Tehran University of Medical Sciences Publication
http:// tums.ac.ir

Iranian J Parasitol

Open access Journal at
http:// ijpa.tums.ac.ir

Iranian Society of Parasitology
http:// isp.tums.ac.ir

Review Article

An Annotated Checklist of the Human and Animal *Entamoeba* (*Amoebida*: Endamoebidae) Species- A Review Article

***Hossein HOOSHYAR [1], Parvin ROSTAMKHANI [1], Mostafa REZAEIAN [2, 3]**

1. *Dept. of Parasitology, School of Medicine, Kashan University of Medical Sciences, Kashan, Iran*
2. *Dept. of Medical Parasitology and Mycology, School of Public Health, Tehran University of Medical Sciences, Tehran, Iran*
3. *Center for Research of Endemic Parasite of Iran (CREPI), Tehran University of Medical Sciences, Tehran, Iran*

Received 10 Dec 2014
Accepted 23 Feb 2015

Keywords:
Amoebida,
Entamoeba,
Checklist,
Species

***Correspondence**
Email:
hooshyar4@yahoo.com

Abstract

Background: The number of valid of pathogen and non-pathogen species of *Entamoeba* has continuously increased in human and animals. This review is performed to provide an update list and some summarized information on *Entamoeba* species, which were identified up to the 2014.

Methods: We evaluated the *Entamoeba* genus with a broad systematic review of the literature, books and electronic databases until February 2014. The synonyms, hosts, pathogenicity and geographical distribution of valid species were considered and recorded. Repeated and unrelated cases were excluded.

Results: Totally 51 defined species of *Entamoeba* were found and arranged by the number of nuclei in mature cyst according to Levin's grouping. Seven of these species within the 4 nucleate mature cysts group and 1 species with one nucleate mature cyst are pathogen. *E. histolytica, E. invadence, E. rananrum* and *E. anatis* causes lethal infection in human, reptiles, amphibians and brides respectively, four species causes non-lethal mild dysentery. The other species were non-pathogen and are important to differential diagnosis of amoebiasis.

Conclusion: There are some unknown true species of *Entamoeba* that available information on the morphology, hosts, pathogenicity and distribution of them are still very limited and more considerable investigation will be needed in order to clarify the status of them.

Introduction

The family Endamoebidae was originally established by Calkins (1926). The all member of Endamoebidae family (order: *Amoebida*) including: *Endamoeba, Entamoeba* , *Iodamoeba* and *Endolimax* are obligate symbiotic forms exception a species of *Entamoeba*, namely *E. moshkovski* found in sewage as free living amoeba but occasionally hosted by man (1, 2).

The term of *Entamoeba* was applied by Casagrandi and Barbagallo (1895), for *Entamoeba coli* and *Entamoeba histolytica* in human that known formerly as *Endamoeba coli*. *Endamoeba* is a genus of Endamoebidae amoebas that infecting invertebrates. The genus of *Entamoeba* (Casagrandi & Barbagallo, 1895) has adapted to live as parasite or commensal in digestive tract of human and other mammals, amphibian, brides, fishes, reptiles, and some invertebrate animals (3, 4). The genus of *Entamoeba* has applied and stable by the International Commission on Zoological Nomenclature in the late 1950s.

Only some species of *Entamoeba* are known to be potential pathogen and harmful, for example: *E. histolytica* (Schaudinn, 1903) sometimes invade the tissue of man and cause about 50 million cases of infections up to 100000 deaths per year worldwide (5, 6).

The correct identification of *Entamoeba* from other genus of Endamoebidae family including; *Endamoeba, Iodamoeba* and *Endolimax*, is on the basis of nuclear structure of trophozoite and cyst. Species of *Entamoeba* possess a vesicular nucleus that has a small or large accumulated endosome (karyosome) at or near the center. The rest space of nucleus appears empty. Chromatin granules are arranged regular or irregular around internal membrane of nucleus. Exception *E. gingivalis* like group, almost the all member of *Entamoeba*, have produce cyst. The cysts contain of one to eight and rarely more nuclei, a few of chromatoidal bar are visible in cyst of some species by light microscopy.

Species of the genus *Entamoeba* have been divided to five groups based on the number of nuclei willing in mature cyst by Levin (3).this groups are as follows:

A: species without cyst or *E. gingivalis* –like group.

B: species with one nucleate mature cyst or *E. bovis* –like group.

C: species with four nucleate mature cyst or *E. histolytica* –like group.

D: species with eight nucleate mature cyst or *E. coli*- like group.

E: inadequately known species.

The validity of this category was confirmed by using riboprinting method by Clark and Diamond in 1997 (5).

This review is performed to provide an update list and some summarized information on *Entamoeba* species, which was identified by Levin's grouping.

