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Diversity of free-living protozoa

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ABSTRACT: Single-celled creatures are known as protozoa. They range in size and shape from amoebas, which can vary in their shape, to parameciums, which have sophisticated structures and a fixed shape. They inhabit many different types of moist habitats, such as freshwater, saltwater, and soil. In order to make nutrients usable by plants and other soil organisms, protozoa play a crucial role in the mineralization of minerals.

Because of their widespread nature, protozoa can withstand a broad variety of physicochemical conditions, such as salinity, pH, temperature, and oxygen concentration. Instead of being dispersed randomly, they reside in tiny areas called microhabitats, which can be as small as a few cubic centimeters, found in moist environments like soil, vegetation, or the bodies of plants and animals. The free-living protozoan's communities are highly diverse, the protozoan's communities of the water and soil in Tigris River were predominantly ciliates which comprise the highest number of species and number of individuals within the groups of protozoa.

Keywords: free-living, protozoa, amoeba, flagellate, ciliate, sporozoan

1. INTRODUCTION

Protozoa (or protozoan, the plural form: protozoans) is a popular word for single-celled eukaryotes that feed on organic materials like organic tissues and debris, other microbes, or both. They can be parasitic or free-living. Protozoa are classified as high taxa in certain biological taxonomy schemes. Protozoology is the study of the microorganisms known as protozoa [protozoan; Greek protos, first, and zoon, animal]. A protozoan is a type of eukaryotic unicellular protist that is typically motile [1]. Protozoa are ubiquitous, meaning they may be found anywhere. Their cysts can be found in even the most hostile regions of the biosphere, and they can be found in any watery or moist environment. The majority feed on bacteria, algae, and other protozoa and are free-living. Soil, seashore sand, and decomposing organic debris are all rich sources of terrestrial protozoa, some of which are parasitic on plants or animals [2]. Some protozoa do not move. Pseudopodia, flagella, or cilia are the three main forms of locomotory organelles that most may use to move [3]. Protozoans are significant and essential elements of aquatic ecosystems. They are generally understood to include autotrophic and heterotrophic flagellates, amoebae, and ciliates. In aquatic food webs, these kinds of organisms are essential to the movement of energy and the cycling of minerals. [4].

The activity of the contractile vacuole is normally much higher in fresh water forms than marine and Endosymbionts. This observation suggests that the primary function of these vacuoles is osmoregulation. Changes in the rate of vsacuolar activity of a particular organism may be affected by the concentration of the surrounding medium. It is often assumed that metabolic products and waste nitrogen substances are removed in the vacuolar fluid. The cytoplasm of protozoa is of three main classes: The fibrillar structures: 1-Protofilaments ,2- The microfilaments which are formed of two protofilaments twisted around one another and 3-microtubules which are cylindrical elements formed from 13 protofilaments. These filaments may be referred to as myonemes or muscles of contraction and locomotion (flagellates, ciliates and in gregarine species). The movement of cilia in the ciliates, which can be described as well-coordinated, was designated by [4], who stated that it is made up by a specific fibrillar system that is most likely neurological in nature, earning the entire apparatus the term neuromotor system. This apparatus involves a motorium from which radiate several strands (fibres) to the various ciliary structures. At the bases of these motor organelles, kinetosomes are found. By using the dry technique, Sharp noticed that the neuromotor system in ciliates appears as follows: The pellicle of Paramecium

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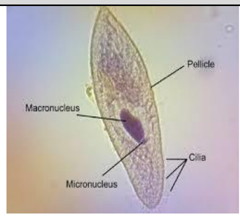
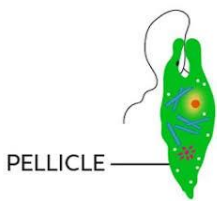
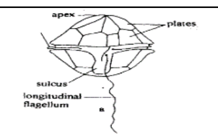
is formed of hexagonal elevations connected with pegs & sockets to ease their movement. From each hexagonal plate arises a cilium which is embedded in the cytoplasm by kinetosomes. Kinetosomes of successive rows are connected to each other by longitudinal fibrils, while kinetosomes of the same row of cilia are connected by transverse fibrils, they are called kinety or kinetosomes. Trichocysts (sensory and defensive) may be also useful in capturing food (Didinium). They arise from the area between two hexagonal plates or elevations. • Within protozoa, the mode of reproduction varies greatly between species. Reproduction is usually initiated by the nuclear division. Most protozoa are a sexual and are reproduced in one of three ways: fission, colony formation, budding, and multiple fisson.

Alternation of Generation: In some cases, the whole cell (individual) can become or can act as gametes (usually female and rarely male) so a gamont is formed Conjugation of Paramecium (autogamy) or formed gametes. If the gametes are not morphologically different, it is isogamety.

Life cycle of *Elphidium*, example of Isogamy, if the gametes differ in size, form or structure. In this case the macrogamete resembles the female cell, while the microgamete is the male cell (ex: Life - cycle of Plasmodium, . Some protists are sexual and exchange genetic materials from one cell to another through conjugation which is the physical contact followed by nucleic exchange between two individuals. The main stage of its life cycle is trophozoite, but they can survive in adverse environments by encapsulating itself which a protective coating called cyst. Every protozoan animal has at least one nucleus. Many protozoa are multinucleate (Diplomonadida, Testacida, Ciliophora and other). Between divisions, the nucleus of the cell is called resting nucleus (physiologically it is not resting). The nucleus is composed of 4 structural elements: 1 – Chromosomes 2 - Nuclear substance (N. S) 3 – Karyoplasm 4 - Nuclear envelop (N. E). In all species of protozoa, the number of chromosomes is constant except in those having micro - and macronucleus, where the chromosomes in the micronucleus are usually constant (as it is responsible for reproduction), while the macronucleus is mostly polyploidy. The presence of more than one type of nucleus within the same cell of protozoa is called nuclear dimorphism: There are generative nuclei which are capable of reproduction and sornatic nuclei which are rather incapable of reproduction but active in other ways (Locomotion, feeding excretion-- etc). In most ciliates the macronucleus is of the second type and 1S polyploidy. The macronucleus differs from the micronucleus in size; it is less compact and has from one to several nucleoli. Vegetative macro. Nuclei include a large variety of forms: - Droplet – shape in (Chilodonella). Divided into 2 parts in (Stylonychia). Kidney – shape in (Paramecium), Horse - shoe shape in (Vorticella, Trichodina) , Band shape and cylindrical in (Euplotes) , Branched (Ephelota) and - Beaded (Spirostomum). Like all animal plant cells, the protozoan cell consists of cytoplasm and nucleus. All protozoa possess a cell membrane (protein – lipid- protein in structure). They range in size and shape from amoebas, which can vary their shape, to parameciums, which have complex structures and a fixed shape. Protozoa are distinguished by the presence of exterior surface coatings, which serve a variety of purposes (Table 1).

Table 1. Outer surface coverings [6].

Outer surface covrings	Descriptions		Diagram
The pellicle	It has a pellicle, a thin covering that shields the cell membrane, but it does not have a cell wall. Because of its stiffness and flexibility, it helps the protists move more freely and keep their shape. The way it works is that the organisms are encircled by swirling protein strips that glide past one another. There is always a cell envelope (pellicle) separating the cytoplasm from the outside world.	Euglena has a stiff pellicle outside the cell membrane that helps it keep its shape, though the pellicle is somewhat flexible and some euglena can be observed scrunching up and moving in an inchworm type fashion. Color the pellicle blue. In cilitates , pellicle of is formed of hexagonal elevations connected with pegs & sockets to ease their movement called ciliary fields . From each hexagonal plate arises a cilium which is embedded in the cytoplasm by kinetosomes.	 
The theca	It is a secreted layer directly opposed to the surface. the chemical composition of which is cellulose , in some organisms , it can be	Example : Glenodium	

	impregnated with inorganic to increase rigidity		
The lorica.	is a vase –like capsule which is loosely applied to the organism surface. it is formed of chitino material alone or chitin reinforced with sand grains or debris. In sessile forms the base of the lorica may be modified for attachment to a substratum or to other members of species, thus giving rise to colonies in many loricate species can extend themselves through an aperture in this cover. if the lorica is crushed the individual can swim away freely,	Example Dinobryon , Gonium	
Test.	A capsule of covering secreted by protozoa for protection. they vary remarkably in their morphological features.	Example *Arcella* secrets a chitinous covering that darkens with age *Difflugia* in contrast glue sand grains remains of diatoms and other debris together ,	 *Arcella*
Shell	Is formed mainly of calcium carbonate secretions in the foraminiferida .it forms a rigid outer skeleton for the animal. it may be formed of one or numerous chambers (multi chambered) in Radiolarida , siliceous skeletons with radiating spines are produce. Radiolaria, in contrast to heliozoa, have a "central capsule" that divides the cytoplasm into extracapsular and intracapsular regions. There is usually a nucleus or nuclei in the intracypsular cytoplasm. The majority of radiolaria have a species-specific skeleton composed of strontium sulfate or silicic acid, which typically has a star-like appearance. In warm-water waters, the majority of radiolaria are located in the deeper planktonic layers. The radiolarians arc exclusively marine and mostly floating. The bottom mud in great depths, where foraminifera shells dissolve, is largely made of siliceous radiolarian skeleton, known as "radiolarian ooze", The preservation of such deposits makes the Radiolarida the oldest known animal group.	*Acanthometron*.	

