions were not available. The majority of the studies were from Iran, Thailand, Malaysia, Turkey, and Indonesia; prevalence rates reported ranged from 1.2% to 83.7%. Only about 24% of these studies reported on Blastocystis spp. subtypes. Subtypes identified were ST1, ST2, ST3, ST4, ST5, ST6 and ST7.

| Country       | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References |
|---------------|-------------------------|-----------------------------|--------------------------|-----------|------------|
| Bangladesh    | 5679                    | 795 (14.0)                  | NA                       | CM, IVC   | Barua et al. [34] |
| Israel        | 45,978                  | 5422 (11.8)                 | NA                       | CM, IVC   | Ben-Shimol et al. [35] |
| China         | 170                     | 1 (0.5)                     | NA                       | MOL       | Zhang et al. [36] |
| China         | 609                     | 87 (14.3)                   | ST1, ST2, ST3            | MOL       | Qi et al. [37] |
| China         | 466                     | 71 (15.2)                   | ST1, ST3, ST6, ST7       | IVC, MOL  | Ning et al. [38] |
| Cambodia      | 308                     | 15 (4.9)                    | NA                       | CM        | Liao et al. [39] |
| India         | 195                     | 32 (16.4)                   | NA                       | CN        | Rayan et al. [40] |
| Indonesia     | 492                     | 147 (29.9)                  | ST1, ST2, ST3            | IVC, MOL  | Yoshikawa et al. [41] |
| Indonesia     | 99                      | 33 (33.3)                   | ST1, ST2, ST3            | MOL       | Zulfa et al. [42] |
| Indonesia     | 141                     | 58 (41.1)                   | ST1, ST3, ST4            | IVC, MOL  | Sari et al. [43] |
| Indonesia     | 219                     | 15 (6.8)                    | NA                       | CM        | Subahar et al. [44] |
| Indonesia     | 157                     | 44 (28.0)                   | NA                       | CM        | Sari et al. [45] |
| Iran          | 124,366                 | 3986 (3.2)                  | ST1, ST2, ST3            | CM, IVC, MOL | Ashtiani et al. [46] |
| Iran          | 864                     | 36 (4.1)                    | ST1, ST2, ST3            | CM, IVC, MOL | Niaraki et al. [47] |
| Iran          | 366                     | 11 (3.1)                    | NA                       | CM        | Mahmoudvand et al. [48] |
| Iran          | 650                     | 37 (5.7)                    | NA                       | CM        | Abdi et al. [49] |

Table 1. Prevalence and subtype distribution of Blastocystis spp. in children in Asia (2010–2021).
Prevalence and subtypes of Blastocystis spp. in immunocompromised individuals in Asia are summarized in Table 2. This category comprised mostly cancer, HIV/AIDS, and pulmonary tuberculosis patients. Reported prevalence rates were generally not above 30% except 54.8% in immunocompromised children with diarrhea in Indonesia, and 42.2% and 53.6% prevalence in HIV/AIDS cases and pulmonary tuberculosis patients respectively in Uzbekistan. Blastocystis spp. subtypes 1, 2, 3, 4, 5, and 7 were identified.

Table 2. Prevalence and subtype distribution of Blastocystis spp. in immunocompromised individuals in Asia (2010–2021).

| Host                  | Country | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References |
|-----------------------|---------|-------------------------|-----------------------------|---------------------------|-----------|------------|
| Cancer patients       | Iran    | 52                      | 11 (21.2)                   | NA                        | CM        | Salehi Kaish et al. [83] |
| (children)            | Iran    | 200                     | 24 (12.0)                   | ST1, ST2, ST3, ST7        | MOL       | Asghari et al. [84]     |
| Cancer patients       | Iran    | 52                      | 11 (21.2)                   | NA                        | CM        | Salehi Kahyesh et al. [85] |
Table 2. Cont.

| Host                      | Country           | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References          |
|---------------------------|-------------------|-------------------------|-----------------------------|--------------------------|-----------|---------------------|
| Cancer patients (children) | Iran              | 89                      | 5 (5.6)                     | NA                       | CM        | Zabolinejad et al. [86] |
| Cancer patients           | Iran              | 67                      | 16 (23.9)                   | NA                       | CM, MOL   | Mahmoudvand et al. [87] |
| Cancer patients           | China             | 381                     | 27 (7.1)                    | ST1, ST3                 | MOL       | Zhang et al. [88]     |
| Cancer patients           | Malaysia          | 61                      | 13 (21.3)                   | NA                       | IVC       | Chandramathi et al. [89] |
| Cancer patients           | Saudi Arabia      | 138                     | 38 (27.5)                   | ST1, ST2, ST5            | MOL       | Mohamed et al. [90]   |
| Cancer patients           | Turkey            | 232                     | 25 (10.8)                   | ST1, ST2, ST3            | CM, IVC, MOL | Yersal et al. [91]   |
| Cancer patients           | Turkey            | 201                     | 29 (14.4)                   | ST1, ST2, ST3            | CM, MOL   | Mulayim et al. [92]   |
| HIV/AIDS cases            | China             | 324                     | 12 (3.7)                    | ST1, ST3, ST4, ST7, ST12 | MOL       | Zhang et al. [98]     |
| HIV/AIDS cases            | China             | 505                     | 21 (4.2)                    | NA                       | MOL       | Zhu-Hua et al. [99]   |
| HIV/AIDS cases            | India             | 452                     | 13 (2.9)                    | NA                       | CM        | Ramana et al. [100]   |
| HIV/AIDS cases            | India             | 200                     | 14 (7.0)                    | NA                       | CM        | Khalil et al. [101]   |
| HIV/AIDS cases            | Iran              | 31                      | 7 (22.6)                    | NA                       | CM        | Berenji et al. [102]  |
| HIV/AIDS cases            | Iran              | 60                      | 10 (16.7)                   | NA                       | CM        | Yosefi et al. [103]   |
| HIV/AIDS cases            | Iran              | 356                     | 14 (3.9)                    | NA                       | CM        | Agholi et al. [104]   |
| HIV/AIDS cases            | Iran              | 102                     | 2 (1.9)                     | NA                       | CM        | Masoumi-Ash et al. [105] |
| HIV/AIDS cases            | Iran              | 73                      | 2 (2.7)                     | NA                       | CM        | Anvari-Taf et al. [106] |
| HIV/AIDS cases            | Iran              | 268                     | 51 (19.0)                   | ST1, ST2, ST3, ST4       | MOL       | Piranshahi et al. [107] |
| HIV/AIDS cases            | Laos              | 137                     | 36 (26.3)                   | NA                       | CM        | Paboriboune et al. [108] |
| HIV/AIDS cases            | Nepal             | 146                     | 9 (6.2)                     | NA                       | CM        | Sharan et al. [109]    |
| HIV/AIDS cases            | Nepal             | 112                     | 1 (0.9)                     | NA                       | CM        | Ghimire et al. [110]   |
| HIV/AIDS cases            | Turkey            | 65                      | 7 (10.8)                    | NA                       | CM        | Zorbozan et al. [111]  |
| HIV/AIDS cases            | Uzbekistan        | 500                     | 211 (42.2)                  | NA                       | CM        | Davis et al. [112]     |
| Tuberculosis              | Iran              | 161                     | 19 (11.8)                   | ST1, ST2, ST3            | CM, MOL   | Taghipour et al. [113] |
| Tuberculosis              | Iran              | 161                     | 19 (11.8)                   | NA                       | CM        | Taghipour et al. [114] |
| Pulmonary tuberculosis    | Uzbekistan        | 300                     | 161 (53.6)                  | NA                       | CM, 1VC   | Li et al. [115]        |
| Pulmonary tuberculosis    | China             | 369                     | 23 (6.2)                    | NA                       | CM, 1VC   | Li et al. [116]        |
| Pulmonary tuberculosis    | China             | 369                     | 23 (6.2)                    | NA                       | CM, 1VC   | Li et al. [116]        |
| Pulmonary tuberculosis    | Iran              | 50                      | 9 (18.0)                    | NA                       | CM        | Taghipour et al. [117] |
| Renal transplant recipients | Iran          | 150                     | 7 (4.7)                     | NA                       | CM        | Azami et al. [118]     |
| Immunocompromised children with diarrhea | Indonesia | 42                      | 23 (54.8)                   | NA                       | IVC       | Idris et al. [119]     |
| Immunocompromised children with diarrhea | Turkey    | 62                      | 6 (9.7)                     | NA                       | CM        | Caner et al. [120]     |
| Immunocompromised patients | Iran            | 265                     | 11 (4.2)                    | NA                       | CM        | Rasti et al. [121]     |
| Immunocompromised patients | Iran            | 204                     | 62 (30.4)                   | NA                       | CM        | Izadi et al. [122]     |
| Immunodeficient patients  | Iran              | 190                     | 32 (16.8)                   | NA                       | CM        | Esteghamati et al. [123] |
| Immunosuppressive drugs recipient | Iran     | 494                     | 49 (10.3)                   | NA                       | CM        | Mirzaei et al. [124]   |
| Immunocompromised patients | Saudi Arabia     | 136                     | 7 (5.2)                     | NA                       | CM        | Al-Megrin et al. [125] |
| Common variable immune deficiency (CVID) syndrome patients | Turkey | 37                      | 3 (8.1)                     | NA                       | CM        | Uysal et al. [126]     |

CM—Conventional microscopy, IVC—in vitro cultivation, MOL—Molecular technique, NA—Not applicable.
It is noted that hematologic and non-hematologic (cranial) cancers with *Blastocystis* spp. infections are most commonly reported in children [82–85]. Whereas, colorectal, stomach, esophagus and non-gastrointestinal cancer such as lung, liver, breast, ovarian, hematologic and other cancers were detected in adults. Among the 10 studies focused on cancer patients, six studies clearly stated that cancer patients were receiving chemotherapy treatment [82–85,87,88]. One study recruited cancer patients who have not received any chemotherapy [89]. While the remaining two were classified as follow-up cases [90] and in- or out-patient cases [91], respectively. It is noted that the highest prevalence of *Blastocystis* spp. infection in cancer patients is detected in those who have not received chemotherapy [89] as compared to the other six studies. This could be due to the existing immunocompromised condition of the cancer patients that allowed an opportunistic infection to occur.

Patients with different gastrointestinal complaints and disorders such as constipation, abdominal pain, diarrhea, irritable bowel syndrome (IBS) and inflammatory bowel disease (IBD) have been examined for *Blastocystis* spp. infection with positive results recorded as shown in Table 3. The prevalence rate was as low as 0.5%, with the highest being 67.1% and all isolates belonged to *Blastocystis* spp. subtypes 1, 2, 3, 4, 5, 6, and 7.