The aim of this review article is introduction of *Entamoeba* species to medical and veterinary parasitologists.

Methods

Electronic and manual searches in international electronic databases and journals were conducted to find the related data reporting on human and animal *Entamoeba* species. The search covered the articles published up to the 2014. Electronic searching was performed in the international databases covering: ISI Web of Science, PubMed, Scirus, EMBASE, Scopus, Science Direct and Google Scholar.

The following key words: "*Entamoeba*" and "Endamoebidae" were used as a panel of key words. For more accuracy, the references of selected articles were checked.

The manual search was carried out in articles published in scientific journals, abstracts of scientific articles related to this topic presented at scientific congresses as well as two textbooks: "Amoebas" (7) and "Veterinary

Protozoology" (3).The search restricted to English and Persian languages, repeated and unrelated cases were excluded. Taxonomy study, phylogeny data and new reports articles about *Entamoeba* were inclusion to study. Data were recorded and arranged based on the mature cyst morphology as the Levine grouping (3). The hosts, geographical distribution, habitat, pathogenicity of the all species and synonyms for some species were recorded.

Results

There are 5 valid species within the group of *Entamoeba* without cyst, 12 valid species within the group of one nucleated cyst producing *Entamoeba*, 19 valid species within the 4 nucleate mature cyst or *E. histolytica* –like group and 15 valid species were found within the group of 8 nucleated cyst producing *Entamoeba*. The others were invalid species or synonyms of accepted and reliable species exception 8 inadequately known species.

Totally 51 defined species of *Entamoeba* were found and recorded by the Levine grouping as the following list:

A: species without cyst or E. gingivalis – like group.

1- ***Entamoeba gingivalis*** (Gros, 1849)
Synonyms: *Amoeba buccalis* (Steinberg, 1862), *Amoeba dentalis* (Grassi, 1879), *Amoeba kartulis* (Doflein, 1901), *Entamoeba buccalis* (Prowazek, 1904), *Entamoeba maxillaris* (Kartulis, 1906), *Amoeba pyogenes* (Verdun & Bruyant, 1907), *Endamoeba gingivalis* (Smith & Barrett, 1915), *Endamoeba buccalis* (Bass & Johns, 1915), *Entamoeba canibuccalis* (Smitch, 1938), *Endamoeba confuse* (Craig, 1916), *Entamoeba equibuccalis* (Simitch, 1938), *Entamoeba suigingivalis* (Tumka, 1959).
Hosts: Human, Dog, Horse, Pig, Cat, Monkey.
Habitat: Oral cavity
Pathogenicity: None
Distribution: Worldwide
Ref: (7, 8, 9)

2-***Entamoeba barreti*** (Taliaferro &Holmes, 1924)
Synonyms: None
Hosts: Snapping turtle
Habitat: Colon
Pathogenicity: None
Distribution: Unknown
Ref : (9, 10)

3- ***Entamoeba gedoelsti*** (Husing, 1930)
Synonyms: *Entamoeba intestinalis*
Hosts: Horse
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: Unknown
Ref: (3, 7, 9)

4- ***Entamoeba caprae*** (Fantham, 1923)
Synonyms: None
Hosts: Goat
Habitat: Large intestine
Pathogenicity: None
Distribution: Unknown
Ref : (1, 11, 12)

5- ***Entamoeba molae*** (Noble E &Noble G, 1966)
Synonyms: None
Hosts: Fish (Ocean sunfish)
Habitat: Hindgut
Pathogenicity: None
Distribution: Southern California
Ref : (7, 13)

B: species with one nucleate mature cyst orr *E. bovis* –like group.

1- ***Entamoeba polecki*** (Von Prowazek, 1912)
Synonyms: *Entamoeba debliecki*
Hosts: Pig, Human, Monkey.
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: southeast Asian, France, United state, Venezuela, Guinea, Iran
Ref: (3, 14, 15)

2- ***Entamoeba chattoni*** (Swellengrebel, 1914)
Synonyms: None
Hosts: Monkey, Human
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: Africa
Ref: (9, 16, 17)