The Protozoa, which includes seven of the 14 phyla found in the kingdom Protista, is regarded by many taxonomists of protozoa as a subkingdom [2]. While [7a] suggested that the protozoa can be classified into 18 phyla and given kingdom status based on features such as the structure of mitochondrial cristae. It is yet unknown, though, if protozoologists will embrace this new categorization. There is no distinct taxon known as the protozoa in current molecular categorization systems. Eukaryotes that resemble protozoa are present at all evolutionary levels [8b]. Much studies, available on free-living protozoans of fresh water and sediment, were conducted in different parts of the world, e.g. [4], [3]. informed an substantial number of species from freshwater wetland ecosystems across India, While [9] studied the diversity of protozoa in Nam-Pong-river (Thailand), [10] made a study on biodiversity of protozoa in fresh water of the ChaoPraya river (Thailand). reported the spatial seasonal variations of protists in a river-Alcustrine system in northeast Brazil, [11] carried out a study on seasonal variation in physical-chemical properties and zooplankton biomass in Greater Zab river (Iraq),[12], Studies on free-living protozoa of fresh water and sediment have been scarcely conducted in on the Ecosystem of the Tigris River,by [13], [14].

1.1 Protozoa and ecosystem function

More than 83,000 known species of protozoa live in water and soil. They belong to a distinct group of creatures known as autotrophic nutritionists. Their diversity has developed as a result of their evolution to make use of the variety of microbial food sources that exist in both temporary and permanent environments [15]. The feeding habits of freshwater protozoa were categorized by [16] into six groups: algivores, non-selective-omnivores, saprotrophs, photosynthetic autotrophs, holozoic nutrition, and predators. Soils include water protozoa that belong to all of these trophic groups. An organism's organic molecules, which are made up of several essential elements like carbon, hydrogen, and oxygen, must be present for them to receive nourishment. Proteins contain also nitrogen and sulphur . Lipids contain phosphorus, while nucleic acids contain nitrogen and phosphorus. Many organisms require a range of growth factors such as vitamins which are complex molecules needed in the production of some coenzymes.

Because multiple stimuli affect protozoa in the natural world, they do not always respond in the same way. A protozoan can respond to stimuli in a variety of ways, including modifications to its body form, mobility, structure, behavior, and reproduction. The most evident reaction is movement, which is readily seen in free-swimming ciliates. One of two directions can be seen in a movement response: either away (negative reaction) or towards (positive reaction) from the stimulus source. A protozoan's response to any external stimulation generally depends on its species and degree of intensity (different individuals may react differently) [17]

1. 2 Behaviour to mechanical stimuli

Negative reaction (avoiding) is observed in an amoeba when it gets in contact with a solid object. It swiftly changes plasmasol flowing, forms new pseudopods, and retards (turns away from the side touched). On the other side, positive reactions are usually towards solid bodies and observed during the ingestion of food particles [17].

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1.3 Behaviour to chemical stimuli

When an advancing amoeba comes in touch with methyl green, methylene blue, or sodium chloride, it reacts negatively. Paramecium responds positively to low concentrations of various acids. On the other hand, negative reactions to powerful acids are noted.

1.4 Behaviour to light stimuli

While most protozoa respond to normal light in diverse ways, there is typically a negative reaction (avoiding) when light intensity abruptly increases. Mastigophora bearing stigmas exhibit a positive response to light, which is also evident in Euglena, which needs light for photosynthesis to occur.

1.5 Reaction to temperature stimuli

Every protozoan appears to have a preferred temperature range. However, generally speaking, a higher temperature corresponds to a higher metabolic rate, which causes faster growth and more frequent reproduction.
The influence of ecological factors on the lives of Protists:
Physical and chemical factors

Protists occur where water is found (salty or fresh), damp soil, damp moss, snow or within the bodies of other animals and plants. These habitats provide conditions within the range of the ecological tolerance of protists. Water, temperature, oxygen, light, pH, and salinity are ecological parameters that are particularly important to the lives of different protist species. If these parameters are within favorable bounds for a given protist species, then the species' occurrence and abundance will depend on the availability of suitable food and the degree of predation. Active trophic Protozoa need water, so are most abundant in aquatic habitats, but are also charactaristic inhabitants of soil and Polar Regions where free water is only present for short periods. Protozoa from these habitats are able to escape shortage of water by encystment. Many Protozoa secrete resistant walls (cyst wall) within which they remain dormant through periods of adverse conditions. In some cases the cyst wall is relatively permeable and the encysted organism cannot survive dryness eg. Didinium. The cyst of soil Protozoa and of some parasites are able to survive drought and other severe conditions as the walls of such cysts are highly resistant and rather impermeable e.g. spores of Monocystis, soil amoebae as Acathamoeba [17].

In general, protists are distributed worldwide. Furthermore, most protozoa primarily function as phagotrophs, or particle consumers, according to [18]. As planktonic or benthic forms, free-living organisms are widely distributed. Certain protozoa can withstand a broad variety of physicochemical conditions, such as salinity, pH, temperature, and oxygen concentration. The hydrogen-ion concentration (pH) of the water is closely associated with its chemical composition. Certain protozoa seem to be tolerant of a broad pH range. Leptomyxa reticulata is an intriguing proteomyxan that grows well in non-nutrient agar between pH 4.2 and 8.7 when the right bacterial strain is used as food. It may be found in soil that ranges in pH from 4.3 to 7.8 [17], [19]. Euglena gracilis (var. bacillaris) grow between pH 3.2 and 8.3, according to [20]. Nonetheless, most protozoa appear to favor a specific pH range for optimal metabolic activity [21], [22]. While in their encysted condition they can tolerate significantly greater temperature fluctuations, most protozoa can only survive in a narrow range of temperatures. The protoplasm freezes at the lower temperature limit, and the body's protoplasm undergoes a destructive chemical change at the upper temperature limit [21]. Protozoa species appear to differ in their tolerance to temperature, and within the same species under various circumstances. [23]. discovered that when food was present, Paramecium multimicronucleatum's tolerance to elevated temperatures was low, but it increased to a maximum when the food was gone. Protozoa are among the known living things found in the 34–36°C thermal waters of hot springs; nevertheless, protozoa appear to be less negatively impacted by the low temperature than by the higher one [24]. In a successive investigations on protozoa found in Japan's diverse thermal waters, [25], [26]. found that a large number of species were able to withstand temperatures as high as 56°C. Numerous protozoans have been shown to survive in water under ice. while the [27]. discovered that Entamoeba histolytica trophozoites survived for 56 hours while being stationary, but perished quickly when the medium froze at -5°C. No survival was noted hen the water in which the organisms are kept freezes .

Oxygen: As many protozoa are micro aerobic, they gravitate toward environments with low oxygen tension. In addition to facilitating the maintenance of nutritional symbionts like sulphide-oxidizing bacteria [28] and endosymbiotic algae, which both benefit from being located in opposing gradients of O_2 and light on the one hand, and CO_2, H_2S, and other reductants on the other, this gets them in touch with elevated abundances of microbial food [29,30,31]. Although many micro-aerobic protozoa can be facultative anaerobes [32], their metabolism is essentially aerobic, in contrast to that of 'true' anaerobes. Less is known about large ciliates in the anoxic benthes of deeper lakes. Certain species disappear or are replaced, while others—like those in the genus Loxodes—seem to be surprisingly tolerant of aerobic circumstances. O_2 is poisonous to ciliates, flagellates, and amoebae, among other free-living protozoa that have developed into true anaerobes. Although there are several species, none are ever particularly prolific. They mostly reside in freshwater and marine sediments. Most likely, the only phagotrophic creatures that can survive indefinitely without oxygen are protozoa [33,34]

Salinity: Another significant element that affects the presence of protozoa in a particular body of water is the chemical composition of the water [35]. Many species that live in freshwater are generally prevented from existing in seawater due to the presence of salt chloride. However, several species have been reported to exist in brackish or saltwater as well as freshwater [21]. Wetness: Protozoa may grow in a broad range of wet environments. Due to their susceptibility to desiccation, protozoa require moisture in order to survive [36]. The reason behind their extreme susceptibility to physical and chemical conditions is that numerous protozoa have particular needs concerning the properties of the medium in which they reside, including the amount of dissolved organic matter, temperature, pH, electric conductivity, and concentration of dissolved oxygen [37], [38]. Among these features, the amount of dissolved oxygen and organic matter in the water establish pollution zones linked to specific species of protozoan indicators [39]. The number of well-described flagellate species has rapidly increased in various prior investigations, particularly those conducted in brackish and marine waters [40]. The majority of these flagellate species seem to be widespread in marine habitats; they can be found in both sea water and sediments [41].