### Table 3. Prevalence and subtype distribution of *Blastocystis* spp. in humans with gastrointestinal symptoms in Asia (2010–2021).

| Host                  | Country          | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References          |
|-----------------------|------------------|-------------------------|----------------------------|--------------------------|-----------|---------------------|
| Children with diarrhea| China            | 850                     | 26 (3.1)                   | ST1, ST2, ST3, ST4       | MOL       | Zhang et al. [36]   |
| Children with diarrhea| Indonesia        | 57                      | 36 (63.1)                  | NA                       | MOL       | Zulfa et al. [42]   |
| Children with diarrhea| Turkey           | 60                      | 4 (6.7)                    | NA                       | CM        | Macin et al. [127]  |
| Children with diarrhea| Iran             | 400                     | 8 (2.0)                    | NA                       | CM        | Asadi et al. [128]  |
| Children with diarrhea| Qatar            | 580                     | 27 (4.7)                   | NA                       | MOL       | Boughattas et al. [129] |
| Children with diarrhea| Nepal            | 588                     | 5 (0.9)                    | NA                       | CM        | Dahal et al. [130]  |
| Children with diarrhea| Iran             | 160                     | 37 (23.1)                  | NA                       | CM        | Khalili et al. [131]|
| Children with GID     | Iran             | 500                     | 81 (16.2)                  | NA                       | CM        | Kiani et al. [132]  |
| Children with GID     | Thailand         | 82                      | 13 (15.9)                  | ST1, ST2, ST3, ST4, ST7  | CM, IVC   | Awe et al. [133]    |
| Children with GID     | Russia           | 1273                    | 62 (4.9)                   | ST1, ST2, ST3, ST4, ST7  | CM, MOL   | Sigidaev et al. [134]|
| Children with GID     | Turkey           | 84                      | 18 (21.4)                  | ST1, ST3, ST4            | MOL       | Dogan et al. [82]   |
| Patients with diarrhea| Indonesia        | 389                     | 22 (5.7)                   | NA                       | CM        | Oyofe et al. [135]  |
| Patients with diarrhea| China            | 271                     | 13 (4.8)                   | NA                       | MOL       | Zhang et al. [136]  |
| Patients with diarrhea| Korea            | 117                     | 8 (6.8)                    | NA                       | MOL       | Won et al. [137]    |
| Patients with diarrhea| Iran             | 134                     | 28 (20.7)                  | ST1, ST2, ST3            | CM, MOL   | Jalaliou et al. [138]|
| Patients with diarrhea| Iran             | 2023                    | 1357 (67.1)                | NA                       | CM        | Najafi et al. [139] |
| Patients with GID     | Iran             | 1301                    | 350 (26.9)                 | ST1, ST2, ST3, ST5       | NA        | Kiani et al. [140]  |
| Patients with GID     | Iran             | 287                     | 65 (22.7)                  | ST1, ST2, ST3, ST5       | IVC, MOL  | Moosavi et al. [141]|
| Patients with GID     | Iran             | 23                      | 23                        | ST1                      | CM, MOL   | Shahbazi et al. [142]|
| IBO patients          | Iran             | 71                      | 9 (12.7)                   | ST1, ST3                 | IVC, MOL  | Mirjalali et al. [143]|
| Adolescents with IBS  | Indonesia        | 137                     | 50 (36.5)                  | ST1, ST2, ST3, ST4, ST5  | MOL       | Kesuma et al. [144] |
| IBS patients          | India            | 150                     | 50 (33.3)                  | ST1, ST3                 | CM, IVC, MOL | Das et al. [145]  |
| IBS patients          | Iran             | 100                     | 15 (15.0)                  | ST1, ST3, ST4, ST5       | NA        | Shafiei et al. [146]|
| IBS patients          | Iran             | 122                     | 24 (19.7)                  | ST3, ST5                 | MOL       | Khandemvatan et al. [147]|
| IBS patients          | Iraq             | 78                      | 38 (48.7)                  | ST3, ST6, ST7            | NA        | Bayal et al. [148]  |
| IBS patients          | Thailand         | 66                      | 11 (16.7)                  | NA                       | IVC       | Surangsrirat et al. [149] |
| Patients with GID     | Thailand         | 579                     | 98 (16.9)                  | NA                       | CM, IVC   | Merza et al. [150]  |
| Patients with GID     | Iran             | 249                     | 92 (36.9)                  | NA                       | CM        | Mutlag et al. [151] |
| Patients with GID     | Thailand         | 5                      | 5 (100.0)                  | ST3, ST6, ST7            | CM, IVC, MOL | Sanpool et al. [152]|
| Patients with diarrhea| Turkey           | 272                     | 16 (5.9)                   | NA                       | CM, MOL   | Koltas et al. [153] |
| Patients with GID     | Turkey           | 490                     | 89 (18.2)                  | NA                       | CM, IVC   | Aykur et al. [154]  |
| Patients with GID     | Turkey           | 14,246                  | 689 (4.8)                  | NA                       | CM        | Uluska et al. [155] |
| Patients with GID     | Turkey           | 2334                    | 134 (5.7)                  | NA                       | CM        | Cekin et al. [156]  |
| Patients with GID     | Iran             | 152                     | 16 (10.5)                  | ST1, ST2, ST3            | CM, IVC, MOL | Beiromvand et al. [157]|
| Patients with diarrhea| Singapore        | 193                     | 1 (0.5)                    | NA                       | CM, MOL   | Feurle et al. [158] |
| Patients with GID     | Saudi Arabia     | 114                     | 15 (13.2)                  | NA                       | CM        | Hawash et al. [159] |
| Patients with GID     | Turkey           | 5624                    | 136 (2.4)                  | NA                       | CM        | Alver et al. [160]  |
Table 3. Cont.

| Host                   | Country | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                  |
|------------------------|---------|-------------------------|----------------------------|--------------------------|-----------|-----------------------------|
| Patients with GID      | Turkey  | 17756                   | 778 (4.4)                  | NA                       | CM        | Inceboz et al. [161]        |
| Patients with GID      | Iran    | 670                     | 38 (5.7)                   | NA                       | IVC       | Rostami Nejad et al. [162]  |
| Patients with GID      | Pakistan| 339                     | 59 (17.4)                  | NA                       | CM        | Haider et al. [163]         |
| Patients with GID      | Turkey  | 29 *                    | 29                         | ST1, ST2, ST3, ST4       | CM, MOL   | Sakalar et al. [164]        |

* Study was carried out on Blastocystis sp. positive hosts, CM—Conventional microscopy, IVC—In vitro cultivation, MOL—Molecular technique, NA—Not applicable, GID—Gastrointestinal disorder, IBD—Inflammatory bowel disease, IBS—Irritable bowel syndrome.

The occurrence of Blastocystis spp. in mental rehabilitation centers was documented by several authors from Iran only (Table 4). Prevalence ranged from 4% to 55.2%; and out of all nine of these studies, only one reported the use of molecular methods wherein ST1, ST3 and ST9 were identified.

Table 4. Prevalence and subtype distribution of Blastocystis spp. in mental rehabilitation centers in Asia (2010–2021).

| Host                                      | Country          | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                  |
|-------------------------------------------|------------------|-------------------------|----------------------------|--------------------------|-----------|-----------------------------|
| Mentally disabled children                | Iran             | 362                     | 20 (5.5)                   | NA                       | CM        | Sharif et al. [165]         |
| Mentally disabled children and adults     | Iran             | 225                     | 9 (4.0)                    | NA                       | CM        | Hazrati Tappeh et al. [166] |
| Psychiatric patients                      | Iran             | 65                      | 15 (23.1)                  | NA                       | CM        | Khalili et al. [167]        |
| Mentally disabled individuals             | Iran             | 173                     | 29 (16.8)                  | NA                       | CM        | Saeidinia et al. [168]      |
| Mentally disabled individuals             | Iran             | 133                     | 12 (9.0)                   | NA                       | CM        | Shokri et al. [169]         |
| Mentally disabled individuals and elderly people | Iran           | 243                     | 81 (33.3)                  | NA                       | CM        | Rasti et al. [170]          |
| Mentally disabled individuals             | Iran             | 126                     | 38 (30.2)                  | NA                       | CM        | Mohammadi-Meskin et al. [171] |
| Mental retardation center personnel       | Iran             | 37                      | 12 (32.4)                  | NA                       | CM        | Mohammadi-Meskin et al. [171] |
| Schizophrenic male patients                | Iran             | 58                      | 32 (55.2)                  | ST1, ST3, ST9            | CM, MOL   | Sheikh et al. [172]         |

CM—Conventional microscopy, MOL—Molecular technique, NA—Not applicable.

Studies on the status of Blastocystis spp. infection in hospital in- and out-patients are shown in Table 5. The diseases/illnesses of these patients were, however, not stated in the reports. Nonetheless, they did not show any gastrointestinal-related symptoms and volunteered as healthy participants in the gastrointestinal studies. As a result of their involvement, though asymptomatic, they were detected positive for Blastocystis spp. infection. Infection rate as low as 0.02% was recorded in 23,278 Saudi Arabian patients, while all (100%) of 15 hospital patients without any gastrointestinal complaints were found positive for Blastocystis spp. Asides Blastocystis spp. subtypes 1, 2, and 3 which were the most commonly observed, STs 6 and 7 were also commonly identified while STs 4 and 5 were few.
Table 5. Prevalence and subtype distribution of *Blastocystis* spp. in patients of health institutions in Asia (2010–2021) who volunteered in gastrointestinal studies.

| Country        | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                  |
|----------------|-------------------------|----------------------------|--------------------------|-----------|-----------------------------|
| China          | 126                     | 3 (2.4)                    | ST5                      | MOL       | Zhu et al. [173]            |
| China          | 198                     | 21 (10.6)                  | ST1, ST3, ST6, ST7       | MOL       | Kang et al. [174]           |
| Iran           | 670                     | 23 (3.4)                   | NA                       | IVC       | Rostami Nejad et al. [162]  |
| Iran           | 1232                    | 154 (12.6)                 | NA                       | CM        | Abdipour et al. [175]       |
| Iran           | 1383                    | 239 (17.3)                 | ST1, ST2, ST3            | CM, MOL   | Bahrami et al. [176]        |
| Iran           | 984                     | 13 (1.3)                   | NA                       | CM        | Gholipoor et al. [177]      |
| Iran           | 417                     | 39 (9.4)                   | NA                       | CM        | Viesi et al. [178]          |
| Iran           | 511                     | 33 (6.5)                   | ST2, ST3, ST5            | MOL       | Badparva et al. [179]       |
| Iran           | 420                     | 60 (14.3)                  | ST2, ST3                 | CM, MOL   | Shaker et al. [180]         |
| Iran           | 802                     | 39 (4.9)                   | ST1, ST2, ST3, ST7       | MOL       | Haghighi et al. [181]       |
| Iran           | 420                     | 60 (14.3)                  | NA                       | CM        | Shaker et al. [182]         |
| Iran           | 1120                    | 65 (5.8)                   | NA                       | CM        | Tork et al. [183]           |
| Iran           | 4788                    | 247 (5.2)                  | NA                       | CM        | Asfaram et al. [184]        |
| Iran           | 210                     | 66 (31.4)                  | ST1, ST2, ST3, ST4, ST5  | MOL       | Bafighi et al. [185]        |
| Iran           | 133                     | 35 (26.3)                  | ST1, ST2, ST3, ST5       | IVC, MOL  | Moosavi et al. [141]        |
| Iran           | 4427                    | 407 (9.2)                  | NA                       | IVC       | Karimazar et al. [186]      |
| Iraq           | 300                     | 146 (48.7)                 | NA                       | CM        | Abdul Ridha and Faiq. [187] |
| Iran           | 618                     | 146 (23.6)                 | ST1, ST2, ST3            | CM, IVC, MOL | Salehi et al. [188] |
| Iran           | 481                     | 69 (14.4)                  | ST1, ST2, ST3, ST4, ST5  | MOL       | Khademvatan et al. [189]    |
| Iran           | 250                     | 41 (16.4)                  | ST1, ST2, ST3            | CM, IVC, MOL | Sardarian et al. [190]    |
| Iran           | 200                     | 63 (31.5)                  | NA                       | CM, IVC   | Hamidi et al. [191]         |
| Iran           | 5000                    | 784 (1.6)                  | NA                       | CM        | Javadi et al. [192]         |
| Iran           | 864                     | 68 (7.9)                   | ST1, ST2, ST3            | CM, IVC, MOL | Delshad et al. [193]   |
| Iran           | 566                     | 10 (1.8)                   | NA                       | CM        | Norouzi et al. [194]        |
| Iran           | 100                     | 13 (13.0)                  | ST1, ST2, ST6            | CM, MOL   | Sharifi et al. [195]        |
| Iran           | 1878                    | 152 (8.1)                  | ST1, ST2, ST3, ST7       | CM, MOL   | Salehi et al. [196]         |
| Lebanon        | 40                      | 23 (57.5)                  | ST1, ST2, ST3            | MOL       | Greige et al. [197]         |
| Lebanon        | 220                     | 42 (19.1)                  | ST1, ST2, ST3, ST4       | CM, MOL   | El Safadi et al. [198]      |
| Lebanon        | 50                      | 27 (54.0)                  | ST1, ST2, ST3            | MOL       | Greige et al. [199]         |
| Saudi Arabia   | 23,278                  | 5 (0.02)                   | NA                       | CM        | Imam et al. [200]           |
| Saudi Arabia   | 130                     | 3 (2.3)                    | NA                       | CM        | Hassen Amer et al. [201]    |
| Saudi Arabia   | 1262                    | 133 (10.5)                 | ST1, ST2, ST3            | IVC, MOL  | Mohamed et al. [202]        |
| Thailand       | 14,325                  | 199 (1.4)                  | NA                       | CM        | Laodim et al. [203]         |
| Thailand       | 562                     | 56 (9.9)                   | ST1, ST3, ST6, ST7       | IVC, MOL  | Jantermctor et al. [204]    |
| Thailand       | 15                      | 15 (100.0)                 | ST1, ST3, ST6, ST7       | CM, IVC, MOL | Sanpool et al. [152]    |
| Turkey         | 192                     | 6 (3.1)                    | NA                       | CM        | Cekin et al. [156]          |
| Turkey         | 20,948                  | 13,245 (63.2)              | NA                       | CM        | Polat et al. [205]          |
| Turkey         | 50,185                  | 275 (0.5)                  | NA                       | CM        | Beyhan et al. [206]         |
| Turkey         | 4030                    | 476 (11.1)                 | ST1, ST2, ST3            | CM, MOL   | Sarzhanov et al. [207]      |
| Turkey         | 6,757                   | 160 (2.4)                  | NA                       | CM        | Selek et al. [208]          |

CM—Conventional microscopy, IVC—In vitro cultivation, MOL—Molecular technique, NA—Not applicable.