3- ***Entamoeba bovis*** (Liebetanz, 1905)
Synonyms: None
Hosts: Cattle, Buffalo
Habitat: Large intestine
Pathogenicity: None
Distribution: Africa
Ref: (3, 7, 18)
4- ***Entamoeba antilocapra*** (Noble, 1953)
Synonyms: None
Hosts: Antelope
Habitat: Large intestine
Pathogenicity: Pathogen, Intestinal lesion, Bowel inflammation, Necrosis
Distribution: America
Ref: (19)
5- ***Entamoeba ovis*** (Swellengrbel, 1914)
Synonyms: *Entamoeba debliecki*
Hosts: Sheep, Goat
Habitat: Large intestine
Pathogenicity: None
Distribution: World wide
Ref: (3, 5, 9)
6- ***Entamoeba dilimani*** (Noble, 1954)
Synonyms: *Entamoeba debliecki*
Hosts: Goat
Habitat: Large intestine
Pathogenicity: None
Distribution: Philippines
Ref: (3, 5, 9)
7- *Entamoeba struthionis* (Martínez-Díaz RA et al, 2000)
Synonyms: None
Hosts: Ostrich
Habitat: Large intestine
Pathogenicity: None
Distribution: Spain
Ref: (4, 20)
8-***Entamoeba suis*** (Hartmann, 1913)
Synonyms: *Entamoeba debliecki*
Hosts: Pig
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: China, Bulgaria, France, Yugoslavia, England, United State
Ref: (5, 14, 15)
9- ***Entamoeba bubalis*** (Noble, 1955)
Synonyms: None
Hosts: Buffalo
Habitat: Large intestine
Pathogenicity: None
Distribution: Philippines
Ref: (1, 5, 7)
10- ***Entamoeba paulista*** (Carini, 1933)
Synonyms: *Brumptina paulista*
Hosts: Opalinata
Habitat: Cytoplasm of Opalinata
Pathogenicity: None
Distribution: United State, Africa, Chili, Uruguay
Ref: (21, 22)
11- ***Entamoeba gadi*** (Bullock, 1966)
Synonyms: None
Hosts: Pollock fish
Habitat: Rectum
Pathogenicity: None
Distribution: North America
Ref: (23)
12- ***Entamoeba nezumia*** (Orias & Noble, 1971)
Synonyms: None
Hosts: Macrourid fish
Habitat: Stomach, Intestine
Pathogenicity: None
Distribution: North Atlantic
Ref: (24)

C: species with four nucleate mature cyst or *E. histolytica* –like group

1- ***Entamoeba histolytica*** (Schaudinn, 1903)
Synonyms: *Amoeba coli* (losch, 1875), *Amoeba dysenteriae* (Councilman &Lafleur1891), *Amoeba lobosa var.coli* (Celli & Fiocca, 1894), *Entamoeba africana* (Hartmann & Prowazek1907), *Entamoeba tetragena* (Viereck, 1907), *Entamoeba schaudinni* (Lesage, 1908), *Poneravuiocba histolytica* (Liihe, 1908), *Entamoeba minuta* (Elmassian, 1909), *Entamoeba nipponica* (Koizumi, 1909), *Entamoeba brasiliensis* (Aragao, 1912), *Loschia histolytica* (Mathis, 1913), *Entamoeba venaticum* (Darling, 1915), *Entamoeba caudata* (Carini & Reichenow 1949), *Endamoeba dysentreriae* (Kofoid, 1920).
Hosts: Human
Habitat: Colon and caecum, large intestine
Pathogenicity: Intestinal and extra intestinal amoebiasis

Distribution: Worldwide
Ref: (1, 25, 26, 27, 28)
2- ***Entamoeba dispar*** (Brumpt, 1925)
Synonyms: Non-pathogenic *E. histolytica*
Hosts: Human, Chimpanzees, Baboon, Macaques
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: Worldwide
Ref: (5, 27.29, 30, 31)
3-***Entamoeba hartmanni*** (Von Prowazek, 1912)
Synonyms: Small race *E. histolytica*, *Entamoeba minuta* (Woodeock & Penfold, 1916), *Entamoeba minutissima* (Brug, 1918), *Entamoeba tenuis* (Kuenen & Swellengrebel, 1917)
Hosts: Human
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: Worldwide
Ref: (5, 7, 9)
4-***Entamoeba moshkovskii*** (Tshalaia, 1941)
Synonyms: Laredo strain of *E. histolytica*, Huff strain
Hosts: Sewage, Human
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: Unknown, Probably World wide
Ref: (2, 30, 32, 33, 34)
5-***Entamoeba ecuadoriensis*** (Clark and Diamond, 1997)
Synonyms: None (It is very similar to *E. moshkovskii*, *E. histolytica*, *E. dispar*)
Hosts: Sewage
Habitat: Sewage
Pathogenicity: None
Distribution: Ecuador
Ref: (5, 9, 35)
6-***Entamoeba bangladeshi*** (Royer et al, 2012)
Synonyms: None (It is very similar to *E. moshkovskii, E. histolytica*)
Hosts: Human
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: Bangladesh
Ref: (36, 37)
7-***Entamoeba invadens*** (Rodhaim, 1934)
Synonyms: *Entamoeba serpentis* (Cunha and Fonseca, 1917)
Hosts: Reptiles: snake, lizard, turtle, crocodile
Habitat: Colon and caecum, large intestine
Pathogenicity: Intestinal and extra intestinal amoebiasis
Distribution: Worldwide
Ref: (22, 38, 39)
8-***Entamoeba insolita*** (Geiman and Wichterman 1937)
Synonyms: None
Hosts: Turtle
Habitat: Large intestine
Pathogenicity: Potential pathogen, intestinal amoebiasis
Distribution: Unknown
Ref: (22, 40)
9- ***Entamoeba terrapinae*** (Sanders and Cleveland, 1930)
Synonyms: None
Hosts: Turtle
Habitat: Colon
Pathogenicity: None
Distribution: Unknown, probably world wide
Ref: (3, 22)
10- ***Entamoeba knowlesi*** (Rodhain and Hoof, 1947)
Synonyms: None
Hosts: Turtle
Habitat: Large intestine
Pathogenicity: None
Distribution: Unknown
Ref: (22, 41)
11-***Entamoeba ranarum*** (Grassi, 1879)
Synonyms: None
Hosts: Frog, Toad
Habitat: Large intestine
Pathogenicity: Intestinal and extra intestinal amoebiasis
Distribution: Unknown, probably world wide
Ref: (5, 40, 42)
12- ***Entamoeba pyrrhogaster*** (Lobeck, 1940)
Synonyms: None
Hosts: Frog, Toad, Salamander
Habitat: Large intestine
Pathogenicity: None
Distribution: Unknown,
Ref: (21, 43)
13- ***Entamoeba aulastomi*** (Noller, 1919)