2. FUNCTIONAL ROLES OF FREE-LIVING PROTOZOA

Protozoa are significant and essential elements of aquatic ecosystems. Generally speaking, protozoa comprise autotrophic and heterotrophic flagellates, amoeba, and ciliates. In aquatic food webs, these species are essential to the food web and the cycling of minerals [42]. Due to their worldwide range, small size, quick generation periods, short life cycles, significant species diversity, and ability to adapt quickly to environmental changes [43], [44.[

1. Protozoa are the principal consumers of the immense natural resource of bacteria and other microorganism, most prey items will be others, usually smaller microbes; they have the ability to manage the microbial communities they feed on and quickly reach enormous population levels. [45], [46.[
2. -Importance of protozoa as bioindicators for pollution and environmental biomonitoring has been recognized since long particularly in water purification plants and in activated sludge processes [47.[
3. -Protozoa are ubiquitous and abundant in aquatic environments, which has led to their identification as a crucial component of the intricate processes of microbial interactions. They can still be utilized as bioindicators or

biomonitors of pollution since they actively participate in vital food webs, the mineralization of nutrients, and the regulation of bacterial development [48.[

4. Many protozoa live epibiotically on the surface of other animals and plants, usually using these organisms only as a support, stalked peritrich ciliates provide an excellent example of this mode of life on both fresh and marine water habitats. There are even epizoic peritrichs living on gills of terrestrial woodlice. A number of such epizoic forms have made the transition to parasitism. Some forms may be seen among the gills in the mantle cavity of bivalve molluscs. Trichodina is a mobiline harmless epizoic peritrich in the urinary bladder of frogs and some fish; so they live as endoparasites. There are some (few) dinoflagellates and amoebae following this mode of life. [45], [47].

2.1 Protozoan diversity and abundance

They live in a wide variety of moist habitats including fresh water, marine environments and the soil, Protozoa range in size from microscopic to macroscopic organisms,Protozoa are the most abundant phagotrophs in biosphere, consists more than 83,000 global total species, but no scientific strategy has emerged that might allow accurate definition of the dimensions of protozoan diversity on a global scale [49 .[

While [50] estimate that the overall world number of living protozoa nonfossil reach 100,000 could well prove to be a gross underestimate that the majority of ciliate species had likely already been discovered in the majority of the more frequently studied habitats, such as rivers and ponds. The same author reported about 732 ciliate species in 1998, 377 of which were from fresh water. They also noted that many habitats remained unexplored and that many taxonomic revisions were necessary [51]. Since protozoa lack logometray organs, they are typically much smaller and more challenging to work with. In ecological investigations, taxonomic determination of these organisms has rarely been attempted [49].For ecological study and the preservation of biodiversity, measuring species diversity is essential. Numerous metrics have been put forth in the ecological literature to evaluate species diversity based on information about the existence or abundance of species [52].The quantity of species in a sample is referred to as its species richness. The simplest and most widely used diversity metric is species richness. However, because of the species-area link [53] and the complexity of getting accurate species lists [54], estimations of species richness are infamously sensitive to scale .Controlling the area is a crucial first step in analyzing spatial patterns in richness because the two issues are closely related: the number of species observed generally increases with the number of individuals sampled, and the number of individuals increases with the size of sampling unit [55], [56]. It is often acknowledged that stress reduces an aquatic community's species richness and variety [10]. However, excessive stress, whether caused by high levels of organic pollutants, heavy metals, or sudden changes in temperature or pH, tends to decrease the species richness of the community and raise the individual abundance of tolerant forms. [57]. Low levels of nutrient enrichment in microbial communities are generally associated with an increase in the number of extant protozoan species. Of the 34 phyla of protozoa classified by [58]..

3. CLASSIFICATION OF THE PROTOZOA

Classification of protozoa based on locomotary organs. Locomotion is a process attained in the presence of certain organelles of locomotion. These organelles may be temporary formed as pseudopodia or permanent as flagella and cilia. Some protozoa perform a gliding movement without the aid of any locomotor organelles, (Table 2), [17]
There are four processes that cause amoeboid mobility (figure 1) [17]

Affixation to the supporting material. 2. The anterior end of the plasmasol gels. 3. The posterior end of the plasmagel is where it solates.4. The posterior end of the plasmagel contracts.

While, if the flagellate organism has more than one flagellum ex: Monas, only one is responsible for locomotion, while the others will serve for obtaining food, sensory or for attachment. The flagellum possesses minute lateral projections called mastigonemes which aid the locomotion. The flagellum propagates an undulating wave from base to tip (figure 1). These waves increase in amplitude and velocity from base to tip. Such an activity of the flagellum causes the body of Euglena to rotate about its axis, at about one complete body turn. Per second and make a corkscrew pathway through water. Euglena is able to change its direction by the action of contractile myonemes which are located just beneath the pellicle the well-coordinated movement of numerous cilia produces rapid movement. The organized movements of cilia, cirri and membranelles also undulating membranes are probably controlled by neuromotor or silver line system. (Figure 1). The ciliary movement is constructed as follows: 1- The longitudinal fibrils are connected to the kinetosomes . 2- The body rotates because the cilia are arranged in oblique diagonal rows; this will force the animal to roll over its left side. 3- The spiral nature of the movement is caused by the cilia around the oral groove which beat more strongly than the body cilia. The result the animal can move forwards in a straight line in a rotating manner. Paramecium can swim backwards when the cilia beat forwards [17].

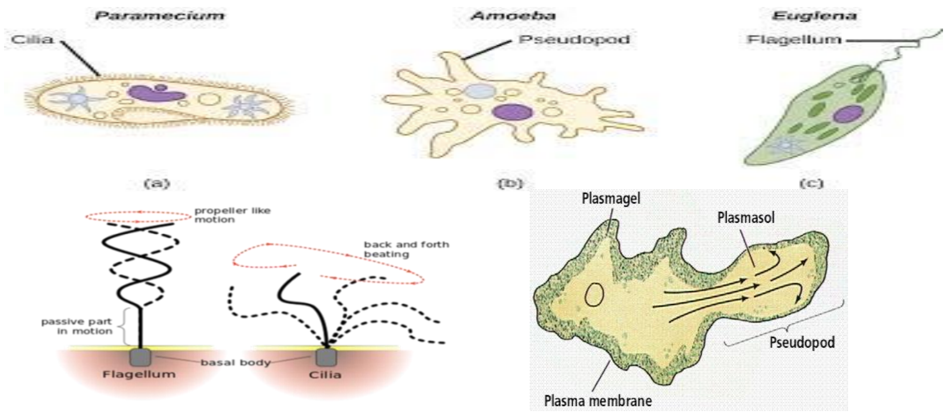
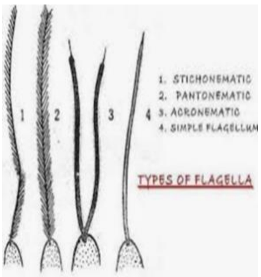
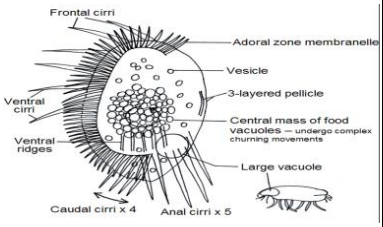
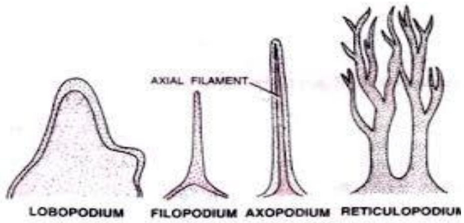


FIGURE 1. locomotary organs [17]