Table 6 is a summary of *Blastocystis* spp. infection in students and working populations in Asia between 2010 and 2021.
| Host                                      | Country/Region | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                  |
|-------------------------------------------|----------------|-------------------------|----------------------------|---------------------------|-----------|-----------------------------|
| Adolescents                              | Indonesia      | 70                      | 20 (28.6)                  | ST1, ST3                  | MOL       | Kesuma et al. [144]         |
| High school students foreign              | Turkey         | 192                     | 63 (32.8)                  | NA                        |           | Yaman et al. [209]          |
| College students                          | China          | 53 *                    | 53                         | ST1, ST3, ST4, ST6, ST7   | IVC, MOL  | Zhan et al. [210]           |
| College students of practical parasitology | Iran           | 175                     | 9 (5.1)                    | NA                        | CM        | Fallahi et al. [211]        |
| courses Students who did not take any     | Iran           | 135                     | 5 (3.7)                    | NA                        | CM        | Fallahi et al. [211]        |
| practical parasitology courses            |                |                         |                            |                           |           |                             |
| University students                       | Thailand       | 1025                    | 416 (40.6)                 | ST1, ST2, ST3             | CM, IVC, MOL | Srichaiporn et al. [212]   |
| Working children                          | Iran           | 175                     | 57 (32.6)                  | NA                        | CM        | Salemi et al. [213]         |
| Caregivers in a childcare center          | Thailand       | 25                      | 6 (24.0)                   | ST1, ST2, ST3             | IVC, MOL  | Pipatsatithpong et al. [22] |
| Cattle breeders                           | Lebanon        | 40                      | 21 (52.5)                  | ST1, ST2, ST3             | MOL       | Greige et al. [197]         |
| Chicken slaughterhouse staff              | Lebanon        | 50                      | 28 (56.0)                  | ST1, ST2, ST3, ST6        | MOL       | Greige et al. [199]         |
| Pig handler and individuals who lived     | Thailand       | 154                     | 10 (6.5)                   | ST1, ST3, ST5             | MOL       | Pintong et al. [214]        |
| near pig farms                            |                |                         |                            |                           |           |                             |
| Pig handler and individuals who           | Thailand       | 117                     | 15 (12.8)                  | ST1, ST2, ST3             | MOL       | Udonsom et al. [215]        |
| lived near pig farms                      |                |                         |                            |                           |           |                             |
| Food handlers                             | Iran           | 210                     | 3 (1.4)                    | NA                        | CM        | Kheirandish et al. [216]    |
| Food handlers                             | Iran           | 1021                    | 40 (3.9)                   | NA                        | CM        | Motazedian et al. [217]     |
| Food handlers                             | Iran           | 1041                    | 29 (2.8)                   | NA                        | CM        | Kheirandish et al. [222]    |
| Food handlers                             | Iran           | 800                     | 194 (24.3)                 | NA                        | CM        | Heydari-Hengami et al. [219]|
| Food handlers                             | Iran           | 1018                    | 7 (7.2)                    | NA                        | CM        | Khodabakhsh et al. [220]    |
| Food handlers                             | Iran           | 1530                    | 44 (2.9)                   | NA                        | CM        | Shahnazi et al. [221]       |
| Food handlers                             | Jordan         | 816                     | 18 (2.2)                   | NA                        | CM        | Abdel-Dayem et al. [223]    |
| Food handlers                             | Iran           | 901                     | 6 (0.7)                    | NA                        | CM        | Downs et al. [224]          |
| Military personnel                        | Iraq           | 437                     | 36 (8.2)                   | NA                        | CM        | Kivatanachai and Rhongbuttri [225] |
| Gardeners                                 | Thailand       | 253                     | 23 (9.1)                   | NA                        | CM        |                             |
| Immigrant workers                         | Thailand       | 600                     | 6 (1.0)                    | NA                        | CM        | Sangwalee et al. [226]      |
| Immigrant workers                         | Qatar          | 608                     | 432 (71.1)                 | ST1, ST2, ST3             | MOL       | Abu-Madi et al. [227]       |
| Immigrant workers                         | Qatar          | 735                     | 479 (65.2)                 | NA                        | CM, MOL   | Abu-Madi et al. [228]       |
| Settled immigrant                         | Qatar          | 9208                    | 398 (4.3)                  | NA                        | CM        | Abu-Madi et al. [229]       |
| Newly arrived immigrants                  | Qatar          | 2486                    | 137 (5.5)                  | NA                        | MOL       | Abu-Madi et al. [230]       |
| Settled immigrants                        | Qatar          | 29,286                  | 1010 (3.5)                 | NA                        | MOL       | Abu-Madi et al. [231]       |
| Resident workers                          | Qatar          | 772                     | 39 (5.1)                   | NA                        | CM        | Abu-Madi et al. [232]       |
| Workers                                   | Saudi Arabia   | 1238                    | 245 (19.8)                 | NA                        | CM        | Wadik [233]                 |
| New employees in a tertiary health care    | Saudi Arabia   | 2490                    | 314 (12.6)                 | NA                        |           | Ahmed et al. [234]          |
| center                                    |                |                         |                            |                           |           |                             |
| Foreign laborers                          | Taiwan         | 7360                    | 190 (2.6)                  | NA                        | CM        | Hsieh et al. [235]          |
| Foreigners                                | Taiwan         | 2875                    | 33 (1.1)                   | NA                        | CM        | Hsieh et al. [236]          |
| Indonesian immigrant workers              | Taiwan         | 128                     | 28 (21.9)                  | ST1, ST2, ST3             | CM, MOL   | Chen et al. [237]           |
| Sanitary and Non-sanitary institutions'    | Turkey         | 2443                    | 175 (7.2)                  | NA                        | CM        | Karaman et al. [238]        |
| workers                                   |                |                         |                            |                           |           |                             |
| Migrant workers                           | Malaysia       | 220                     | 68 (30.9)                  | ST1, ST2, ST3             | IVC, MOL  | Sahimin et al. [239]        |

* Study was carried out on Blastocystis spp. positive hosts, CM—Conventional microscopy, IVC—in vitro cultivation, MOL—Molecular technique, NA—Not applicable.
Food handlers and immigrant workers were commonly screened in Iran and Qatar, respectively. In addition to *Blastocystis* spp. subtypes 1, 2, and 3; ST6 was isolated from chicken slaughterhouse staff in Lebanon [199], and ST5 in pig handlers in Thailand [214].

The majority of the studies on *Blastocystis* spp. infections in humans in Asia within 2010 and 2021 were on general populations of apparently healthy status; such participants comprised urban dwellers, rural dwellers, and healthy control for immunocompromised persons. As depicted in Table 7, low prevalence rates of less than 5% and rates as high as 50% were reported from the different countries where these studies were undertaken, and various techniques were used for the detection of this protist. *Blastocystis* spp. subtypes reported were STs1-7 and ST10, whose only record was from Lebanon.

### Table 7. Prevalence and subtype distribution of *Blastocystis* spp. in apparently healthy general populations in Asia (2010–2021).

| Country | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References |
|---------|------------------------|------------------------------|--------------------------|-----------|------------|
| Bangladesh | 140 | 51 (36.4) | NA | CM | Noor et al. [240] |
| Cambodia | 218 | 40 (18.4) | NA | CM | Schär et al. [241] |
| Cambodia | 210 | 116 (55.2) | ST1, ST2, ST3 | MOL | Wang et al. [242] |
| China | 497 | 215 (43.3) | NA | CM | He et al. [243] |
| China | 5939 | 494 (8.3) | NA | MOL | Chen et al. [244] |
| China | 26,886 | 2 (0.01) | NA | CM | Umar et al. [245] |
| China | 1023 | 1 (0.1) | NA | CM | Jiang [246] |
| China | 6710 | 19 (0.3) | NA | CM | Zhang et al. [247] |
| China | 303 | 67 (22.1) | NA | IVC | Tian et al. [95] |
| China | 294 | 64 (21.8) | NA | IVC | Tian et al. [96] |
| China | 149 | 9 (6.0) | NA | MOL | Zhang et al. [136] |
| China | 366 | 28 (7.6) | NA | CM, IVC | Li et al. [85] |
| China | 289 | 13 (4.5) | ST1, ST3, ST4 | MOL | Gong et al. [248] |
| China | 507 | 48 (9.5) | ST1, ST2, ST3, ST4 | MOL | Deng et al. [249] |
| China | 1118 | 390 (34.9) | ST2, ST5 | MOL | Ma et al. [250] |
| Cyprus | 230 | 64 (27.8) | ST1, ST2, ST3, ST4, ST6, ST7 | MOL | Seyer et al. [251] |
| India | 279 | 105 (37.6) | NA | MOL | Padukone et al. [252] |
| India | 200 | 16 (8.0) | NA | CM | Khalil et al. [101] |
| India | 100 | 15 (15.0) | ST1, ST3 | CM, IVC, MOL | Das et al. [145] |
| India | 23 | 13 (56.5) | NA | MOL | Lappan et al. [253] |
| Indonesia | 646 | 15 (2.3) | NA | CM | Wiriya et al. [254] |
| Indonesia | 54 | 5 (9.3) | NA | IVC | Yuli et al. [255] |
| Indonesia | 424 | 146 (34.4) | NA | CM | Sungkar et al. [256] |
| Indonesia | 53 | 9 (17.0) | NA | CM | Hayashi et al. [257] |
| Iran | 5073 | 368 (7.3) | NA | CM | Turgay et al. [258] |
| Iran | 399 | 16 (4.0) | NA | CM | Mahmoudi et al. [259] |
| Iran | 130 | 40 (30.1) | ST1, ST2, ST3 | CM, IVC, MOL | Beirmavand et al. [157] |
| Iran | 20 | 3 (15.0) | NA | CM | Berenji et al. [102] |
| Iran | 166 | 35 (21.1) | ST1, ST2, ST3 | IVC, MOL | Mirjalali et al. [143] |
| Iran | 181 | 17 (9.4) | NA | CM | Taghipour et al. [114] |
| Iran | 225 | 5 (2.2) | NA | CM | Azami et al. [118] |
| Iran | 166 | 35 (21.1) | ST1, ST2, ST3 | CM, MOL | Jalallou et al. [138] |
| Iran | 147 | 0 (0.0) | NA | CM | Anvari-Tafti et al. [106] |
| Iran | 122 | 21 (17.2) | ST1, ST3, ST4, ST5 | MOL | Khademvatan et al. [147] |
| Iran | 100 | 6 (6.0) | NA | CM | Shafei et al. [146] |
| Iran | 67 | 6 (9.0) | NA | CM, MOL | Mahmoudvand et al. [97] |
| Iran | 250 | 41 (16.4) | ST1, ST2, ST3 | CM, IVC, MOL | Sardarian et al. [190] |
| Iran | 1410 | 47 (3.3) | ST3, ST4, ST5, ST7 | CM, MOL | Khooshnood et al. [260] |
| Iran | 655 | 180 (27.5) | NA | CM | Pestehchian et al. [261] |
| Iran | 5743 | 54 (0.9) | NA | CM | Sadeghi et al. [262] |
| Iran | 5739 | 30 (0.5) | NA | CM | Sadeghi and Borji [263] |
| Iran | 2838 | 139 (5.0) | NA | CM | Badparva et al. 2014 [264] |
| Iran | 1060 | 145 (13.7) | NA | CM | Mahni et al. [265] |
Table 7. Cont.