Synonyms: None
Hosts: Leech specially *Haemopis sanguisgua*
Habitat: Intestine
Pathogenicity: None
Distribution: Unknown
Ref: (44, 45)

14- ***Entamoeba ctenopharyngodoni*** (Chen, 1955)
Synonyms: None
Hosts: Carp Fish
Habitat: Rectum
Pathogenicity: None
Distribution: China
Ref: (13, 46)

15- ***Entamoeba anatis*** (Fantham, 1921)
Synonyms: None
Hosts: Duck, Bustard
Habitat: Caecum
Pathogenicity: Intestinal amoebiasis
Distribution: South Africa, Asia, United state
Ref: (4, 47)

16- ***Entamoeba lagopodis*** (Fantham, 1910)
Synonyms: None
Hosts: Duck, Lagopus
Habitat: Caecum
Pathogenicity: None
Distribution: Unknown
Ref: (7, 20)

17-***Entamoeba equi*** (Fantham, 1921)
Synonyms: None
Hosts: Horse
Habitat: Large intestine
Pathogenicity: Potential pathogen, intestinal amoebiasis
Distribution: South America
Ref: (7, 9, 11)

18- ***Entamoeba nuttali*** (Castellani, 1908)
Synonyms: *Entamoeba duboscqi* (Mathis1913), *Entamoeba cynomolgi* (Brug, 1923), *Entamoeba ateles* (Eichhorn and Gallagher, 1916), EHMfas1, NASA6, P19-061405
Hosts: Baboon, Macaques, Chimpanzees
Habitat: Large intestine
Pathogenicity: Potential pathogen, intestinal and extra intestinal amoebiasis
Distribution: Japan, Nepal, southwest China.
Ref: (31, 48, 49)

19-***Entamoeba philippinensis*** (Kidder, 1937)
Synonyms: None
Hosts: Termite, Cockroaches
Habitat: Hindgut
Pathogenicity: None
Distribution: Unknown
Ref: (3, 7)

D: species with eight nucleate mature cyst or *E. coli*- like group

1-***Entamoeba coli*** (Grassi, 1879)
Synonyms: *Entamoeba hominis* (Casagrandi & Barbagallo, 1897), *Entamoeba Loeschi* (Lesage, 1908), *Loschia coli* (Chatton & Lalung-Bonnaire, 1912), *Endamoeba coli* (Craig, 1917), *Endamoeba hominis* (Pestana, 1917), *Councilmania lafleuri* (Kofoid &swezy, 1921)
Hosts: Human
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: Worldwide
Ref: (1, 3, 7, 25, 26)

2- ***Entamoeba muris*** (Grassi, 1879)
Synonyms: *Councilmania decumani* (Rudovsky, 1921), *Entamoeba coli Var ratti, Endamoeba ratti* (Kessel , 1923), *Amoeba muris, Councilmania muris*.
Hosts: Rats, mice, Hamster, Wild and domestic rodent
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: Worldwide
Ref: (3, 50, 51)

3- ***Entamoeba citelli*** (Becker, 1926)
Synonyms: None
Hosts: Ground squirrel
Habitat: Colon and caecum, large intestine
Pathogenicity: None
Distribution: Unknown
Ref: (52, 53)

