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Review Article

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

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Received 10 Dec 2014 Accepted 23 Feb 2015	Abstract Background: The number of valid of pathogen and non-pathogen species of <i>Entamoeba</i> has continuously increased in human and animals. This review is performed to provide an update list and some summarized information on <i>Entamoeba</i> species, which were identified up to the 2014. Methods: We evaluated the <i>Entamoeba</i> 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 <i>Entamoeba</i> 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. <i>E. histolytica</i> , <i>E. invadence</i> , <i>E. rananrum</i> and <i>E. anatis</i> 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 <i>Entamoeba</i> 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.
Keywords: Amoebida, <i>Entamoeba</i> , Checklist, Species	
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Introduction

The family Endamoebidae was originally established by Calkins (1926). The all member of Endamoebidae family (order: *Amoebida*) including: *Entamoeba*, *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*. *Entamoeba* 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, birds, 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 sui gingivalis* (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 or *E. bovis* -like group.

1- *Entamoeba polecki* (Von Prowazek, 1912)

Synonyms: *Entamoeba deblickei*

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* (Swellengrabel, 1914)

Synonyms: *Entamoeba deblickei*

Hosts: Sheep, Goat

Habitat: Large intestine

Pathogenicity: None

Distribution: World wide

Ref: (3, 5, 9)

6- *Entamoeba dilimani* (Noble, 1954)

Synonyms: *Entamoeba deblickei*

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 deblickei*

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* (Iosch, 1875), *Amoeba dysenteriae* (Councilman & Lafleur 1891), *Amoeba lobosa var. coli* (Celli & Fiocca, 1894), *Entamoeba africana* (Hartmann & Prowazek 1907), *Entamoeba tetragena* (Viereck, 1907), *Entamoeba schaudinni* (Lesage, 1908), *Poneraiocba 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 dysentriae* (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* (Woodecock & 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 *Haemopsis sanguisuga*

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), *Loeschia 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 trivittatus*)

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. ranarum* and *E. anatis* causes lethal infection in human, reptiles, amphibians and birds 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.

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