| Country   | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                  |
|-----------|-------------------------|----------------------------|---------------------------|-----------|-----------------------------|
| Iran      | 880                     | 55 (6.3)                   | NA                        | CM        | Tork et al. [266]           |
| Iran      | 652                     | 48 (7.4)                   | NA                        | CM        | Jahari et al. [267]         |
| Iran      | 561                     | 159 (28.4)                 | NA                        | CM        | Hemmati et al. [268]        |
| Iran      | 554                     | 93 (16.8)                  | NA                        | CM, IVC   | Riai et al. [269]           |
| Iran      | 345                     | 85 (24.6)                  | ST1, ST2, ST3             | CM, IVC, MOL | Mardani Kafaki et al. [270] |
| Iran      | 861                     | 114 (13.2)                 | NA                        | CM        | Abbaspazadeh Afshar et al. [271] |
| Iran      | 732                     | 63 (6.3)                   | NA                        | CM        | Sobati [272]                |
| Iran      | 184                     | 45 (24.5)                  | ST1, ST2, ST3             | MOL       | Shirvani et al. [273]       |
| Iran      | 283                     | 20 (7.1)                   | NA                        | CM        | Barati et al. [274]         |
| Iran      | 2838                    | 129 (4.5)                  | NA                        | CM        | Badparva et al. [275]       |
| Iran      | 565                     | 144 (25.5)                 | NA                        | CM        |    Bairamizandeh Azarpotamani et al. [276] |
| Iran      | 1025                    | 182 (17.8)                 | NA                        | CM        | Sarksa et al. [277]         |
| Iran      | 1000                    | 669 (13.7)                 | NA                        | CM        | Sharifdini et al. [278]     |
| Iran      | 184                     | 45 (24.5)                  | ST1, ST2, ST3             | MOL       | Pagheh et al. [279]         |
| Iran      | 283                     | 81 (3.6)                   | NA                        | CM        | Beiravand et al. [280]      |
| Iran      | 861                     | 114 (13.2)                 | NA                        | CM        | Taherkhani et al. [281]     |
| Iraq      | 78                      | 1 (1.3)                    | NA                        | CM, IVC   | Sayal et al. [148]          |
| Korea     | 324                     | 29 (9.0)                   | ST1, ST2, ST3             | MOL       | Kim et al. [282]            |
| Laos      | 669                     | 91 (13.6)                  | NA                        | CM        | Sayasone et al. [283]       |
| Laos      | 305                     | 45 (14.8)                  | NA                        | CM        | Ribas et al. [284]          |
| Laos      | 60                      | 32 (51.7)                  | ST1, ST2, ST3, ST7        | CM, IVC, MOL | Sanpool et al. [285]       |
| Lebanon   | 7477                    | 178 (2.3)                  | NA                        | CM        |   Araj et al. [286]          |
| Lebanon   | 306                     | 195 (63.7)                 | ST1, ST2, ST3, ST10       | MOL       | Khaled et al. [287]         |
| Malaysia  | 77                      | 45 (5.2)                   | NA                        | CM        | Sinniah et al. [288]        |
| Malaysia  | 500                     | 102 (20.4)                 | NA                        | CM        | Anuar et al. [149]          |
| Malaysia  | 243                     | 45 (18.5)                  | ST1, ST2, ST3             | MOL       | Mohammad et al. [290]       |
| Malaysia  | 466                     | 191 (41.0)                 | NA                        | CM, IVC, MOL | Noradilah et al. [291]     |
| Malaysia  | 253                     | 103 (40.7)                 | NA                        | CM, IVC, MOL | Mohammad et al. [292]       |
| Malaysia  | 473                     | 191 (40.4)                 | ST1, ST2, ST3, ST4        | MOL       | Mohammad et al. [293]       |
| Malaysia  | 466                     | 191 (41.0)                 | NA                        | CM, IVC, MOL | Mohammad et al. [294]       |
| Malaysia  | 253                     | 45 (17.8)                  | ST1, ST2, ST3             | MOL       | Mohammad et al. [295]       |
| Malaysia  | 416                     | 18 (4.3)                   | NA                        | CM        | Mohammad et al. [296]       |
| Myanmar   | 172                     | 16 (9.3)                   | ST1, ST3, ST4             | MOL       | Mohammad et al. [297]       |
| Nepal     | 241                     | 63 (26.1)                  | ST1, ST2, ST4             | IVC, MOL  | Mohammad et al. [298]       |
| Philippines | 110                    | 36 (32.7)                  | NA                        | IVC       | Santos and Rivera [299]     |
| Philippines | 1271                   | 166 (13.0)                 | ST1, ST2, ST3, ST4, ST5   | IVC, MOL  | Belleza et al. [300]        |
| Philippines | 35                     | 29 (82.9)                  | ST1, ST3, ST4             | MOL       | Adao et al. [301]           |
| Philippines | 1271                   | 165 (13.0)                 | NA                        | IVC       | Belleza et al. [302]        |
| Philippines | 412                    | 242 (58.7)                 | NA                        | MOL       | Weerakoon et al. [303]      |
| Saudi Arabia | 140                  | 96 (68.6)                  | NA                        | CM        | AlDahhasi et al. [304]      |
| Saudi Arabia | 80                    | 12 (15.0)                  | ST1, ST2, ST5             | MOL       | Mohammad et al. [305]       |
| Saudi Arabia | 50                    | 4 (8.0)                    | NA                        | CM        | Hawash et al. [306]         |
| Saudi Arabia | 90                    | 2 (2.2)                    | NA                        | CM        | Hawash et al. [307]         |
| Saudi Arabia | 795                    | 131 (16.5)                 | NA                        | CM        | Alqumber et al. [308]       |
| Saudi Arabia | 795                    | 209 (26.3)                 | NA                        | CM        | Alqumber et al. [309]       |
| Thailand  | 249                     | 1 (0.4)                    | NA                        | CM        | Kaewpitoon et al. [310]     |
| Thailand  | 60                      | 6 (10.0)                   | NA                        | IVC       | Surangsrirat et al. [311]   |
| Thailand  | 475                     | 58 (12.2)                  | NA                        | CM, IVC   | Kaewjai et al. [312]        |
Table 7. Cont.

| Country | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References |
|---------|------------------------|-----------------------------|--------------------------|-----------|------------|
| Thailand | 230                    | 25 (10.8)                   | ST1, ST3, ST4            | MOL       | Popruk et al. [306] |
| Thailand | 1047                   | 29 (2.8)                    | NA                       | CM        | Prommi et al. [307] |
| Thailand | 178                    | 41 (23.0)                   | ST1, ST2, ST3, ST4, ST6, ST7 | MOL       | Yowang et al. [308] |
| Thailand | 324                    | 13 (4.0)                    | NA                       | CM        | Punsawad et al. [309] |
| Thailand | 220                    | 13 (5.9)                    | ST2, ST3, ST6            | MOL       | Palasuwan et al. [310] |
| Thailand | 247                    | 2 (0.8)                     | NA                       | CM        | Kitvatanachai et al. [311] |
| Thailand | 253                    | 4 (1.6)                     | NA                       | CM        | Boonjaraspinyo et al. [312] |
| Thailand | 224                    | 1 (0.4)                     | NA                       | CM        | Suntaravutun and Dokmaikaw [313] |
| Thailand | 733                    | 57 (7.8)                    | NA                       | IVC       | Wongthamarin et al. [314] |
| Thailand | 207                    | 77 (37.2)                   | ST1, ST2, ST3, ST4       | MOL       | Popruk et al. [315] |
| Turkey   | 30                     | 4 (13.0)                    | NA                       | CM, MOL   | Karasartova et al. [316] |
| Turkey   | 150                    | 16 (10.7)                   | NA                       | CM        | Karadag et al. [317] |
| Turkey   | 105                    | 30 (28.6)                   | NA                       | IVC       | Dogruman-Al et al. [318] |
| Turkey   | 27,664                 | 581 (2.1)                   | ST1, ST2, ST3, ST4       | CM        | Koksal et al. [319] |
| Turkey   | 176                    | 30 (17.0)                   | NA                       | CM        | Alver et al. [160] |
| Turkey   | 16,445                 | 2602 (15.8)                 | NA                       | CM        | Çetinkaya et al. [320] |
| Turkey   | 17,711                 | 1353 (7.6)                  | NA                       | CM        | Düzyl et al. [321] |
| Turkey   | 251                    | 54 (21.5)                   | NA                       | CM        | Kurt et al. [322] |
| Turkey   | 6267                   | 968 (15.4)                  | NA                       | CM        | Yılmaz et al. [323] |
| Turkey   | 87,100                 | 640 (0.7)                   | NA                       | CM        | Gülmez et al. [324] |
| Turkey   | 111,889                | 306 (0.3)                   | NA                       | CM        | Kırkoyun Uysal et al. [325] |
| Turkey   | 7353                   | 1884 (63.6)                 | NA                       | CM        | Öncel [326] |
| Turkey   | 200                    | 93 (46.5)                   | ST1, ST2, ST3, ST7       | MOL       | Malatyali et al. [327] |
| Turkey   | 69,633                 | 18,460 (26.5)               | NA                       | CM        | Taş Cengiz et al. [328] |
| Turkey   | 104                    | 10 (9.6)                    | ST1, ST2, ST3, ST6       | MOL       | Gülhan et al. [329] |
| Turkey   | 56                     | 28 (50.0)                   | ST1, ST2, ST3, ST4, ST5, ST6, ST7 | MOL       | Koltas and Eroğlu [330] |
| United Arab Emirates | 133              | 59 (44.4)                   | ST1, ST2, ST3            | MOL       | AbuOdeh et al. [331] |
| Uzbekistan | 300            | 31 (10.3)                   | NA                       | CM        | Toychiev et al. [332] |
| Uzbekistan | 550              | 99 (18.0)                   | NA                       | CM        | Davis et al. [112] |

CM—Conventional microscopy, IVC—in vitro cultivation, MOL—Molecular technique, NA—Not applicable.

The presence of *Blastocystis* spp. in various other human categories that do not quite fit into those discussed above is summarized in Table 8.