4- ***Entamoeba cobayae*** (Walker, 1908)
Synonyms: *Entamoeba caviae* (Chatton, 1918)
Hosts: Guinea pig
Habitat: Large intestine
Pathogenicity: None
Distribution: Worldwide
Ref: (7, 54)

5- ***Entamoeba criceti*** (Starkoff, 1942)
Synonyms: None
Hosts: Hamster
Habitat: Large intestine
Pathogenicity: None
Distribution: Unknown
Ref: (50, 55)
6- ***Entamoeba cuniculi*** (Brug, 1918)
Synonyms: None
Hosts: Rabbits
Habitat: Large bowel
Pathogenicity: None
Distribution: Korea, Russia
Ref: (3, 7)
7- ***Entamoeba dipodomysi*** (Hegner, 1926)
Synonyms: *Endamoeba dipodimysi*
Hosts: Kangaroo rats
Habitat: Large bowel
Pathogenicity: None
Distribution: Mexico, United state
Ref: (3, 56)
8- ***Entamoeba funambulae*** (Ray & Bunik 1966)
Synonyms: None
Hosts: Indian palm squirrel
Habitat: Large intestine
Pathogenicity: None
Distribution: India
Ref: (57)
9- ***Entamoeba marmotae*** (Crouch, 1936)
Synonyms: None
Hosts: Marmot
Habitat: Large intestine
Pathogenicity: None
Distribution: Unknown
Ref: (58, 59)
10-***Entamoeba chiropteris*** (Mandal and Choudhury, 1988)
Synonyms: None
Hosts: Bats
Habitat: Large bowel
Pathogenicity: None
Distribution: India, Bengal
Ref : (7)
11-***Entamoeba gallinarum*** (Tyzzer, 1920)
Synonyms: None
Hosts: Fowl
Habitat: Caecum
Pathogenicity: None
Distribution: Worldwide
Ref: (1, 3, 60)
12-***Entamoeba wenyoni*** (Galli-Valerio, 1935)
Synonyms: None
Hosts: Goat, Camel
Habitat: Large intestine
Pathogenicity: None
Distribution: Unknown
Ref: (3, 11, 12)
13-***Entamoeba flaviviridis*** (Knowles & Das Gupta, 1935)
Synonyms: None
Hosts: Lizard
Habitat: Intestine
Pathogenicity: None
Distribution: Sudan
Ref: (61)
14-***Entamoeba apis*** (Fantham and Porter, 1911)
Synonyms: None
Hosts: Bee (*Apis mellifica*)
Habitat: Intestine
Pathogenicity: None
Distribution: Unknown
Ref : (7)
15-***Entamoeba polypodia*** (Schultze, 1954)
Synonyms: None
Hosts: Bug (*Leptocoris trivitlatus*)
Habitat: Ventricle, Intestine and rectum
Pathogenicity: None
Distribution: Unknown
Ref: (62)

E: inadequately known species

The members of this group are not well studied. The life cycle, hosts and morphology of cysts are still incompletely known. Additional surveys for new data are needed to define the correct position and classification of these amoebas.

Some of these *Entamoeba* species are: *Entamoeba testudinis* (Hartmann, 1910), *Entamoeba varani* (lavier, 1928), *Entamoeba michini*, *Entamoeba phallusae*, *Entamoeba cervum* (Jian Han & Yang, 1989), *Entamoeba celestini* (Froilano de Mello, 1946), *Entamoeba bobaci* (Li Yuan Po, 1928), *Entamoeba blostomae* (Brug, 1922).

Discussion

The number of nuclei in the mature *Entamoeba* cyst is a reliable criterion for *Entamoeba* taxonomy based on the morphological feature. The validity of this grouping was supported by molecular methods such as riboprinting and comparisons of full-length 16S-like rDNA sequences (5, 63). Among all of the known *Entamoeba* species, only *E. antilocapra* in the *Entamoeba* species with one nucleate mature cyst group and 7 members of the *Entamoeba* with four nucleate mature cyst (*E. histolytica, E. invadence, E. insoltia, E. ranarum, E. anatis, E. equi, E. nutalli*) are pathogen (1, 3, 7, 9, 11, 21) and the others are commensal. *E. histolytica, E. invadence, E. rananrum* and *E. anatis* causes lethal infection in human, reptiles, amphibians and brides respectively and all of them belong to the *Entamoeba* species group with 4 nucleus per mature cyst. They have significant important to medicine and veterinary and economy world-wide. *E. insoltia, E. equi, E. nutalli*, *E. antilocapra* causes non-lethal mild dysentery.