Table (2) locomotary organs [17]

locomotary organs		
Flagella	**Cilia**	**Pseudopodia**
Flagella are divided into four types by the arrangement of <u>Mastigonemes</u> on the flagellum.(Mastigonemes are lateral "hairs" on the flagella. It is believed that they assist in locomotion by reversing the thrust caused when a flagellum beats). 1. The Stichonematic flagellum : has one row of mastigonemes . Ex : *Euglena* 2. The Pantonematic : has two rows of hairs or mastigonemes . 3. Acronematic: Flagellum has no hairs, it ends with a fine filament. Ex: *Chlatnydomonas.* 4. The Simple: This flagellum will not show hairs or end in fibre. Ex : *Dinoflagellates*[17]	The cilium was the move organelles found in the Ciliophora and Opalinata . They function as tactile organelles and aid in food digestion. There are several, short, and fine cilium. They could vary in length, getting longer near the edges of particular regions. The cilia can be placed on ridges or in furrows and organized longitudinally, obliquely, transversely, or in spiral rows. A kinetosome implanted in the ectoplasm gives rise to a cilium. The structure of cilia is similar to that of flagella; in the Hypotrichida, cilia are substituted with cilia. In certain species, both exist. Cirrus is made up of many cilia organized in two or three rows that combine to form a single structure. The cilia are confined to the dorsal surface while the cirri to the ventral surface. The cirri may be arranged in groups on certain areas of the body as frontal, ventral, marginal and caudal cirri (Euplotes). Cilia different from that cirri can move in any direction, so that the organism shows various types of locomotion. <u>The Memberanella</u> is a double ciliary lamella fused completely into a plate. They are usually found along	A pseudopodium is a temporary extension projection of part of the cytoplas, found in protozoa which do not possess a rigid pellicle. Pseudopodia are therefore a characteristic organelle for locomotion in Sarcodina, many Mastigophora and other groups which are devoid of pellicle. According to their form and structure , <u>they are usually distinguished into four kinds</u> : <u>1-</u> Lobopodium: Created by the endoplasmic flow projecting from the ectoplasm. Its distal end is rounded, and it resembles a finger or tongue. It can occasionally branch. It is retarded and quickly stretched. When there are multiple pseudopodiums (Amoeba) present, the larger one will frequently lead the smaller ones, causing the organism to go in a single direction. There might just be one pseudopodium (*Pelomyxa*) in other varieties. However the function of all pseudopodia is the general flow of cytoplasm 2- Filopodium: It is almost a filamentous projection formed of ectoplasm: sometimes has branched, but do not anastomose. Many testaceans form this type (Arcella & Difflugia) . <u>3- Rhizopodium</u>: It is also filamentous but branches anastomose forming a large network which serves in capturing preys together with movement. In certain Testacida and all Foraminiferida this type of pseudopodia is common

	the peristom forming Adoralzone (AZM) serving for bringing food to the cytostome [17]. 	4- Axopdium : Unlike the former three types , it is composed of an axial rod covered with cytoplasmic envelop . Axopodia are formed in many Heliozoida (Actinosphaerium) . The axial rod is formed of a number of fibrils that arise from the central part of the body. Although semi - permanent in structure, the axial rod can be easily absorbed and reformed. The axial rod fibrils are arranged lengthwise; enter deep through the endoplasm and end near the nucleus. Since there are transitional pseudopodia between any two of the four forms of pseudopodia, there is no clear distinction between them. An individual's pseudopodia often have distinctive morphologies, although they can also take on various appearances at different times. for example, the *limax amoeba* changes the shapes of pseudopdium when expoures to chemicals material. [17] 

The first use of Protozoa as a taxon of major rank is credited to Golfuss [17]., modified later by Van Siebold [17]. To include only "one - celled animals". Until recently, it was popular to call the Protozoa as phylum of animals [41]. It was now popular to place Protozoa as a phylum or subkingdom in the kingdom Protista. Protozoans are important organisms in the web of life on Earth. The Protozoa are essentially single-celled eukaryotic organisms. (Table 3). While [52]. Suggested that the bases for classification of protozoa are:

(1) Morphological characteristics these consist of: (a) locomotion-related organelles; (b) the body's size, shape, and composition. (c) Attachment organelles to substrata; (d) colonial organization; (e) superficial or pellicular differentiation; (f) subpellicular bodies and fibrillar systems; (g) feeding organelles; (h) cytoplasmic inclusions and internal differentiation; and (i) nuclear characteristics.

(2) Non-morphological characteristics; Examples include: (a) the ecological assessment of free-living forms; (b) the host-parasite dynamics of symbiotic forms; (c) general physiological characteristics; (d) biochemical and serological characteristics; (e) pigments, coloration in general, distinctive food reserves; and (f) morphogenetic features: consideration of entire life cycles (g) Phylogenetic considerations and genetic factors. The 14 phyla that make up the kingdom Protozoa Gold fuss, 1818, together with the authorships and dates of their names, together with a breakdown of the types and quantities of protists that are included in each phyletic taxon based on condensed characterisation data from [60], [61], [62].

Table (3) phyla of protozoa [17], [63], [64]

Phyla	Description
Mastigophora	• Members of the category are commonly referred to as flagellates. • The majority of the around 1,500 species are unicellular heterotrophic protozoans of the kingdom Protista, driven by one or more flagella. • A few people have pseudopodia. • Sexual reproduction in certain species occurs by a process known as syngamy, which is the fusing of two gametes created after meiosis. • Asexual reproduction occurs by equal longitudinal, binary, or repetitive fission. Certain parasitic members of the Mastigophora are the organisms that cause illness in both humans and other animals. Divided into the two classes. Class: Phytomastigophorea Usually containing chloroplasts; in the event that they are absent, the link to pigmented forms is evident, and they are primarily free-living. Divided into orders of which : 1-Order: Cryptomonadida ex: *Chryptomonas*, *Chilomonas*. -2-Order: Dinoflagellida ex: Ceratium, Gymnodinium, Noctiluca. -3Order: Euglenida ex: Euglena, *Astasia, Copromonas*. -4Order: Chrysomonadida ex: *Chrysamoeba, Dinobryon*; Synura. 5- Order: Volvocida ex: Volvox, Chlamydomonas, Gonium. Class: Zoomastigophorea Chloroplasts absent; have one to many flagella; amoeboid forms (in some groups); sexuality known in some groups. Divided into orders of which : 1- Order: Choanoflagellida ex: *Monosiga*, *Codosiga*. 2 -Order: Retortomonadida ex: *Chilomastix*, *Retortomonas*. 3 -Order: Trichomonadida ex: *Trichomonas*. 4 -Order: Diplomonadida ex: *Hexamita*, *Giardia*. 5 -Order: Rhizomastigida ex: *Mastigamoeba*, *Histomonas*. 6- Order: Hypermastigida ex: *Trichonympha*..
Sarcodina	are heterotropic protozoans lacking permanent locomotive organelles like cilia or flagella. To move and to catch prey, they use transient cellular extensions, pseudopods . Protozoa that form pseudopodia in their trophic states. Flagella when present usually limited to developmental stages. Body naked or with external test or internal skeleton. •Asexual reproduction by binary fission; Sexual if present associated with gametes . •The key-stone in the classification of the group is the type of pseudopodia produced. •According to their shape and organization they are: lobopods, filopods, rhizo- or reticulopods and axopods. Which divided to: A: Superclass: Rhizopoda Pseudopodia are lobopodia, filopodia or reticulopodia or by protoplasmic flow without production of pseudopodia. : Class: Lobosea • Pseudopods lobose to more or less filiform, produced from a broader, usually hyaline lobe • Usually uninucleate; while multinucleate forms are not much-represented.

	• Lobosea are usually called "amoebas" their bodies are either naked or housed in a flexible to firmer, secreted covering (Tectum or test). • Almost any water in nature, if it contains some vegetable material or bottom debris, and preferably a little or each, may contain a few to many amoebas, even if the water may be somewhat polluted. They occur, too, in surface films of fresh and marine waters, Great numbers of certain species live in surface-soils, even of desert. • Some species can live in the digestive tracts or wounds of animals , or as facultative parasites in almost any tissue of the mammalian body. The class is divided into two subclasses: a- Subclass: Gymnamoeba b- Subclass: estacealobosia
Ciliophora	This is the largest and most homogeneous of the major protozoan groups with at least more than 10,000 species. Members of this phylum possess cilia, the ciliary structures which serves as organelles of locomotion and feeding. A cytostome and cytopharynx are mostly present.Nuclei are heterokaryotic i.e. formed of two types: vegetative macronuclei, capable of synthesizing RNA and DNA and reproductive micronuclei concerned with the synthesis of DNA only. Macro and micronuclei are present in all ciliates without exception. • Nutrition is holozoic or saprozoic. Asexual reproduction is by binary fission or budding, and sexual reproduction is by conjugation or autogamy in which micronuclei play an important role.The majority are free living, but some groups include ecto and endoparasites of invertebrates and vertebrates (Amphibia and fish). *Balantidium coli* is the only ciliate parasitic in humans • . Class 1: Kinetofragminophorea Body ciliature generally holotrichous. Cytostome is apical or sub apical, sometimes replaced by suctorial tentacles. Classified to 4 subclasses Subclass 1: Gymnostomata Chiefly large with uniform somatic ciliature, but sometimes limited to certain areas only. Order: Haptorida Active predators on small organisms, somatic ciliature reduced, ex: *Didinium* which eats Paramecium. Subclass II: Vestibulifera Cytostome-cytopharyngeal apparatus preceded by a vestibule lined with cilia. Order 1: Trichostomatida Somatic ciliature typically uniform, no buccal ciliaturee, but the mouth does not open at the surface, it sinks to the base of a vestibule parasites in the alimentary canal of invertebrates and vertebrates. *Balantidium coli* in the intestine. It infects man causing balantidiosis. Order 2: Colpodida Vestibular cilia highly organized. Many live in soil, some are symbionts in terrestrial moluscs ex: *Colpoda* Subclass III: Hypostomata Body dorsoventrally flattened with cilia only on ventral surface. 6 orders of free living or ecto- or endocommensals of invertebrates or ectoparasites on the gills of fish or aquatic molluscs. An example of this subclass is the order Cryptophorida, Order: Cryptophorida Many freshwater and marine species, ex: Chilodonella common in stagnant freshwater. Also it may be found as an ectoparasite on freshwater fish. Subclass IV: Suctoria Mainly marine. Mature stages without external ciliature, typically sessile forms attached by a non-contractile stalk. Food is delivered by two types of tentacles—one with a suctorial function and the other with a piercing function—instead of a cytostome. Order: Suctorida ex: *Ephelota* Class 2: Oligohymenophorea Somatic ciliarure may be absent, when present it is uniform row covering much of the body, buccal ciliature distinct Colony formation is common in some. Divided into 2 subclasses:

	Subclass I: Hymenostomata Order: Hymenostomatida Small ciliates, with uniform body cilia, ex. *Paramecium*, *Tetrahymena* which is an ectoparasite on fish causing fatal disease. *Colpidium* and *Glaucoma* in freshwater ponds. Subclass II-Peritricha Fixed ciliates, cilia reduced over the body, but very prominent on oral pole; includes one order. Order: Peritrichida have two suborders: 1- .Mobilina: Free swimming 2-Sessilina: Attached to submerged objects, lacking body ciliature, with buccal ciliature e.g. *Trichodina* which is disc shaped parasite of fish, frogs. *Episltyll*s colonial, stalked ectoparasites on gills of fish and some mollusks, crayfish. Vorticella, solitary and stalked Class 3: Polyhymenophorea Body cilia reduced and replaced by cirri . Subclass: Spirotricha Order 1: Heterotrichida Often very large, highly contractile, with uniform dense body cilialure and cirri. Ex: Stentor, Spirostomun, Belpharisma, Nyctotherus which is an endocommensal in intestine of many invertebrates. and vertebrates including frogs, toads and cockroaches. Order 2: Hypotrichida Simple cilia absent. Cirri are characteristic, present in definite arrangement according to their location as: 8-9 frontal cirri, 5 ventral cirri, 5 anal cirri, 3 or 4 short caudal cirri and marginal cirri on both sides. Body dorsoventrally flattened, they are marine or freshwater free living. Ex: *Stylonychia* show typical arrangement of cirri and with bi-lobed macronucleus. *Euplote*s the cirri are reduced and a horse-shoe shaped macronucleus.
Apicomplexa	•All Apicomplexa are parasites and some of them are important as disease agents. Malaria is the most important disease of man; coccidiosis causes heavy losses in domestic animals and Piroplasms kill many domestic animals in many countries, while the gregarines may become biological control agents for disease vectors. •The name Apicomplexa is derived from the fact that the interior end of certain stages shows a group of structures named as the apical complex . •Apicomplexa gathers several species of obligate intracellular protozoan parasites classified as Sporozoa or Sporozoans, because they form reproductive cells known as spores. •The Apicomplexa lack locomotory organelles, but some species presenting only gliding movements are exhibited. Cilia are absent and flagella may appear only in the male gametes of some species. Nutrition is osmotrophic, the storage products appear to be lipids and glycogen, complex life cycle with sexual and asexual generations. Divided to: Subclass I: Gregarinasina (Gregarinia) Ex: Monocystis spp. Subclass II: Coccidiasina (Coccidia)Order: Eucoccidiorida

4. WHERE IS PROTOZOA FOUND?

Everywhere they are discovered, protozoa are ubiquitous; their cysts can be found in even the most hostile regions of the biosphere. Protozoa can be found in any watery or moist habitats [17]. They consume bacteria, algae, and other protozoa and are mostly free-living. Some colored species live as mutualistic "Zooxanthellae". Ceratium hirundinella is both photo-and phagotrophic in fresh and salt waters Noctiluca is completely phagotrophic. It is large specie; with thick pellicle, one vestigial flagellum and a long thick cross striated tentacle which assists in locomotion and feeding. It has a cytostome that can ingest even small larvae Noctiluca species are bioluminescent. Bioluminescence on the surface of the sea is largely due to Dinoflogellates, especially Noctiluca. This is due to the oxidation of lipids, proteins resulting in brief flashes. [65[

Under certain conditions dinoflagellates increase in number in certain sea causing "red-tide" and luminescence at night. Sometimes this is accompanied by the death of fish and marine birds in huge numbers. Sometimes certain species of colonial chrysomonads become too numerous in water stored in reservoirs and makes it unsuitable for drinking. This is due to the odors of the aromatic oils produced by these organisms and liberated from their bodies when they die. The oils of Dinobryon have a fishy odor, while that of Synura has an odor that resembles ripe cucumbers and bitter and spicy taste, many are solitary, ex. Chlamydomonas. Haematococcus which is red and produce the phenomenon of "red rain" by it sudden appearance in rain pools The family volvocidae is well known by its colonial forms ex. Gonium (discoid) Pandorina and Volvox (spheroid). Sexual reproduction (isogamous and anisogamous) is common. - Order: Trichomonadida [17.[

Living in the alimentary tract of their hosts. Flagella 2-6 one directed posteriorly and may be attached by an undulating membrane, Axostyle and parabasal apparatus. Cysts unknown, infection takes place by the ingestion of trophozoites. Three species of Trichomonas infect man: T tenax in the mouth, T. hominis in the intestine (Both are nonpathogenic) and T. vaginalis in the genital system causing inflammation. Order: Diplomonadida Flagella 8, body bilaterally symmetrical, with 2 nucleus. They occure in the hosts alimentary tract. Some free living, ex: Hexamita which may occur in rich waters. Hexamita may also occur in intestine of some vertebrates other than man and insects. The best well known species Giardia lambia in the small intestine of man causing Giardiasis. Order: Hypermastigida: Live in intestine of cockroaches. They have many flagella and branched or multiple parabasal bodies. The most highly complicated of all flagellates. Phagotrophic and some digest cellulose and therefore bear mutualistic relations with their insect hosts, ex: Trichonympha in termites and Lophomonas in cockroaches This zooflagellate occurs as a symbiotic in the intestine of the termites. Trichonympha secretes cellulose digesting enzymes β-glucosidases which convert cellulose into glucose. The digested food is shared by the termite. Without Trichonympha the termites starve and die. Sub-order: Bodonina [17.[

Flagella typically two, unequal, one trailing. Free-living examples as Bodo in stagnant waters. Cryptobia (=Trypanoplasma) has its trailing flagellum attached to an undulating membrane; many species are found in the blood of fish and transmitted by leeches. Tryponosomatin, the sub-order, has a single flagellum that can be free or linked to an undulating membrane. All parasitic forms are included in the family Trypanosomatidae, having polymorphic members with four chief life-cycle stages: amastigote (leishmanial), promastigote (leptomonad), epimastigote (crithedial), trypomastigote (trypanosomal). During its life cycle, each genus of the family is characteristically passes by two or more of these morphological stages. The genus Trypanosoma and Leishmania are the important species Family: Plasmodidae: This family contains the genus Plasmodium, which cause malaria in man, lower primates, birds and other animals. The genus Plasmodium is divided in a number of sub-genera and includes the true malaria parasites, There are about 155 species mostly in primates, rodents, birds and reptiles. The known vectors are mosquitoes Four species (P. falciparum, P. vivax, P. malariae and P. ovale) cause malaria in man which is the most important human disease in the world, causing l50 million cases and 1 to 5 million deaths each year. Family: Sarcocyctidae: The members of this family are heteroxenous, with asexual multiplication in a prey (intermediate host) and sexual reproduction in a predator (definitive host) which eats the intermediate host, all members of the family have oocysts in the predator host, they resemble those of Isospora with 2 sporocysts, each 4 sporozoites. Toxoplasma gondii is common, widely infecting mammals (man) Sarcocystis parasite of skeletal and cardiac muscles in cattle, sheep, horses, rodents and man; less frequently in birds and reptiles. The parasite develops large cysts whose walls contain several layers of muscles. The cysts are divided into chambers called trabiculae which contain a number of sporozoites. [17], [65], [66].