Table 8. Prevalence and subtype distribution of *Blastocystis* spp. in various human categories in Asia (2010–2021).

| Host                              | Country | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References           |
|-----------------------------------|---------|-------------------------|-----------------------------|--------------------------|-----------|----------------------|
| Acute appendicitis patients       | Turkey  | 136                     | 8 (5.9)                     | NA                       | CM        | Hatipoğlu et al. [333] |
| Adult male prison inmates         | Malaysia| 294                     | 43 (14.6)                   | ST1, ST3, ST6            | CM, IVC, MOL| Angal et al. [334]   |
| Adults with intestinal parasitic infection | Malaysia| 35                      | 17 (48.0)                   | NA                       | IVC       | Chandramathi et al. [335] |
| Asymptomatic *Blastocystis* positive patients | Iran   | 25 *                    | 25                          | ST1, ST2, ST3, ST7       | MOL       | Rezaei Riabi et al. [336] |
| Asymptomatic *Blastocystis* positive patients | Iran   | 34 *                    | 34                          | ST2, ST3                | CM, MOL   | Shahbazi et al. [142] |
| Chronic spontaneous urticaria (adults) | Turkey | 38                      | 7 (18.4)                    | NA                       | CM        | Vezir et al. [337]   |
Table 8. Cont.

| Host                                                                 | Country      | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                                           |
|---------------------------------------------------------------------|--------------|-------------------------|-----------------------------|---------------------------|-----------|------------------------------------------------------|
| Chronic spontaneous urticaria (children)                            | Turkey       | 76                      | 13 (17.1)                   | NA                        | CM        | Vezir et al. [337]                                   |
| Urticarial patients                                                 | Turkey       | 133                     | 16 (12.0)                   | ST1, ST2, ST3             | CM, MOL   | Aydin et al. [338]                                   |
| Diarrheic and non-diarrheic patients                                | Iran         | 400                     | 58 (14.5)                   | ST1, ST2, ST3             | IVC, MOL  | Alinaghizade et al. [340]                            |
| Dengue patients                                                     | Malaysia     | 89                      | 21 (23.6)                   | ST1, ST3, ST4, ST6        | IVC, MOL  | Thergarajan et al. [341]                             |
| Dialysis patients                                                   | Turkey       | 142                     | 34 (23.9)                   | NA                        | CM        | Karadag et al. [317]                                 |
| Patients suspected to have intestinal parasites                     | Turkey       | 918                     | 38 (4.2)                    | NA                        | CM        | Koltas et al. [345]                                 |
| Patients with chronic renal failure                                 | Saudi Arabia | 50                      | 8 (16.0)                    | NA                        | CM        | Hawash et al. [302]                                 |
| Patients with chronic viral Hepatitis C                             | Russia       | 327                     | 108 (33.0)                  | ST3, ST5, ST6             | CM, MOL   | Sigidaev et al. [134]                                |
| Patients with Erythema Nodosum                                      | Turkey       | 81                      | 2 (2.5)                     | NA                        | CM        | Ozbagcivan et al. [346]                              |
| Patients with gastrointestinal and/or dermatologic symptoms          | Turkey       | 37,108                  | 2537 (6.8)                  | NA                        | CM        | Tunali et al. [347]                                 |
| Patients with intestinal protozoan infections                        | Iran         | 75                      | 5 (6.7)                     | NA                        | CM        | Jafari et al. [348]                                 |
| Patients with systemic lupus erythematosus (SLE)                    | Malaysia     | 187                     | 1 (0.5)                     | NA                        | not stated| Teh et al. 2018 [349]                                |
| Post-traumatic splenectomized patients                              | Turkey       | 30                      | 12 (40.0)                   | ST1, ST3                  | CM, MOL   | Karasartova et al. [316]                             |
| Pregnant women with Symptomatic Blastocystis positive patients       | Turkey       | 100                     | 14 (14.0)                   | ST1, ST2, ST3             | CM, IVC, MOL | Malatyali et al. [350]                             |
| Ulcerative colitis patients with refractory symptoms                | Iran         | 30(*)                   | 30                          | ST1, ST2, ST3, ST6        | MOL       | Rezaei Riabi et al. [336]                            |
| Ulcerative colitis patients responsive to treatment                 | China        | 49                      | 6 (12.2)                    | NA                        | CM        | Tai et al. [351]                                    |
| Visceral Leishmaniasis cases                                        | China        | 73                      | 1 (1.4)                     | NA                        | CM        | Tai et al. [351]                                    |
| * Study was carried out on Blastocystis spp. positive hosts         |              |                         |                             |                           |           |                                                     |

4. Blastocystis spp. Infection in Animals

In Asia, Blastocystis spp. infection have been documented in hoofed mammals (Table 9), carnivores (Table 10), non-human primates (NHPs) (Table 11), birds (Table 12), rodents (Table 13), reptiles (Table 14), insects and some other mammalian groups (Table 15).
### Table 9. Prevalence and subtype distribution of *Blastocystis* spp. in ungulates in Asia (2010–2021).

| Host                  | Country  | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                  |
|-----------------------|----------|-------------------------|----------------------------|--------------------------|-----------|----------------------------|
| Artiodactyla          |          |                         |                            |                          |           |                            |
| Alpaca                | China    | 14                      | 12 (85.7)                  | ST10, ST14, ST18         | MOL       | Zhao et al. [352]          |
| Alpaca                | China    | 27                      | 4 (14.8)                   | ST10, ST14               | MOL       | Li et al. [353]            |
| Alpaca                | China    | 366                     | 87 (23.8)                  | ST5, ST10, ST14          | MOL       | Ma et al. [354]            |
| Alpaca                | China    | 11                      | 4 (36.4)                   | ST10, ST14               | MOL       | Deng et al. [3]            |
| Blesbuck              | China    | 2                       | 1 (50.0)                   | ST5                      | MOL       | Li et al. [353]            |
| Buffalo               | India    | 1                       | 1 (100.0)                  | NA                       | CM        | Sreekumar et al. [355]     |
| Buffalo               | Nepal    | 19                      | 4 (21.1)                   | ST4                      | IVC, MOL  | Lee et al. [18]            |
| Bushbuck              | China    | 18                      | 8 (61.5)                   | ST10, ST14               | MOL       | Zhao et al. [352]          |
| Camel                 | China    | 10                      | 5 (50.0)                   | ST1, ST10                | MOL       | Zhao et al. [352]          |
| Camel                 | China    | 40                      | 14 (35.0)                  | ST2, ST10, ST14          | MOL       | Zhang et al. [14]          |
| Camel                 | Lebanon  | 254                     | 161 (63.4)                 | ST5, ST7, ST10, ST14     | MOL       | Geie et al. [197]          |
| Deer (Caspian red deer) | Iran    | 1                       | 1 (100.0)                  | NA                       | IVC       | Hemalatha et al. [356]     |
| Deer (Javan rusa)     | Malaysia | 50                      | 14 (28.0)                  | ST10                     | MOL       | Mohammad et al. [388]      |
| Deer (Mousedeer)      | Malaysia | 4                       | 1 (25.0)                   | Unknown (Clade IV)       | IVC, MOL  | Shariﬁ et al. [195]       |
| Deer (Sambur deer)    | Malaysia | 14                      | 4 (28.6)                   | ST5                      | CM, MOL   | Hemalatha et al. [356]     |
| Deer (Sika deer)      | Malaysia | 50                      | 16 (32.0)                  | ST10                     | MOL       | Mohammad et al. [371]      |
| Deer (Red deer)       | China    | 5                       | 2 (40.0)                   | ST10                     | MOL       | Li et al. [353]            |
| Deer (Red deer/Wapiti)| China    | 3                       | 1 (33.3)                   | ST10                     | MOL       | Zhao et al. [352]          |
| Deer (Fallow deer)    | China    | 2                       | 1 (50.0)                   | ST10                     | MOL       | Zhao et al. [352]          |
| Deer (White-tipped deer) | China | 1                       | 1 (100.0)                  | ST10                     | MOL       | Zhao et al. [352]          |
| Deer (Sika deer)      | China    | 8                       | 3 (37.5)                   | ST10                     | MOL       | Zhao et al. [352]          |
| Deer (Sika deer)      | China    | 82                      | 12 (14.6)                  | ST10, ST14               | MOL       | Wang et al. [373]          |
| Deer (Sika deer)      | China    | 11                      | 1 (9.1)                    | ST1                      | MOL       | Deng et al. [3]            |
| Deer (Sika deer)      | China    | 760                     | 6 (0.8)                    | ST10, ST14               | MOL       | Ni et al. [374]            |
| Deer (Spotted deer)   | Bangladesh | 30                    | 1 (3.3)                    | ST14                     | MOL       | Li et al. [375]            |
| Deer (Water deer)     | Korea    | 125                     | 51 (40.8)                  | ST4, ST14                | MOL       | Kim et al. [376]           |
| Eland                 | China    | 9                       | 6 (66.7)                   | ST10, ST14               | MOL       | Zhao et al. [352]          |
| Gayal                 | Bangladesh | 4                    | 1 (25.0)                   | ST14                     | MOL       | Li et al. [375]            |
| Giraffe               | China    | 10                      | 2 (20.0)                   | ST12                     | MOL       | Zhao et al. [352]          |
| Goat                  | China    | 789                     | 458 (58.0)                 | ST1, ST3, ST4, ST5, ST10, ST14 | MOL       | Song et al. [377]          |
| Goat                  | China    | 781                     | 2 (0.3)                    | ST1                      | MOL       | Li et al. [378]            |
| Goat                  | China    | 59                      | 28 (47.5)                  | ST10, ST14               | MOL       | Zhang et al. [14]          |
| Goat                  | Nepal    | 400                     | 3 (0.8)                    | NA                       | CM        | Ghimire and Bhattacharyya [379] |
| Host          | Country       | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (Sts) Identified | Method(s) | References                        |
|--------------|---------------|-------------------------|-----------------------------|--------------------------|-----------|-----------------------------------|
| Goat         | Malaysia      | 236                     | 73 (30.9)                   | ST1, ST3, ST6, ST7       | MOL       | Tan et al. [380]                  |
| Goat         | Malaysia      | 31                      | 8 (25.8)                    | ST4, ST8, ST10           | MOL       | Noradilah et al. [15]             |
| Goat         | Malaysia      | 65                      | 14 (21.5)                   | NA                       | IVC       | Abd Razak et al. [357]            |
| Goat         | Malaysia      | 20                      | 13 (65.0)                   | NA                       | IVC       | Hemalatha et al. [356]            |
| Goat         | Nepal         | 29                      | 1 (3.4)                     | ST4                      | IVC, MOL  | Lee et al. [18]                   |
| Goat         | Philippines   | 6                       | 1 (16.7)                    | ST14                     | IVC, MOL  | Adao et al. [381]                 |
| Goat         | Thailand      | 38                      | 36 (94.7)                   | ST10, ST12, ST14         | MOL       | Udonsom et al. [215]              |
| Goral (Himalayan) | Nepal    | 19                      | 1 (5.3)                     | NA                       | CM        | Adhikari et al. [382]             |
| Guanaco      | China         | 20                      | 14 (70.0)                   | ST10, ST22               | MOL       | Zhao et al. [352]                 |
| Guar         | Malaysia      | 10                      | 3 (30.0)                    | NA                       | IVC       | Hemalatha et al. [356]            |
| Oryx         | China         | 2                       | 1 (50.0)                    | ST10                     | MOL       | Zhao et al. [352]                 |
| Oryx         | China         | 11                      | 1 (9.1)                     | ST5                      | MOL       | Li et al. [353]                   |
| Pig          | Cambodia      | 73                      | 33 (45.2)                   | ST5                      | MOL       | Wang et al. [242]                 |
| Pig          | China         | 560                     | 419 (74.8)                  | ST1, ST3, ST5, ST10      | MOL       | Song et al. [383]                 |
| Pig          | China         | 68                      | 6 (8.8)                     | ST5                      | MOL       | Wang et al. [367]                 |
| Pig          | China         | 801                     | 174 (21.7)                  | ST1, ST3, ST5            | MOL       | Wang et al. [364]                 |
| Pig          | China         | 866                     | 433 (50.0)                  | ST1, ST3, ST5            | MOL       | Han et al. [385]                  |
| Pig          | China         | 396                     | 170 (42.9)                  | ST1, ST5                 | MOL       | Zou et al. [386]                  |
| Pig          | India         | 1                       | 1 (100.0)                   | NA                       | CM        | Sreekumar et al. [355]            |
| Pig          | India         | 90                      | 85 (94.4)                   | NA                       | CM        | Arpitha et al. [387]              |
| Pig          | Indonesia     | 93                      | 81 (87.1)                   | ST1, ST2, ST5, ST17      | IVC, MOL  | Yoshikawa et al. [41]             |
| Pig          | Indonesia     | 100                     | 63 (63.0)                   | NA                       | CM        | Mahendra et al. [388]             |
| Pig          | Indonesia     | 100                     | 69 (69.0)                   | NA                       | CM        | Wisidusupatri et al. [389]        |
| Pig          | Korea         | 646                     | 390 (60.4)                  | ST1, ST2, ST3, ST5       | MOL       | Paik et al. [390]                 |
| Pig          | Nepal         | 11                      | 4 (36.4)                    | ST4                      | IVC, MOL  | Lee et al. [18]                   |
| Pig          | Philippines   | 49                      | 36 (73.5)                   | ST1, ST2, ST3, ST5       | MOL       | Adao et al. [391]                 |
| Pig          | Philippines   | 99                      | 20 (20.2)                   | ST1, ST3, ST7            | IVC, MOL  | Adao et al. [381]                 |
| Pig          | Philippines   | 122                     | 47 (38.5)                   | NA                       | CM, IVC   | De La Cruz et al. [392]           |
| Pig          | Philippines   | 100                     | 14 (14.0)                   | ST1, ST5                 | IVC, MOL  | Evidor and Rivera [393]           |
| Pig          | Philippines   | 101                     | 2 (2.0)                     | NA                       | CM        | Murao et al. [394]                |
| Pig          | Thailand      | 102                     | 32 (31.4)                   | ST1, ST3, ST12, ST14     | MOL       | Sanyanusin et al. [395]           |
| Pig          | Thailand      | 90                      | 32 (35.6)                   | ST1, ST3, ST5            | MOL       | Pintong et al. [214]              |
| Pig          | Thailand      | 87                      | 40 (46.0)                   | ST1, ST5                 | MOL       | Udonsom et al. [215]              |
| Pig          | Malaysia      | 10                      | 10 (100.0)                  | NA                       | IVC       | Hemalatha et al. [356]            |
| Pig          | Vietnam       | 12                      | 10 (100.0)                  | ST5                      | MOL       | Alfellanli et al. [396]           |
| Sheep        | Iran          | 150                     | 29 (19.3)                   | ST7, ST10                | CM, MOL   | Rostami et al. [364]              |
| Sheep        | China         | 832                     | 50 (6.0)                    | ST5, ST10, ST14          | MOL       | Li et al. [378]                   |
| Sheep        | China         | 109                     | 6 (5.5)                     | ST1, ST5, ST10, ST14     | MOL       | Wang et al. [367]                 |
| Sheep        | China         | 38                      | 16 (42.1)                   | ST2, ST10, ST14          | MOL       | Zhang et al. [14]                 |
| Sheep        | China         | 78                      | 42 (53.8)                   | ST2, ST10, ST14          | MOL       | Zhang et al. [14]                 |
| Sheep        | United Arab Emirates | 11                  | 7 (63.6)                    | ST10, ST14               | MOL       | AbuOdeh et al. [369]              |
| Sheep        | Malaysia      | 38                      | 22 (57.9)                   | NA                       | IVC       | Hemalatha et al. [356]            |
| Sheep        | Malaysia      | 20                      | 2 (10.0)                    | NA                       | IVC       | Abd Razak et al. [357]            |
| Small ruminants | India      | 107                     | 15 (14.0)                   | NA                       | CM        | Arpitha et al. [387]              |
| Takin        | China         | 49                      | 28 (57.1)                   | ST10, ST12, ST14         | MOL       | Zhao et al. [352]                 |
| Waterbuck    | China         | 3                       | 3 (100.0)                   | ST12, ST14               | MOL       | Zhao et al. [352]                 |
| Waterbuck    | China         | 2                       | 1 (50.0)                    | ST21                     | MOL       | Zhao et al. [352]                 |
| Waterbuck    | Bangladesh    | 7                       | 1 (14.3)                    | ST10                     | MOL       | Li et al. [375]                   |
| Wild boar    | South Korea   | 433                     | 45 (10.4)                   | ST5                      | MOL       | Lee et al. [397]                  |
| Wild Boar    | Iran          | 25                      | 11 (44.0)                   | NA                       | CM        | Yaghoubi et al. [398]             |
| Wild Boar    | Iran          | 1                       | 1 (100.0)                   | NA                       | CM        | Mirzazapour et al. [370]          |
| Yak          | China         | 1027                    | 278 (27.1)                  | ST10, ST12, ST14         | MOL       | Ren et al. [399]                  |
| Yak          | China         | 102                     | 39 (38.2)                   | ST2, ST10, ST14          | MOL       | Zhang et al. [14]                 |
| Yak          | China         | 6                       | 3 (50.0)                    | ST10, ST14               | MOL       | Zhao et al. [352]                 |
| Perissodactyla | Horse       | China         | 32                      | 9 (28.1)                   | ST2, ST10 | MOL       | Zhang et al. [14]                 |
| Perissodactyla | Horse       | China         | 4                       | 1 (25.0)                   | ST10       | MOL       | Zhao et al. [352]                 |
| Perissodactyla | Wild Ass   | China         | 5                       | 2 (40.0)                   | ST10, ST12 | MOL       | Zhao et al. [352]                 |
| Perissodactyla | Pony       | China         | 6                       | 1 (16.7)                   | ST10       | MOL       | Zhao et al. [352]                 |
| Perissodactyla | Zebra       | China         | 7                       | 1 (14.3)                   | ST10       | MOL       | Li et al. [353]                  |
### Table 9. Cont.