There are no evidence for pathogenicity of the member of *E. bovis* and *E. gingivalis*–like groups, but these species are important to differential diagnosis. *Entamoeba gingivalis*, *E. polecki, E. chattoni* and *E. dispar* are zoonosis (5, 9, 15, 16, 48). Some of the *Entamoeba* species with uncertain or doubtful status have been reported from human and animal infections. Many of them have not been generally accepted as a distinct species and may be atypical form or a synonym of known species, for example there are up to 14 synonyms for *E. histolytica* (26). The members of other genus of amoeba have been misdiagnose as *Entamoeba* species for instance: *E. williamsi* after further studies was placed in other genera as "*Iodamoeba butschlii*" (7). Nevertheless, there are some unknown true species of *Entamoeba* that available information on the morphology, hosts, pathogenicity and distribution of them are still very limited and more considerable investigation will be needed in order to clarify the status of them.

Conclusion

At least eight species of Entamoeba are known as human commensal or parasite. The number of *Entamoeba* species has continuously increased. The most recent species is *E. bangladeshi* that identified in human in 2012. Using of molecular tools can increase our knowledge about member of Endamoebidae family.

Acknowledgements

The authors would like to thank all authors who provided the material for this review and appreciation to S Fallah for his helpful suggestion on this manuscript. The authors declare that there is no conflict of interests.

References

1. Kreire JP, Baker J R. Parasitic Protozoa. Allen and unwin, inc.USA; 1987.
2. Hamzah Z, Petmitr S, Mungthin M, Leelayoova S, Petmitr PC.Differentioal detection of *Entamoeba histolytica, Entamoeba dispar* and *Entamoeba moshkovskii* by a single-round PCR assay. J Clin Microbiol. 2006;44 (9):3196-3200.
3. Levine ND. Veterinary Protozoology.Iowa State University Press. Ames, IA, 414; 1985.
4. Martínez-Díaz RA, Herrera S, Castro A, Ponce F. *Entamoeba* sp. (*Sarcomastigophora: Endamoebidae*) from Ostriches (*Struthio camelus*) (Aves: *Struthionidae*). Vet Parasitol. 2000; 92 (3):173-9.
5. Clark CG, Diamond LS. Intraspecific variation and phylogenetic relationships in the genus *Entamoeba* as revealed by riboprinting. J Euk Microbiol. 1997; 44: 142–154.
6. Tengku SA, Norhayati M. Public health and clinical importance of amoebiasis in Malaysia: A review. Trop Biomed. 2011; 28(2): 194–222.