5. SAMPLE PROCESSING AND INVESTIGATION

5.1 Water samples

From each collecting water sample one milliliter was investigated within 5-48 hours [67] by direct observation for counting and identification of protozoans, Using a compound microscope with a magnification of (X10–X40), a 0.1 milliliter water drop was placed on a microscope slide, covered with a cover glass, and studied. Free living protozoa observed in each examined slide were counted by direct methods for counting active testate amoebae, ciliates and flagellates proposed by [68], the shape, structure, measurement and movement organelles were recorded for classification following [1], [21]. specimens were examined alive [67], sometimes methyl cellulose (2-10%) was used 24hr before examination for slowing down the movement of fast moving ciliates [68] and also In order to identify peripheral organelles and as a killing agent, Lugol's solution was added [69]. Ocular micrometer was used for specimens measuring. The calculation of protozoa was performed by using haemocytometer chamber slide

5.2 Sediment samples

Sediment samples were investigated by direct approaches for observation and counting active testate amoebae, ciliates and flagellates in sediment suspension [53] , Ten milliliters of distilled water were added to a small beaker along with five grams of sediment sample from each sample, which was then carefully mixed using a spatula. One milliliter of sediment suspension per sample was investigated for protozoan counting and pre-identification using the same protocol as described for the study of water samples. A little suspension was put into a sterilized test tube and centrifuged at 1500 r.p.m. for 10 minutes.

6. PROTOZOA IN IRAQ

There are no studies on protozoa, In her study on the Tigris River, she referred to protozoa [13], [14]. The only study that dealt with the diversity and ecology of protozoa wasThe protozoa community of the water and sediment at Tigris river bank in Baghdad city was studied from January to October 2012, (table 4)A total of 180 samples have been collected at monthly interval of 9 samples from each of the water surface and soil at the east bank of river Tigris at three sites in Baghdad., During the study period total of 115 protozoan taxa were recorded from the water and sediment samples through microscopic examination for live specimens, most of these taxa were considered to be new records to Iraqi protozoan's communities. From the water 112 taxa were extracted, 63 of cilites, 25 of flagellates and 24 of sarcodines).While 22 taxa were extracted from the sediment (Table5), (12 of ciliates and 5 of each flagellates and sarcodines,The mean population density in the water was 117216.7 ind/L-1, of ,these 1601140, 1083760 and 846750 ind /L-1 were counted from sites 1, 2 and 3 respectively.The mean indices of diversity in the water were ranged from 8.948 at S2 during October and 0.268 at S1 during January.The ciliata comprised the main group in the both habitat (water and sediment). Dominant protozoan species of water were Aspidisca sp ,Cinetochilum sp., Coleps hirtus, Cyclidium sp. of ciliata and Pseudochlamys patella of sarcodina,Among the 22 protozoan taxa recorded from the sediment three ,protozoan taxa (Pleuronema marinum, Pleuronema setigera, Uronema marinum) were recorded from the sediment only, while the remaining 19 species were found in the both habitat (water and sediment) [70].

Table 4: List of protozoan taxa found in the Water of Tigris River [70]

PROTOZOA TAXA		
Ciliata	**Flagellata**	**Sarcodina**
Metopus es Müller,1786	Ceratum hirundinella (Müller) Dujardin, 1841	Actinophrys sol Ehrenberg,1830
Colpoda maupasi Enriques, 1908	Glenodinium sp. Ehrenberg,1837	ctinosphaerium eichhornii Ehrenberg,1840
Stentor coeruleus Ehrenberg, 1830	Anisonema acinus Dujardin, 1841	Choanocystis aculata Hertwig & Lesser, 1874
Stentor niger Müller, 1773	Euglena acus Ehrenberg,1830	Heterophrys sp. Archer,1869
Stentor polymorphus Müller, 1773	Euglena anabena Mainx, 1928	Trichomoeba villosa Wallich , 1863
Spirostomum sp. Ehrenberg, 1833	Euglena clavata Skuja, 1948	Polychaos sp. Schaeffer,1926
Spirostomum ambiguum Ehrenberg 1835	Euglena caudate Hübner, 1886	Striamoeba striata Penard, 1890
Spirostomum minus Roux, 1901	Euglena ehrinbergii Klebs, 1883	Discamoeba sp. Jahn,Bovee & Graffith,1979
Blepharisma sp. Perty,1849	Euglena oxyuris Schmarda, 1846	Rosculus sp. Hawes,1963
Parablepharisma sp. Kahl	Euglena pisciformis Klebs, 1883	Korotnevella sp. Goodkov,1988
Loxodes magnus Stokes, 1887	Euglena sociabilis Dangeard , 1901	Mayorella sp. Schaeffer,1926
Acineta sp. Ehrenberg,1834	Euglena texta Hübner, 1886	Cochliopodium sp. Hetwig & Lesser,1874
Homalozoon sp. Stokes,1890	Euglena viridis Ehrenberg,1830	Arcella sp. Ehrenberg,1832

Lacrymaria olar Müller,1786	Phacus longicauda)Ehrenberg) Dujardin, 1841	Difflugia sp. Leclerc,1815
Trachelophyllum sp. Claperède & Lachmann 1859	Phacus pleuronectes)Müller) Dujardin, 1841	Difflugia bipes
Cranotheridium taeniatum Schewiakoff, 1893	Phacus torta (Lemmermann) Skvortsov, 1928	Centropyxis aculata Ehrenberg,1830
Amphileptus sp. Ehrenberg, 1832	Peranema trichophorum Ehrenberg,1838	Centropyxis ecornis Ehrenberg,1841
Litonotus sp. Wrzesniowski,1870	Heteronema acus Ehrenberg,1830	Nebela sp. Leidy,1874
Pseudomicrothorax sp. Mermod, 1914	Mastigamoeba sp. Schulze,1875	Nuclearia sp. Cienkowski,1865
Cyclogramma sp.	Pyramimonas tetrahynchus Schmarda,1849	Plagiophrys sp. Claperède & Lachmann,1858
Frontonia sp. Ehrenberg, 1838	Bodo sp. Ehrenberg,1830	Euglypha sp. Dujardin,1841
Paramecium multimicronucleatum Powers& Mitchell,1910	Chilomonas paramecium	Pelomyxa sp. Greeff,1874
Paramecium aurelia Ehrenberg1838 ,	Ehrenberg,1838	Pseudochlamys patella Claperède & Lachmann
Paramecium caudatum Ehrenberg ,1833	Anthophysis vagitans Müller	Amoeba radiosa Ehrenberg
Paramecium bursaria Ehrenberg 1831 ,	Pandorina morum Müller, 1783	
Cyclidium sp. Müller, 1773	Volvex sp. Linnaeus,1758	
Cinetochilum sp. Perty,1849		
Cothurnia minutum		
Thuricola sp. Kent, 1881		
Pyxicola affinis Kent, 1882		
Vaginicola sp. Lamarck,1816		
Carchesium sp. Ehrenberg, 1830		
Vortecilla sp. Linnaeus,1767		
Vortecilla campanula Ehrenberg1831 ,		
Vortecilla microstoma Ehrenberg1830 ,		
Vortecilla picta Ehrenberg,1833		
Orbopercularia sp. Lust,1950		
Propyxidium sp. Corliss,1979		

Ophrydium sp. Vincent,1827
Ophrydiopsis sp. Penard,1922
Epistylis sp. Ehrenberg,1830
Podophrya fixa Müller, 1786
Sphaerophrya sp. Claperède & Lachmann 1859
Trichophrya columbiae Wailes
Chilodonella sp. Strand,1928
Phascololodon vorticella Stein1859 ,
Phascololodon sp. Stein,1859
Coleps hirtus Müller,1786
Prorodon sp. Ehrenberg,1833
Pseudoprorodon sp. Blochmann1886 ,
Halteria sp. Dujardin,1841
Claperède & Lachmann 1859
Uroleptus limnetis Stokes, 1885
Oxytricha sp. Bory,1825
Steinia sp. Diesing,1866
Stylonychia sp. Ehrenberg,1830
Strombidium sp
Urosoma caudatum Ehrenberg,1833
Stichotricha intermedia Froud1949 ,
. Spiretella sp. Borror,1972
Aspidisca sp. Ehrenberg,1830
Euplotes sp. Ehrenberg,1830

Table 5: List of protozoan taxa found in the sediment of Tigris River [70].