| Host            | Country       | No. of Samples Examined | No. of Positive Samples (%) | No. of Positive Subtypes (STs) Identified | Method(s) | References                  |
|-----------------|---------------|-------------------------|-----------------------------|-------------------------------------------|-----------|-----------------------------|
| Proboscidea     |               |                         |                             |                                           |           |                             |
| Elephant        | Bangladesh    | 3                       | 1 (33.3)                    | ST11                                       | MOL       | Li et al. [375]             |
| CM—Conventional microscopy, IVC—In vitro cultivation, MOL—Molecular technique, NA—Not applicable.

### Table 10. Prevalence and subtype distribution of *Blastocystis* spp. in carnivorous animals in Asia (2010–2021).

| Host             | Country   | No. of Samples Examined | Number of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                  |
|------------------|-----------|-------------------------|--------------------------------|---------------------------|-----------|-----------------------------|
| Artic fox        | China     | 213                     | 4 (1.9)                        | ST1, ST4, ST7             | MOL       | Wang et al. [373]           |
| Bear             | China     | 12                      | 3 (25.0)                       | ST17                       | MOL       | Deng et al. [3]             |
| Bear             | China     | 312                     | 45 (14.4)                      | ST1                        | MOL       | Ni et al. [374]             |
| Cat              | China     | 346                     | 2 (0.6)                        | ST1                        | MOL       | Li et al. [400]             |
| Cat              | Indonesia | 90                      | 48 (53.3)                      | NA                         | MOL       | Patagi et al. [401]         |
| Cat              | Iran      | 140                     | 20 (14.3)                      | NA                         | CM        | Khademvatan et al. [402]    |
| Cat              | Iran      | 119                     | 21 (17.7)                      | ST1, ST3, ST4, ST10, ST14  | MOL       | Mohammadpour et al. [403]   |
| Cat              | South Korea | 158                  | 1 (0.6)                        | ST4                        | MOL       | Kwak and Seo [404]          |
| Cat              | Malaysia  | 60                      | 12 (20.0)                      | ST1                        | MOL       | Farah Nazijah et al. [405]  |
| Cat              | Turkey    | 3                       | 3 (100.0)                      | ST3                        | MOL       | Eroglu and Koltas [19]      |
| Common raccoon   | Iran       | 30                      | 5 (6.7)                        | ST1, ST2, ST3              | MOL       | Mohammad Rahimi et al. [406] |
| Dog              | China     | 136                     | 4 (2.9)                        | ST1, ST4                   | MOL       | Wang et al. [373]           |
| Dog              | China     | 651                     | 35 (5.4)                       | ST1, ST3, ST10             | MOL       | Liao et al. [407]           |
| Dog              | India     | 80                      | 19 (24.0)                      | ST1, ST4, ST5, ST6         | MOL       | Wang et al. [408]           |
| Dog              | Iran      | 301                     | 59 (19.6)                      | ST1, ST3, ST10             | MOL       | Mohaghegh et al. [409]      |
| Dog              | Iran      | 552                     | 29 (5.2)                       | ST2, ST3, ST4, ST7, ST8, ST10 | MOL       | Mirbadie et al. [410]      |
| Dog              | Iran      | 154                     | 29 (18.8)                      | ST1, ST2, ST3              | MOL       | Mohammadpour et al. [403]   |
| Dog              | Turkey    | 4                       | 4 (100.0)                      | ST1, ST2                   | MOL       | Eroglu and Koltas [19]      |
| Dog              | Philippines | 145                  | 21 (14.5)                      | ST1, ST2, ST3, ST4, ST5    | IVC, MOL  | Belleza et al. [297]        |
| Dog              | Malaysia  | 84                      | 40 (47.6)                      | ST1, ST3, ST4, ST8, ST10   | MOL       | Noradilah et al. [15]       |
| Dog              | Thailand  | 13                      | 1 (7.7)                        | ST3                        | MOL       | Udonsom et al. [215]        |
| Dog              | Cambodia  | 80                      | 1 (1.3)                        | ST2                        | MOL       | Wang et al. [408]           |
| Dog              | China     | 7                       | 1 (14.3)                       | ST10                       | MOL       | Li et al. [353]             |
| Leopard          | China     | 3                       | 2 (66.7)                       | ST1, ST5                   | MOL       | Deng et al. [3]             |
| Meerkat          | Iran      | 1                       | 1 (100.0)                      | NA                         | CM        | Mirzapour et al. [370]      |
| Meerkat          | China     | 2                       | 1 (50.0)                       | ST5                        | MOL       | Li et al. [353]             |
| Panda (Giant panda) | China  | 81                      | 10 (12.3)                      | ST1                        | MOL       | Deng et al. [411]           |
| Panda (Red panda)| China     | 23                      | 2 (8.7)                        | ST1                        | MOL       | Deng et al. [411]           |
| Raccoon dog      | China     | 40                      | 3 (7.5)                        | ST3                        | MOL       | Wang et al. [373]           |
| Tiger (Siberian tiger) | China | 13                      | 1 (7.7)                        | ST10                       | MOL       | Li et al. [353]             |
| Tiger (White tiger)| China  | 9                       | 1 (11.1)                       | ST10                       | MOL       | Li et al. [353]             |

CM—Conventional microscopy, IVC—In vitro cultivation, MOL—Molecular technique, NA—Not applicable.
Table 11. Prevalence and subtype distribution of *Blastocystis* spp. in non-human primates in Asia (2010–2021).