7. Hooshyar H, Rezaian M. Amoebas. Tehran University of Medical Sciences Publication. Tehran; 2011.
8. Kikuta N, Yamamoto A, Goto N. Detection and identification of *Entamoeba gingivalis* by specific amplification of rRNA gene. Can J Microbiol. 1996;42(12):1248-1251.
9. Clark CG, Kaffashian F, Tawari B, Windsor JJ, Twigg-Flesner A, Davies-Morel MC, Blessmann J, Ebert F, Peschel B, Le Van A, Jackson CJ, Macfarlane L, Tannich E.New insights into the phylogeny of *Entamoeba* species provided by analysis of four new small-subunit rRNA genes. Int J Syst Evol Microbiol. 2006;56(Pt 9):2235-2259.
10. Gillin FD, Diamond LS.Clonal Growth of *Entamoeba histolytica* and other Species of *Entamoeba* in Agar. J Protozool. 1978; 25(4):539-43.
11. Noble G A and Noble E R. *Entamoebae* in Farm Mammals. J Parasitol. 1952;38(6):571-595.
12. Hoare CA. On an *Entamoeba* occurring in English goats.Parasitol. 1940; 32: 226-237.
13. Noble ER, Noble GA. Amebic parasites of fishes.J Euk Microbiol. 1966;13(3):478-480.
14. Solaymani-Mohammadi Sh, Rezaian M, Hooshyar H, Mowlavi GR, Babaei Z, Anwar MA. Intestinal protozoa in Wild Boars (*Sus scrofa*) in western Iran. J Wildlife Dis. 2004;40(4):801-803.
15. Desowitz RS, Barnish G. *Entamoeba polecki* and other intestinal protozoa in Papua New Guinea highland children.Ann Trop Med Parasitol. 1986;80(4):399-402.
16. Sargeaunt PG, Patrick S, O'Keeffe D.Human infections of *Entamoeba chattoni* masquerade as *Entamoeba histolytica*.Trans R Soc Trop Med Hyg. 1992;86:633-634.
17. Muehlenbein MP. Parasitological analyses of the male chimpanzees (*Pantroglodytes schweinfurthii*) at Ngogo, Kibale National Park, Uganda. Am J Primatol. 2005;65 (2):167–179.
18. El-Refaii AH. *Entamoeba bovis* Liebetanz 1905 recorded from large ruminants in Egypt. J Egypt Soc Parasitol. 1993 ;23 (1):239-45.
19. Kingston N, Williams ES, Thorne T. Invasive *Entamoebae* in pronghorn (*Antilocapra amricana*) from Wyoming. J Wildlife Dis. 1990;26 (1):50-54.
20. Ponce-Gordo F, Martínez-Díaz RA, Herrera S. *Entamoeba struthionis* n. sp. (*Sarcomastigophora: Endamoebidae*) from ostriches (*Struthio camelus*). Vet Parasitol.2004;119:327–335.
21. Poynton SL, Whitaker BR. Protozoa and metazoa infecting amphibians. In: K.M. Wright and B.R. Whitaker, Editors. Amphibian Medicine and Captive Husbandry, Krieger Publishing Company, Malabar, FL, USA; 2001pp:193-222.
22. Geimana QM, Ratcliffea HL. Morphology and life-cycle of an *Amoeba* producing amoebiasis in Reptiles.Parasitol.1936;28:208-228.
23. Bullock WL. *Entamoeba gadi* Sp.N. from the rectom of the Pollock, Pollachius virens (L., 1758), with some observation on its cytochemistry.J Parasitol. 1966;52 (4):679-684.
24. Orias DJ, Noble ER. *Entamoeba nezumia* spn and other parasites from a North Atlantic fish. J Parasitol.1971;57 (5):945-947.
25. Ravdin JI (ed). Amoebiasis: Human infection by *Entamoeba histolytica*. Wiely Medical Publication, New York; USA, 1988.
26. Ravdin JI (ed). Amoebiasis:Series ontropical medicine:Science and practice.Vol 2.Imperial Collge press, London; 2000.
27. World health organization. *Entamoeba* Taxonomy. Bull WHO. 1997;75 (5):291-92.
28. Ximenez C, Moran P, Rojas L, Valadez A, Gomez A.Reassessment of the epidemiology of amebiasis: State of the art.Infect Genet Evol. 2009 ;9 (6):1023-32.
29. Clark CG. *Entamoeba dispar*, an organism reborn. Trans R Soc Trop Med Hyg. 1998;92: 361-364.
30. Hooshyar H, Rostamkhani P, Rezaian M.Molecular epidemiology of human intestinal amoebas in Iran. Iran J Public Health. 2012;41 (9):10-17.
31. Feng M, Cai J, Min X, Fu Y, Xu Q, Tachibana H, Cheng X. Prevalence and genetic diversity of *Entamoeba* species infecting macaques in southwest China. Parasitol Res. 2013;112 (4):1529-36.
32. Clark CG, Diamond L. The Laredo strain and other "*Entamoeba histolytica*-Like" amoeba are *Entamoeba moshkovskii*. Mol Bioch Parasitol.1991;46:11-18.