Protozoa taxa		
Ciliate		Sarcodina
Pleuronema marinum Dujardin,1836	Euglena ehrinbergii Klebs, 1883	Amoeba radiosa Ehrenberg
Pleuronema setigerum Calkins, 1903	Euglena acus Ehrenberg,1830	Actinophrys sol Ehrenberg,1830

Cyclidium sp. Müller, 1773	Euglena sociabilis Dangeard, 1901	Pseudochlamys patella Claperède & Lachmann
Uronema marinum Dujardin,1841	Peranema trichophorum Ehrenberg,1838	Difflugia sp. Leclerc,1815
Cinetochilum sp. Perty,1849	Bodo sp. Ehrenberg,1830	Rosculus sp. Hawes,1963
Stylonychia sp. Ehrenberg,1830		
Aspidisca sp. Ehrenberg,1830		
Oxytricha sp. Bory,1825		
Strombidium sp. Claperède & Lachmann, 1859		
Colpoda maupasi Enriques, 1908		
Euplotes sp. Ehrenberg,1830		
Parablepharisma sp. Kahl		

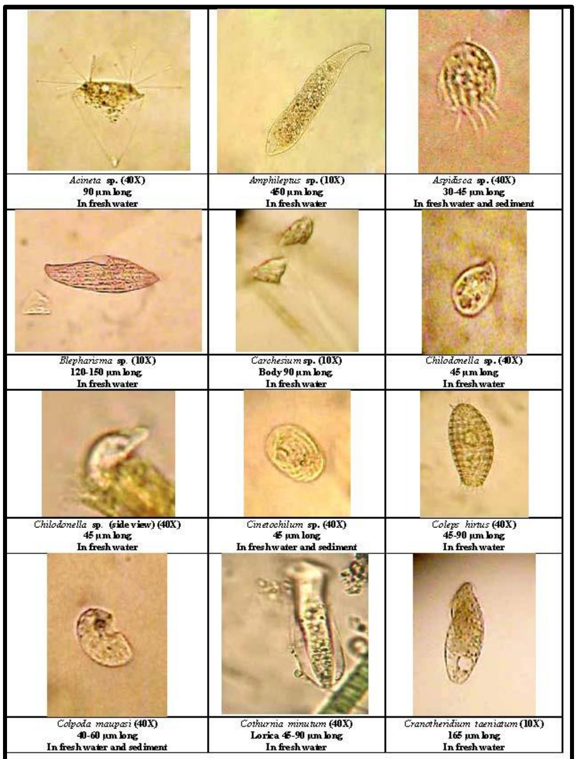
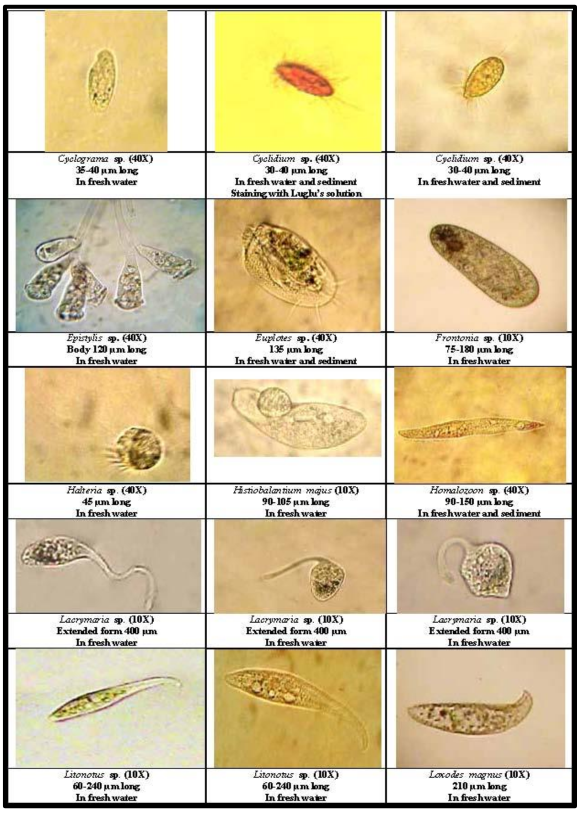
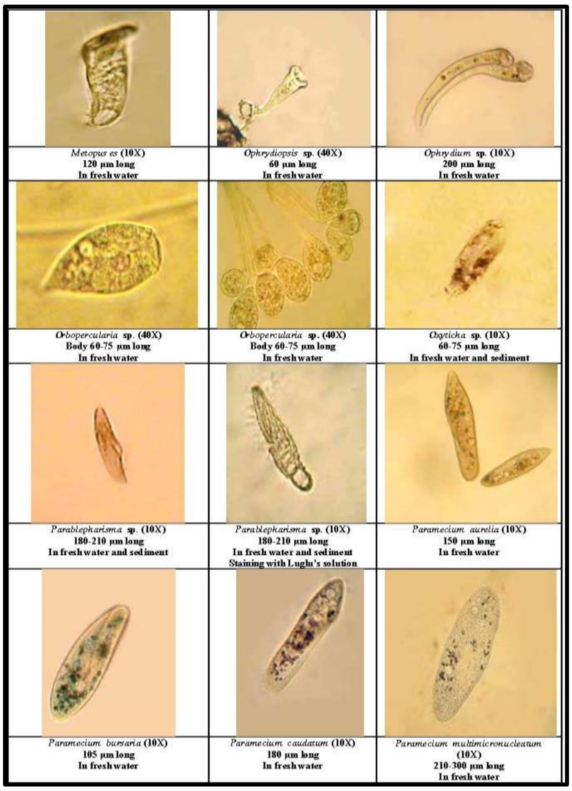


Plate A-1: Ciliata in fresh water and sediment, photo by Zahraa Yehia





Metopus es (10X) 120 µm long In fresh water

Ophrydiopsis sp. (40X) 60 µm long In fresh water

Ophrydium sp. (10X) 200 µm long In fresh water

Orbopercularia sp. (40X) Body 60-75 µm long In fresh water

Orbopercularia sp. (40X) Body 60-75 µm long In fresh water

Oxyticha sp. (10X) 60-75 µm long In fresh water and sediment

Parablepharisma sp. (10X) 180-210 µm long In fresh water and sediment

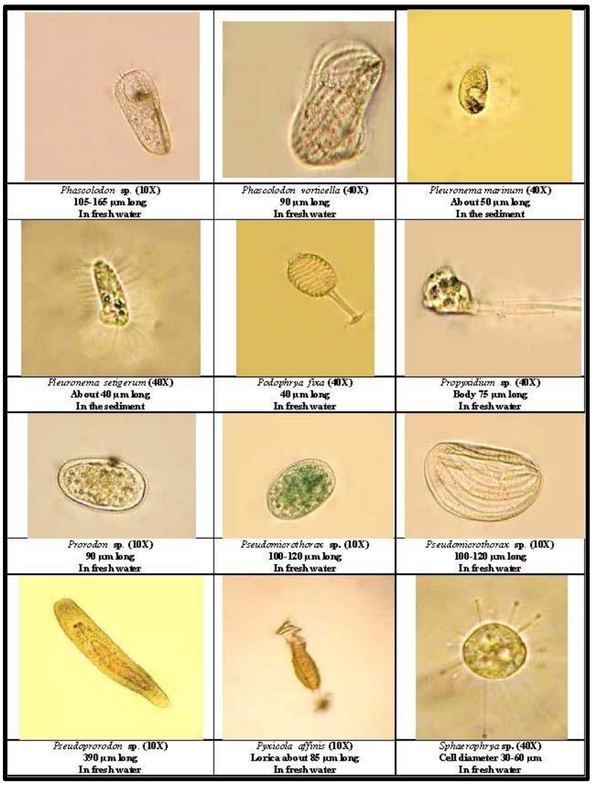
Parablepharisma sp. (10X) 180-210 µm long In fresh water and sediment Staining with Lughu's solution