| Host                  | Country        | No. of Samples Examined | Number of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References         |
|-----------------------|----------------|-------------------------|--------------------------------|---------------------------|-----------|--------------------|
| Primates              |                |                         |                                |                           |           |                    |
| Langur                | Bangladesh     | 5                       | 3 (60.0)                       | ST1, ST13                 | MOL       | Li et al. [375]    |
| Grey langur           | Bangladesh     | 2                       | 1 (50.0)                       | ST1                       | MOL       | Li et al. [375]    |
| White-cheeked gibbon  | China          | 4                       | 1 (25.0)                       | ST1                       | MOL       | Ma et al. [250]    |
| White-cheeked gibbon  | China          | 4                       | 4 (100.0)                      | ST2, ST3                  | MOL       | Deng et al. [3]    |
| Ring-tailed lemur      | China          | 6                       | 2 (33.3)                       | ST2, ST4                  | MOL       | Li et al. [355]    |
| Ring-tailed lemur      | China          | 16                      | 7 (43.8)                       | ST3, ST5, ST9             | MOL       | Ma et al. [250]    |
| Ring-tailed lemur      | China          | 13                      | 6 (46.2)                       | ST1, ST2, ST3             | MOL       | Deng et al. [3]    |
| Macaque               | China          | 97                      | 85 (87.6)                      | ST1, ST2, ST3             | MOL       | Zanzani et al. [412]|
| Macaque (experimental) | China         | 185                     | 12 (7.0)                       | ST1, ST2, ST3             | MOL       | Zhu et al. [173]   |
| Rhesus macaque        | Bangladesh     | 62                      | 20 (32.3)                      | ST1, ST2, ST3             | MOL       | Li et al. [375]    |
| Rhesus macaque        | China          | 29                      | 28 (96.6)                      | ST1, ST2, ST3, ST19       | MOL       | Zhao et al. [352]  |
| Rhesus macaque        | China          | 17                      | 10 (58.8)                      | ST1                       | MOL       | Deng et al. [3]    |
| Rhesus macaque        | China          | 18                      | 6 (33.3)                       | ST2, ST3                  | MOL       | Ma et al. [250]    |
| Japanese macaque      | China          | 33                      | 6 (18.2)                       | ST2, ST3                  | MOL       | Ma et al. [250]    |
| Macaque               | Philippines    | 50                      | 5 (10.0)                       | NA                        | CM        | Casim et al. [414] |
| Long-tailed macaque   | Thailand       | 628                     | 263 (41.9)                     | ST1, ST2, ST3             | IVC, MOL  | Vaisusuk et al. [415]|
| Crab-eating macaque   | China          | 13                      | 3 (23.1)                       | ST2, ST3                  | MOL       | Ma et al. [250]    |
| Orangutan             | Indonesia      | 262                     | 36 (13.7)                      | NA                        | CM        | Labes et al. [416] |
| Orangutan             | Malaysia       | 10                      | 5 (50.0)                       | NA                        | IVC       | Hemalatha et al. [356] |
| Vervet monkey         | Iran           | 40                      | 3 (7.5)                        | NA                        | CM        | Dalimi et al. [417] |
| Vervet monkey         | Bangladesh     | 7                       | 3 (42.9)                       | ST2, ST3, ST13            | MOL       | Li et al. [375]    |
| Hamadryas baboon      | Saudi Arabia   | 823                     | 349 (42.4)                     | NA                        | CM        | Alqumber [303]     |
| Hamadryas baboon      | China          | 23                      | 13 (56.5)                      | ST1, ST3                  | MOL       | Zhao et al. [352]  |
| Chimpanzee            | China          | 10                      | 8 (80.0)                       | ST2                      | MOL       | Zhao et al. [352]  |
| Chimpanzee            | China          | 15                      | 3 (13.3)                       | ST1, ST5                  | MOL       | Ma et al. [250]    |
| Francois’ leaf monkey | China          | 1                       | 1 (100.0)                      | ST2                      | MOL       | Zhao et al. [352]  |
| Francois’ leaf monkey | China          | 3                       | 2 (66.7)                       | ST1                      | MOL       | Ma et al. [250]    |
| Mandrill              | China          | 4                       | 1 (25.0)                       | ST3                      | MOL       | Zhao et al. [352]  |
| Mandrill              | China          | 15                      | 9 (60.0)                       | ST1, ST4                  | MOL       | Ma et al. [250]    |
| De Brazza’s monkey    | China          | 5                       | 4 (80.0)                       | ST1, ST10                 | MOL       | Zhao et al. [352]  |
| De Brazza’s monkey    | China          | 5                       | 5 (100.0)                      | ST1, ST2                  | MOL       | Ma et al. [250]    |
| Golden snub-nosed monkey | China     | 46                      | 41 (89.1)                      | ST1, ST13                 | MOL       | Zhao et al. [352]  |
| Snub-nosed monkey     | China          | 22                      | 9 (40.9)                       | ST1, ST2                  | MOL       | Ma et al. [250]    |
| Golden monkey         | China          | 37                      | 18 (48.6)                      | ST1, ST2, ST3             | MOL       | Ma et al. [418]    |
| Squirrel monkey       | China          | 93                      | 19 (20.4)                      | ST17                     | MOL       | Deng et al. [3]    |
| Common squirrel monkey| China          | 30                      | 9 (30.0)                       | ST1, ST5                  | MOL       | Ma et al. [250]    |
| Red-faced spider monkey | China      | 4                       | 2 (50.0)                       | ST2, ST3                  | MOL       | Ma et al. [250]    |
| Monkey                | Philippines    | 4                       | 4 (100.0)                      | ST1, ST2, ST3             | MOL       | Rivera [21]        |
| Non-human primates    | Malaysia       | 308                     | 5 (1.6)                        | NA                       | CM        | Adrus et al. [419] |

CM—Conventional microscopy, IVC—In vitro cultivation, MOL—Molecular technique, NA—Not applicable.
Table 12. Prevalence and subtype distribution of *Blastocystis* spp. in birds in Asia (2010–2021).

| Host          | Country  | No. of Samples Examined | Number of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References |
|---------------|----------|-------------------------|--------------------------------|---------------------------|-----------|------------|
| Duck          | Philippines | 31                      | 3 (9.6)                        | ST7, *B. pyriformis*      | IVC, MOL  | Adao et al. [381] |
| Birds         | Turkey    | 5                       | 5 (100.0)                      | ST1, ST2                  | MOL       | Eroglu and Koltas [19] |
| Chicken       | China     | 46                      | 6 (13.0)                       | ST6, ST7                  | MOL       | Wang et al. [373]   |
| Chicken       | Philippines | 34                     | 5 (14.7)                       | ST7, Mixed                | IVC, MOL  | Adao et al. [381] |
| Chicken       | India     | 24                      | 20 (83.3)                      | NA                        | CM        | Sreekumar et al. [355] |
| Chicken       | India     | 170                     | 50 (29.4)                      | NA                        | CM        | Arpitha et al. [387] |
| Chicken       | Indonesia | 38                      | 13 (34.2)                      | ST7                      | IVC, MOL  | Yoshikawa et al. [41] |
| Chicken       | Lebanon   | 223                     | 71 (31.8)                      | ST6, ST7                  | MOL       | Greige et al. [199] |
| Chicken       | Malaysia  | 104                     | 27 (26.0)                      | ST1, ST3, ST6, ST7, ST9   | MOL       | Noradilah et al. [15] |
| Chicken       | Malaysia  | 15                      | 1 (6.7)                        | ST6                      | MOL       | Mohammad et al. [296] |
| Chicken       | Malaysia  | 107                     | 27 (25.2)                      | NA                       | IVC       | Farah Haziqah et al. [420] |
| Chicken       | Malaysia  | 179                     | 47 (26.3)                      | ST1, ST6, ST7, ST8        | IVC, MOL  | Farah Haziqah et al. [421] |
| Crested ibis  | China     | 63                      | 6 (9.5)                        | NA                       | CM        | Zhang et al. [422]   |
| Crow (Hooded) | Iran      | 144                     | 64 (44.4)                      | ST13, ST14                | IVC, MOL  | Asghari et al. [423] |
| Duck          | Malaysia  | 20                      | 8 (40.0)                       | ST1, ST2, ST3, ST7        | MOL       | Noradilah et al. [15] |
| Green-naped lorikeet | China | 2                   | 1 (50.0)                        | ST10                      | MOL       | Li et al. [353]     |
| Ostrich       | China     | 9                       | 3 (33.3)                       | ST5, ST10, ST20           | MOL       | Zhao et al. [352]   |
| Ostrich       | China     | 19                      | 6 (31.6)                       | ST5                      | MOL       | Deng et al. [3]     |
| Ostrich       | Malaysia  | 37                      | 37 (100.0)                     | ST6                      | IVC, MOL  | Chandrasekar et al. [424] |
| Ostrich       | Malaysia  | 37                      | 37 (100.0)                     | NA                       | IVC       | Hemalatha et al. [424] |
| Ostrich       | China     | 3                       | 2 (66.7)                       | ST5                      | MOL       | Li et al. [353]     |
| Green peafowl | China     | 12                      | 1 (8.3)                        | ST3                      | MOL       | Deng et al. [3]     |
| Green peafowl | China     | 15                      | 1 (6.7)                        | ST8                      | MOL       | Deng et al. [411]   |
| Indian peafowl | China     | 20                     | 3 (15.0)                       | ST7, ST8                 | MOL       | Li et al. [353]     |
| Pigeon        | China     | 34                      | 4 (11.8)                       | ST8                      | MOL       | Deng et al. [3]     |
| Pigeon        | China     | 47                      | 1 (2.1)                        | ST6                      | MOL       | Wang et al. [373]   |
| Pigeon        | Iran      | 156                     | 67 (42.9)                      | ST13                     | IVC, MOL  | Asghari et al. [423] |
| Poultry       | Iran      | 132                     | 21 (15.9)                      | ST7, ST10, ST14           | CM, MOL   | Rostami et al. [364] |
| Red crowned crane | China | 43                   | 6 (14.0)                      | ST6, ST7                 | MOL       | Wang et al. [373]   |
| Red-crowned crane | China | 2               | 1 (50.0)                      | ST14                     | MOL       | Li et al. [353]     |
| Ruddy shelduck | China    | 11                     | 2 (18.2)                       | ST8                      | MOL       | Deng et al. [411]   |
| Swan          | Malaysia  | 20                      | 7 (35.0)                       | ST1, ST3                 | MOL       | Noradilah et al. [15] |
| Black swan    | China     | 38                      | 4 (10.5)                       | ST8                      | MOL       | Deng et al. [411]   |
| Turkey        | India     | 4                       | 3 (75.0)                       | NA                       | CM        | Sreekumar et al. [355] |

CM—Conventional microscopy, IVC—In vitro cultivation, MOL—Molecular technique, NA—Not applicable.

Table 13. Prevalence and subtype distribution of *Blastocystis* spp. in rodents in Asia (2010–2021).

| Host            | Country           | No. of Samples Examined | Number of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References |
|-----------------|-------------------|-------------------------|--------------------------------|---------------------------|-----------|------------|
| Flying squirrel | China             | 207                     | 63 (30.4)                      | ST1, ST3, ST13            | MOL       | Xiao et al. [425] |
| Eastern chipmunk| China             | 171                     | 8 (4.7)                        | ST4                      | MOL       | Chai et al. [426] |
| Eurasian red squirrel | China | 72               | 7 (9.7)                       | ST4                      | MOL       | Chai et al. [426] |
| Black great squirrel | China | 1           | 1 (100.0)                    | ST4                      | MOL       | Deng et al. [3] |
| Red giant flying squirrel | China | 1              | 1 (100.0)                    | ST4                      | MOL       | Deng et al. [3] |
| Indian palm squirrel | United Arab Emirates | 4          | 2 (50.0)                     | ST4                      | MOL       | AbuOdeh et al. [369] |
| Shrew-faced squirrel | United Arab Emirates | 1          | 1 (100.0)                    | ST17                     | MOL       | AbuOdeh et al. [369] |
| Chinese striped hamster | China | 98          | 12 (12.2)                   | ST4                      | MOL       | Chai et al. [426] |
| Chinchilla      | China             | 72                      | 3 (4.2)                        | ST4, ST17                | MOL       | Chai et al. [426] |
| Chinchilla      | China             | 6                       | 4 (66.7)                       | ST17                    | MOL       | Deng et al. [3] |
| Guinea pig      | China             | 90                      | 12 (13.3)                      | ST4                     | MOL       | Chai et al. [426] |
| Patagonian mara | China             | 15                      | 3 (20.0)                       | ST4                     | MOL       | Li et al. [353] |
| Rat *Mus musculus* | China | 108          | 4 (3.7)                       | ST4                      | MOL       | Wang et al. [373] |
Table 13. Cont.

| Host                        | Country   | No. of Samples Examined | Number of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                      |
|-----------------------------|-----------|-------------------------|--------------------------------|--------------------------|-----------|---------------------------------|
| Laboratory rats             | China     | 355                     | 29 (8.2)                       | ST4, ST7                 | MOL       | Li et al. [427]                 |
| Rat (Rattus exulans)        | Indonesia | 77                      | 10 (13.0)                      | ST4                      | IVC, MOL  | Yoshikawa et al. [41]           |
| Rat                         | Indonesia | 98                      | 6 (6.0)                        | NA                       | CM        | Prasetyo [428]                  |
| Rodents                     | Indonesia | 67                      | 11 (16.4)                      | ST4                      | MOL       | Katsumata et al. [429]          |
| Rat (Rattus norvegicus)     | Iran      | 127                     | 20 (15.8)                      | ST1, ST3, ST4            | MOL       | Mohammadpour et al. [403]       |
| Rat (Rattus norvegicus)     | Malaysia  | 95                      | 48 (51.0)                      | NA                       | CM        | Premalatha et al. [431]         |
| Rat (Rattus norvegicus)     | Malaysia  | 290                     | 133 (45.9)                     | ST1, ST4, ST5, ST7       | IVC, MOL  | Farah Haziqah et al. [432]      |
| Wild rats (Rattus norvegicus)| Japan    | 48                      | 12 (25.0)                      | ST4                      | MOL       | Katsumata et al. [429]          |
| Swiss-Webster mice          | Iran      | 50                      | 1 (2.0)                        | NA                       | CM        | Kalani et al. [433]             |

CM—Conventional microscopy, IVC—In vitro cultivation, MOL—Molecular technique, NA—Not applicable.