33. Beck DL, Dogan N, Maro V, Sam NE, Shao J, Houpt ER.High prevalence of *Entamoeba moshkovskii* in a Tanzanian HIV population.Acta Trop. 2008 ;107 (1):48-9.
34. ElBakri A, Samie A, Ezzedine S, Odeh RA.Differential detection of *Entamoeba histolytica, Entamoeba dispar* and *Entamoeba moshkovskii* in fecal samples by nested PCR in the United Arab Emirates (UAE). Acta Parasitol. 2013;58 (2):185-90.
35. Clark CG, Diamond LS. Ribosomal RNAgens of pathogenic and non-pathogenic *Entamoeba histolytica* are distinct. Mol Bioch Parasitol.1991;49:279-302.
36. Royer TL, Gilchrist C, Kabir M, Arju T, Ralston KS, Haque R, Clark CG, Petri WA Jr. *Entamoeba bangladeshi* nov. sp., Bangladesh. Emerg Infect Dis. 2012;18 (9):1543-5.
37. Gilchrist CA. *Entamoeba Bangladeshi*: An insight. Trop Parasitol. 2014;4 (2):96-98.
38. Bradford CM, Denver MC, Cranfield MR.Development of a polymerase chain reaction test for *Entamoeba invadens*.J Zoo Wildl Med. 2008;39 (2):201-7.
39. Arroyo-Begovich A, Carabez-Trejo A, Ruiz-Herrera J. Identification of the structural component in the cyst wall of *Entamoeba invadens*. J Parasitol. 1980; 66:735–741.
40. Clark CG. Axenic Cultivation of *Entamoeba dispar* Brumpt 1925, *Entamoeba insolita* Geiman and Wichterman 1937 and *Entamoeba ranarum* Grassi 1879. J Euk Microbiol. 1995;42 (5):590-593.
41. Neal R A. Survival of *Entamoeba* and related amoebae at low temperature—I. Viability of *Entamoeba* cysts at 4°C. Int J Parasitol. 1974;4 (3):227-29.
42. Dobell C. Are *Entamoeba histolytica* and *Entamoeba ranarum* the same Species? An Experimental Inquiry. Parasitol. 1918; 10 (2):294-310.
43. Lobeck EA. *Entamoeba pyrrhogaster* n. sp., with Notes on Other Intestinal Amoebae from Salamanders. J Parasitol. 1940;2 (4):243-272.
44. Bishop A. *Entamoeba aulastomi* Nöller Cultivation, Morphology, and Method of Division; and Cultivation of *Hexamita* sp. Parasitol.1932;24 (2):225-232.
45. BishopA. Further observations upon *Entamoeba aulastomi* Nöller. Parasitol.1937; 29 (1):57-69.
46. Molnar K. Protozoan parasites of fish species indigenous in Hungary.Parasit Hung. 1979; 12: 5-8.
47. Silvanose CD, Samour JH , Naldo JL , Bailey TA.Oro-pharyngeal protozoa in captive bustards:clinical and pathological onsiderati-ons. Avian Pathol. 1998; 27:526-530.
48. Tachibana H, Yanagi T, Pandey K, Cheng XJ, Kobayashi S, Sherchand JB, Kanbara H.An *Entamoeba sp.* strain isolated from rhesus monkey is virulent but genetically different from *Entamoeba histolytica*. Mol Bioch Parasitol. 2007;133 (2):107-114.
49. Tachibana H, Yanagi T, Lama C, Pandey K, Feng M, Kobayashi S, Sherchand JB.Prevalence of *Entamoeba nuttali* infection in wild rhesus macaques in Nepal and characterization of the parasite isolates. Parasitol Int. 2013;62:230-235.
50. Franjola R, Soto G, Montefusco A. Prevalence of protozoa infections in synanthropic rodents in Valdivia City, Chile. Bol Chil Parasitol. 1995 ;50 (3-4):66-72.
51. Won YS, Jeong ES, Park HJ, Lee CH, Nam KH, Kim HC, Hyun BH, Lee SK, Choi YK.Microbiological Contamination of Laboratory Mice and Rats in Korea from 1999 to 2003. Exp Animals. 2006; 55 (1):11-16.
52. Becker ER. *Endamoeba citelli* sp. nov. from striped ground squirrel *Citellus tridecemlineatus*, and the life-history of its parasite, *Sphaerita endamoebae* sp.nov. Biol Bull. 1926;50 (4):444-454.
53. Davis SD. Hibernation: Intetinal protozoa population in ground Squirrel.Exp Parasitol. 1969;26:156-165.
54. Gill NJ, Ganguly NK, Mahajan RC, Bhusnurmath SR, Dilawari JB.Progesterone-induced amoebic liver abscess in guinea-pigs, a new model. Trans R Soc Trop Med Hyg.1983;77 (1):53-58.
55. Slighter RG, Yarinsky A, Drobeck HP, Bailey DM.Activity of quinfamide against natural infections of *Entamoeba criceti* in hamsters: a new potent agent for intestinal amoebiasis. Parasitol. 1980;81 (1):157-68.
56. Hegner RW. *Giardia beckeri* n. sp. from the ground squirrel and *Endamoeba dipodomysi* n. sp. from the kangaroo rat. J Parasitol. 1926;12 (4):203-207.

57. Ray HN, Banik DC. *Entamoeba funambulae* n.sp., from indian palm squirrel, *funambulus palmarum*. Bull Calcutta Sch Trop Med. 1964;12:114-5.
58. Russel Gabel JR. Protozoa of the Mountain Marmot, *Marmota flaviventer* Audubon and Bachman, 1841. Trans Am Micro Soc. 1961;80 (1):43-53.59.
59. Hampton JR, Grundmann AW. Transfaunation Studies with Germ-Free Mus Musculus Using the *Entamoeba* from Three Rodent Species. Trans Kansas Acad Sci. 1970; 73 (3):376-381.
60. Tyzzer ED. Amoebae of the caeca of the common fowl and of the turkey-*Entamoeba gallinarum* , sp.n. and *Pygolymax gregariniformis*. J Med Res. 1920;178:199-210.
61. Neala RA. Amoebae found in the intestine of lizards from the Sudan.Parasitol. 1954;44 (3-4):422-427.
62. Kay MW. Two New Amoebae from the Box Elder Bug, *Leptocoris trivittatus Say*. Am Midland Natural. 1940; 23 (3):724-728.
63. Silberman JD, Clark CG, Diamond LS, Sogin ML.Phylogeny of the Genera *Entamoeba* and *Endolimax* as Deduced from Small-Subunit Ribosomal RNA Sequences.Mol Biol Evol. 1999;16 (12):1740–1751.