Paramecium aurelia (10X) 150 µm long In fresh water

Paramecium bursaria (10X) 105 µm long In fresh water

Paramecium caudatum (10X) 180 µm long In fresh water

Paramecium multimicronucleatum (10X) 210-300 µm long In fresh water



Phascolodon sp. (10X) 105-165 µm long In fresh water

Phascolodon vorticella (40X) 90 µm long In fresh water

Pleuronema marinum (40X) About 50 µm long In the sediment

Pleuronema setigerum (40X) About 40 µm long In the sediment

Podophrya fixa (40X) 40 µm long In fresh water

Propyxidium sp. (40X) Body 75 µm long In fresh water

Prorodon sp. (10X) 90 µm long In fresh water

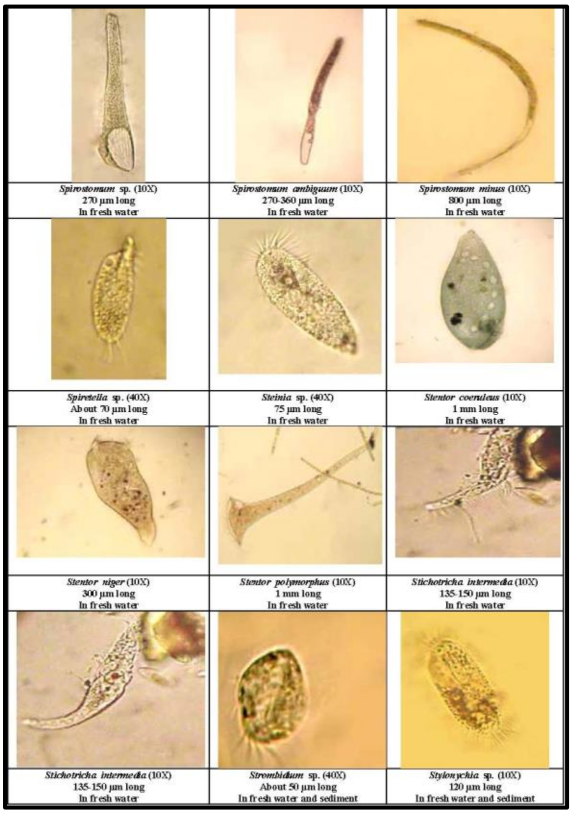
Pseudomicrothorax sp. (10X) 100-120 µm long In fresh water

Pseudomicrothorax sp. (10X) 100-120 µm long In fresh water

Pseudoprorodon sp. (10X) 390 µm long In fresh water

Pyxicola affinis (10X) Lorica about 85 µm long In fresh water

Sphaerophrya sp. (40X) Cell diameter 30-60 µm In fresh water



Spirostomum sp. (10X) 270 µm long In fresh water

Spirostomum ambiguum (10X) 270-360 µm long In fresh water

Spirostomum minus (10X) 800 µm long In fresh water

Spiretella sp. (40X) About 70 µm long In fresh water

Steinia sp. (40X) 75 µm long In fresh water

Stentor coeruleus (10X) 1 mm long In fresh water

Stentor niger (10X) 300 µm long In fresh water

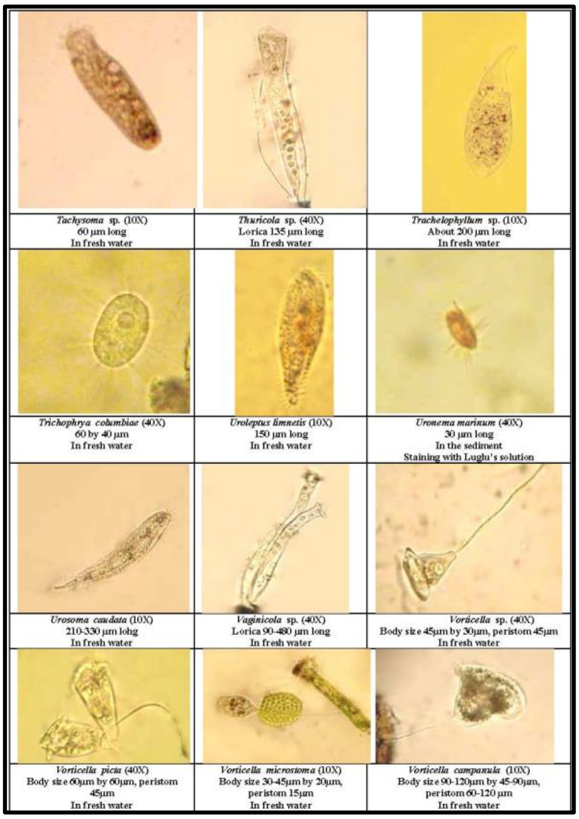
Stentor polymorphus (10X) 1 mm long In fresh water

Stichotricha intermedia (10X) 135-150 µm long In fresh water

Stichotricha intermedia (10X) 135-150 µm long In fresh water

Strombidium sp. (40X) About 50 µm long In fresh water and sediment

Stylonychia sp. (10X) 120 µm long In fresh water and sediment



Tachysoma sp. (10X) 60 µm long In fresh water

Thuricola sp. (40X) Lorica 135 µm long In fresh water

Trachelophyllum sp. (10X) About 200 µm long In fresh water

Trichophrya columbiae (40X) 60 by 40 µm In fresh water

Uroleptus limnetis (10X) 150 µm long In fresh water

Uronema marinum (40X) 30 µm long In the sediment Staining with Luglu's solution

Urosoma caudata (10X) 210-330 µm lohg In fresh water

Vaginicola sp. (40X) Lorica 90-480 µm long In fresh water

Vorticella sp. (40X) Body size 45µm by 30µm, peristom 45µm In fresh water

Vorticella picta (40X) Body size 60µm by 60µm, peristom 45µm In fresh water

Vorticella microstoma (10X) Body size 30-45µm by 20µm, peristom 15µm In fresh water

Vorticella campanula (10X) Body size 90-120µm by 45-90µm, peristom 60-120 µm In fresh water

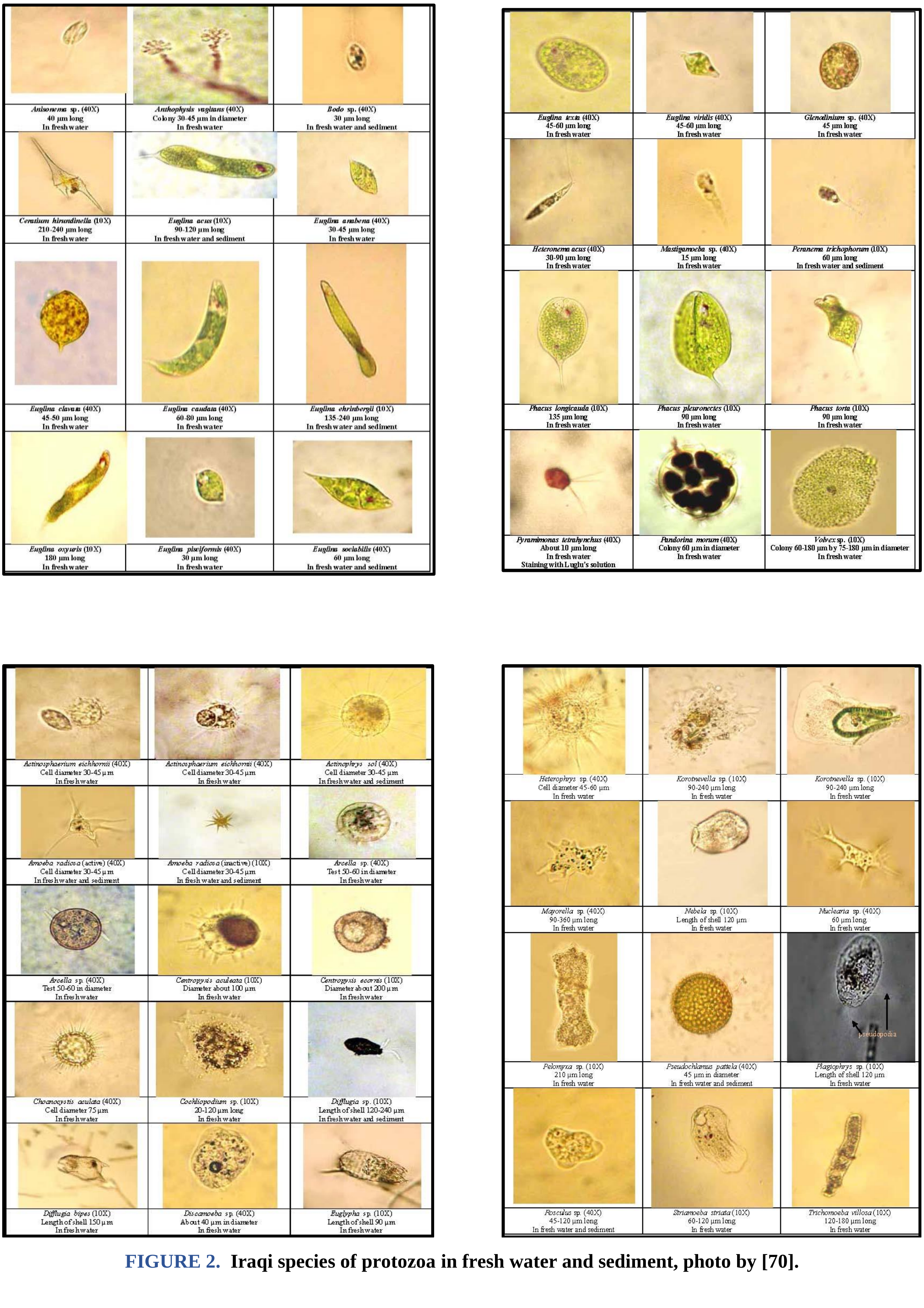


FIGURE 2. Iraqi species of protozoa in fresh water and sediment, photo by [70].

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