Table 14. Prevalence and subtype distribution of Blastocystis spp. in reptiles in Asia (2010–2021).

| Host                        | Country           | No. of Samples Examined | Number of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                      |
|-----------------------------|-------------------|-------------------------|--------------------------------|--------------------------|-----------|---------------------------------|
| Squamata                    | Iran              | 1                       | 1 (100.0)                      | NA                       | CM        | Mirzapour et al. [370]          |
| Cobra snake                 | Iran              | 1                       | 1 (100.0)                      | NA                       | CM        | Mirzapour et al. [370]          |
| Albino python               | Iran              | 1                       | 1 (100.0)                      | Unknown                  | CM        | Mirzapour et al. [370]          |
| Water monitor lizard        | Malaysia          | 6                       | 1 (1.6)                        | Unknown (Clade VIII)     | IVC, MOL  | Mohd Zain et al. [372]          |
| Testudines                  | United Arab Emirates | 19                | 5 (26.3)                       | Unknown                  | MOL       | AbuOdeh et al. [369]            |
| African spurred tortoise    | United Arab Emirates | 2                 | 5 (50.0)                       | Unknown                  | MOL       | AbuOdeh et al. [369]            |
| Greek tortoise              | United Arab Emirates | 1                 | 5 (50.0)                       | Unknown                  | MOL       | AbuOdeh et al. [369]            |

CM—Conventional microscopy, IVC—In vitro cultivation, MOL—Molecular technique, NA—Not applicable.

Table 15. Prevalence and subtype distribution of Blastocystis spp. in insects and other animal groups in Asia (2010–2021).

| Host                        | Country           | No. of Samples Examined | Number of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References                      |
|-----------------------------|-------------------|-------------------------|--------------------------------|--------------------------|-----------|---------------------------------|
| Blattodea                   | China             | 116                     | 96 (82.8)                      | ST2                      | MOL       | Ma et al. [418]                 |
| Cockroach                   | Thailand          | 920                     | 9 (1.0)                        | NA                       | CM        | Chamaviti et al. [434]          |
| Cockroach                   | Thailand          | 450                     | 18 (4.0)                       | NA                       | CM        | Suntaravith [435]               |
| Cockroach (Blatella germanica) | Turkey        | 138                     | 57 (41.0)                      | NA                       | CM        | Oguz et al. [436]               |
| Cockroach (Blatella germanica) | Iran            | 496                     | 5 (1.0)                        | NA                       | CM        | Motevali-Haghi et al. [437]     |
| Cockroach (Periplaneta americana) | Malaysia   | 151                     | 61 (40.4)                      | ST3                      | IVC, MOL  | Farah Haziqah et al. [438]      |
| Diprotodontia               | China             | 11                      | 8 (72.7)                       | ST10                     | MOL       | Zhao et al. [352]               |
| Gray kangaroo               | China             | 15                      | 2 (13.3)                       | ST11                     | MOL       | Li et al. [353]                 |
| Red-necked wallaby         | Indonesia         | 100                     | 100 (100.0)                    | NA                       | CM, IVC   | Natalia et al. [439]            |
| Sugar glider                | New Zealand white rabbit | China     | 215                     | 7 (3.3)                    | ST4        | MOL       | Wang et al. [373]               |
| Rabbit                      | China             | 616                     | 6 (1.0)                        | NA                       | MOL       | Li et al. [440]                 |
| Rabbit                      | United Arab Emirates | 3                 | 1 (33.3)                       | ST14                     | MOL       | AbuOdeh et al. [369]            |
| Eulipotyphla                | Iran              | 1                       | 1 (100.0)                      | NA                       | CM        | Mirzapour et al. [370]          |

CM—Conventional microscopy, IVC—In vitro cultivation, MOL—Molecular technique, NA—Not applicable.
The prevalence of *Blastocystis* spp., reported in the last ten years, varied widely among the ungulates. Infection was mostly reported in livestock animals such as cattle, goats, sheep and pigs. *Blastocystis* spp. ST10 and ST14 were the most frequently isolated from deer, alpacas, cattle, yaks, sheep and goats, while ST1 and ST5 were the most common in pigs.

*Blastocystis* spp. has been isolated from carnivores, both domestic and wild, in Asia. Prevalence ranged from 0.6% to 100%, with STs 1–8 and ST10 being identified. NHPs have been commonly described to harbor *Blastocystis* spp., with a reported prevalence reaching a 100%. Genetic analyses have recognized ST1, ST2, and ST3 as being the most common in this group of mammals. Interestingly, *Blastocystis* spp. ST9 was isolated from ring-tailed lemur from China [250].

*Blastocystis* spp. infections in birds have been reported. Prevalence varied widely, however, subtype identification revealed ST6, ST7, ST8 as the most frequently isolated. The isolation of *Blastocystis* spp. ST9 in chicken in Malaysia [15] is peculiar. Diverse genera of rodents have been found as hosts to *Blastocystis* spp. Although STs 1, 3, 5, 7 and 13 have been reported, ST4 and ST17 were the most frequently identified.

A few studies have reported on the infection of reptiles with *Blastocystis* spp. with the highest sample size being 19. Prevalence ranged from 26.3% to 100%, no subtype has yet been mentioned. Although studies are still few, cockroaches have been found as hosts to *Blastocystis* spp. Two out of six studies have described infection to the subtype level, ST2 was identified in China [418] while ST3 was identified in Malaysia [438].

Other animals found as hosts to *Blastocystis* spp. are the gray kangaroo, red-necked wallaby, sugar glider, rabbit, and hedgehog.

### 5. *Blastocystis* spp. in Food and Environmental Sources

In the past decade, the presence of *Blastocystis* spp. has been reported in tap water, river water, seawater, wells, fishponds, wastewater, food and even ambient air in Asia. The prevalence rate ranged from 2.1% to 100% in the various water sources, and 2.8% to 10.2% in leafy vegetables (Table 16). The only study on *Blastocystis* spp. in ambient air reported a prevalence of 1.4%. *Blastocystis* spp. subtype identification is only available for water sources. STs 1, 2, 3, 4, 6, 8, 10 have so far been recorded from water samples; and although the prevalence of ST3 was highest, ST1 was the most widespread subtype.

#### Table 16. Prevalence and subtype distribution of *Blastocystis* spp. in food and environmental sources in Asia (2010–2021).

| Country | Food/Environmental Source | No. of Samples Examined | No. of Positive Samples (%) | Subtypes (STs) Identified | Method(s) | References |
|---------|---------------------------|-------------------------|----------------------------|--------------------------|-----------|------------|
| Iran    | Treated wastewater        | 12                      | 5 (41.7)                  | ST2, ST6, ST8            | F, MOL    | Javanmard et al. [441] |
| Malaysia| River water               | 480                     | 133 (27.7)                | NA                       | MB, IVC   | Ithoi et al. [442]    |
| Malaysia| Drinking water treatment plants | 85               | 22 (25.9)                | NA                       | IMS, CM   | Richard et al. [443]  |
| Malaysia| River water               | 14                      | 14 (100.0)                | ST1, ST2, ST3, ST4, ST8, ST10 | MF, MOL  | Noradilah et al. [444] |
| Malaysia| Various water sources     | 7                       | 3 (42.9)                  | NA                       | MF, IVC   | Noradilah et al. [23] |
| Nepal   | River water               | 16                      | 1 (6.3)                   | ST1, ST4                 | C, MOL    | Lee et al. [18]       |
| Philippines| Wastewater (influent)    | 31                      | 7 (23.0)                  | ST1, ST2                 | C, IVC, MOL Banatica and Rivera [445] |
| Turkey  | Tap water                 | 25                      | 3 (12.0)                  | ST1                      | MOL       | Eroglu and Koltas, [19] |
| Turkey  | Streams and drinking water| 228                     | 47 (20.6)                 | NA                       | CM        | Karaman et al. [446]  |
| Turkey  | River water               | 195                     | 9 (4.6)                   | ST1, ST3                 | C, MOL    | Koloren et al. [447]  |
| Turkey  | Sea water                 | 48                      | 1 (2.1)                   | ST1                      |            |                      |
| Turkey  | Surface water             | 75                      | 4 (5.3)                   | ST1, ST3                 | C, MOL    | Koloren and Karaman [448]  |
| Saudia Arabia | Leaty vegetables         | 470                     | 13 (2.8)                  | NA                       | S, CM     | Al-Megrin [27]        |
| Iran    | Fresh vegetables          | 240                     | 10 (4.2)                  | NA                       | S, CM     | Isazadeh et al. [449] |
| Syria   | Fresh vegetables          | 128                     | 13 (10.2)                 | NA                       | MOL       | Al Nahhas and Abousalcham [450] |
| Korea   | Ambient air               | 71                      | 1 (1.4)                   | NA                       | MOL       | Han et al. [451]      |

C—Centrifugation, CM—Conventional microscopy, F—Filtration, IMS—Immunomagnetic separation technique, IVC—In vitro cultivation, MB—Membrane filtration, MOL—Molecular technique, S—Sedimentation, NA—Not applicable.
6. Distribution of Blastocystis spp. by Country

From 2010 till now, the identification of Blastocystis spp. has been described for a total of 31 Asian countries. Out of these 31, genetic characterization and Blastocystis spp. subtype identification was available for 22 countries. Figure 1 reveals the distribution of the subtypes of Blastocystis spp. in these countries with a glimpse of subtypes shared by humans, animals, and water sources. Blastocystis spp. ST1 was the most widespread subtype, found in all of the 22 countries.

7. Discussion

Blastocystis spp. have been reported in over 50% of the countries in the continent of Asia. Although the most documented hosts to infection were humans and several animal species, this organism has also been detected in water sources, vegetables, and ambient air.

Variation of prevalence rates was seen within and between the various human host categories. Although authors have described both significant and insignificant differences between Blastocystis spp. infection in patients with and without known disease conditions, this variation could be a result of the methods employed in the detection of Blastocystis spp. Blastocystis spp. STs 1–7 have been identified in humans in Asia. ST1, ST2, ST3 and ST4 were more widespread and more frequently isolated than ST5, ST6 and ST7. This finding is in agreement with studies from other parts of the world [2,13,452,453].

The isolation of Blastocystis spp. STs 1–14, and ST18–22 (novel subtypes) were reported in animal hosts. ST1, ST2, ST3, ST4, ST5, ST6 and ST7 were found common to humans and animals. ST9 was observed in ring-tailed lemurs and chickens in China [250] and Malaysia [15] respectively; however, no article included in this review reported on the identification of ST9 in humans in these countries. The characteristic presence of ST5 in pigs, ST10 and ST14 in goats, sheep and cattle, and ST6 and ST7 in chickens underscore suggestions that these STs are specific to the respective animal hosts. Also, reports of isolation of ST5 in pig handlers [214] and ST6 in chicken slaughterhouse staff [199] are pointers to possible zoonotic transmission.
Where stated, cysts were the *Blastocystis* spp. forms observed in vegetables and water samples. The presence of cysts in the life cycle of *Blastocystis* spp. enable their existence outside of human and animal hosts; also, the chloroform-resistant nature of these cysts probably explains the presence of *Blastocystis* spp. even in treated water.

8. Conclusions

The growing interest in the study of *Blastocystis* spp. as an area of research is very obvious and fundamental to unraveling the much that is hitherto unknown of the epidemiology, biology and pathogenicity of this protist. *Blastocystis* spp. have been isolated from biotic and abiotic sources in Asia. Considering that humans and animals are in constant interactions with their environment, epidemiological studies of *Blastocystis* spp. from an ecological perspective are essential. In essence, continuous surveillance of human and animal hosts alongside their food and water sources and other possible sources of infection such as soil across different geographical locations and climatic conditions is needed. The use of molecular detection methods in epidemiological studies are recommended to provide information on *Blastocystis* spp. STs in as many regions as possible. Incorporating the One Health (OH) method into epidemiological studies will equip researchers and other stakeholders with information on the possible influence of ecosystems on *Blastocystis* spp., it will further elucidate transmission routes and provide clues required to break the transmission of this protist successfully. Morphological studies of *Blastocystis* spp. in various host species and environmental sources are insufficient but essential; electron microscopy could help to accentuate structural details of isolates from various hosts and the differences or similarities between them, and contribute to the understanding of a proper, more detailed *Blastocystis* spp. lifecycle.

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