TLS
Trends in Life Sciences
An International Peer-Reviewed Journal

www.sciencejournal.in

DAMA INTERNATIONAL

MORPHOLOGICAL STUDY OF *PARAMECIUM CAUDATUM* FROM FRESH WATERS OF NASHIK DISTRICT OF MAHARASHTRA, INDIA

Bhamare S. N.*, Nikam S. V., Jadhav B. N.*** and Dama L.B.******

*Department of Zoology, K.R.A. College, Deola, Nashik, Maharashtra, (M.S.), India.

**Department of Zoology, Dr. Babasaheb Ambedkar Maharathwad University Aurangabad, (M.S.), India.

***Department of Zoology, Swami Muctanand College, Gangapur, Aurangabad (M.S.), India.

****Department of Zoology, D. B. F. Dayanand College, of Arts, Science and Commerce, Solapur, (M.S.), India.

ABSTRACT

Present study of free living ciliates the water samples were collected from different parts of Nashik District (Deola, Nandgaon; Surgana, Satana) of Maharashtra State, India.

KEY WORDS:

INTRODUCTION

The protozoa of the freshwater environment range in size from about 1mm in the case of Stentor and some of the multinucleate amoebae, down to 5µm or so in the case of the smaller flagellates, and they are extremely varied in both appearance and lifestyle. Apart from the very smallest, which are apparently able to absorb nutrients directly through their cell wall, they feed upon other microorganisms. The amoebae feed mainly upon bacteria and algal unicells, as do most of the ciliates. Whereas the amoebae ingest food particles by absorbing them with their pseudopodia, the ciliates feed by either actively capturing or engulfing prey organisms, or by using their cilia to create currents in the surrounding water which bring the food organisms to their mouths. The captured organism is enclosed in a food vacuole, a membrane-bound vesicle which moves through the cytoplasm as digestion occurs. Undigested remains are discharged into the surrounding water, usually at a definite location in the organism's outer pellicle.

The freshwater protozoa regulate the water content of their bodies by the expansion and periodic collapse of their contractile vacuole, a vesicle which increases in size as it extracts water from the interior of the cell and collapses to nothing as it expels the extracted water. The contractile vacuole is not observed in the marine protozoa.

Both in organic pollution of the natural environment and in the biological processing of human and domestic animal sewage, the ceaseless activity of the protozoa - particularly the colonial ciliates - in the extraction and digestion of bacteria and other suspended particles is the main element of the natural process by which the water supply is rendered once again fit for consumption by humans and other creatures. Any change in our environment which threatens the life of a balanced community of protozoans threatens to the continuity of a clean water supply for humans as well. This is particularly relevant in the light of our current over-use of kitchen and lavatory disinfectants and their effect upon the ciliates at sewage processing plants and in the waterways beyond.

The ciliates are one of the most important groups of Protozoa, common almost everywhere there is water (lake, pond, and oceans) and soils with many ecto and endosymbiotic members, as well as some obligate opportunistic parasites. Free living ciliates are found in fresh, marine, estuarine waters and in the soil. An excellent source is a shallow semi-permanent pond in a farm yard. The marshes and sloughs on the shore of the lakes are often rich sources of food. Any stream large or small, or any freshwater hole, temporary or permanent, water at the base of aquatic plants is likely to be a valuable source of material. Such places as moist crotches or bark (crevices) in trees or any other moist or water containing silt, floating algal mats provide food. Cilia covering the body of the organism or a part of it are a major defining characteristic of this group and hence the phylum name “Ciliophora”.

Extensive studies have been made during the last 80 years, with numerous outstanding and noteworthy contributions in the field of Protozoology, covering cytology, cytochemistry, structure, life cycle transmission, evolution, and ultrastructure; and inter relationship a verity of protozoa. Ciliates were among the first living microscopic organisms to be discovered and described. Leeuwenhoek (Dobell, 1932) has attracted much scientific interest in Protozooloy. He made the first reliable observation of live ciliates, found ciliates (*Nyctotherus*) from the frog’s gut (1683) and described *chilodonella, coleps, clopidium, cyclidium, Dileptus, karana, Vorticella, paramecium* and other ciliates (Corliss,1975). He observed morphological details of the “animalcules” and measured them, and described their reproduction, retroactivity and some conjugation stages. Present work is concern with the diversity of different types of Paramecia in Nashik district of Maharashtra

MATERIALS AND METHODS

Present study of free living ciliates the water samples were collected from different parts of Nashik District (Deola, Nandgaon; Surgana, Satana) of Maharashtra State, India. Water samples were collected in wide mouth, sterilized glass bottles. Due care was taken and the samples were collected from where the submerged plants and decaying leaves were present. Mostly the samples were collected during morning and evening. The temperature of the sample bottles were maintained with the help of ice bags.

Rapid movements of ciliates make it difficult to identify ciliate species. To immobilize their movements methyl cellulose solution was used.

Culture methods –

For cultivation various media are used such as

- Hay infusion
- Wheat infusion
- Rice infusion

RESULTS AND DISCUSSIONS

Key for the identification of Paramecia

Genus- *Paramecium*

It seems highly probable that Antony von Leeuwenhoek, the discoverer of protozoa and bacteria also discovered members of the genus *Paramecium* as early as 1674 and 1677. In an account of the early history of *Paramecium*, Woodruff (1945) reported that, according to newly published manuscripts Leeuwenhoek corresponded to Constantijn Huygens (senior) and informed him of some of his observation. Huygens passed on the information to his son Christiaan, who repeated certain of the observation. In 1678 Chistiaan wrote a letter accompanied by sketches to his brother Constantijn (Huygens, 1888) and several Protozoa which he found in infusions, including one that can be identified as a species of *Paramecium*.

Figure 1. Map of Nashik District

In a careful writing of Leeuwenhoek, Dobell (1932) mentioned that this discoverer of Protozoa also discovered *Paramecium.* In 1718 Joblot published an account with figure generally accepted as representing *Paramecium* called by him "Chausson" (slipper), Joblet was second, who represent a drawing of *Paramecium* and he is the first to refer to *Paramecium* as the "Slipper-shaped animalcule" a term in use even today. Ledemuller (1763) utilize the name *Infusoria* was at first to include all members of entire kingdum, Protozoa. As the name implies, *Infusoria* was at first used to embrace all those forms commonly found in infusion of decaying animal and vegetable matter.

Hill (1752) first attempted to apply scientific names to microscopic animals and was the first use the genus name, *Paramecium*. Hill probably used the Greek adjective 'paramec' which means oblong or longish (to distinguish it from the rounded forms) he then added *ium* to the stem *Paramec* to make a noun. He has done characterization of the members in the group. *Paramecium* and description of four species is vague. For *Paramecium* he wrote "Animal which have no visible limbs or tail and are of an irregularly oblong figure". He described each of his four species with short single sentence and used word 'oblong' in each definition as follows-

- "The *Paramecium* with an oblong voluble body, obtuse at each end"
- "The *paramecium* with an oblong body, smallest towards the head"
- "The *paramecium* with an oblong body, narrowest toward the middle"
- "The *paramecium* with a slender, oblong body"

The next great scholar student of microscopic organisms was O. F. Muller, the first Microscopist to apply the Linnaean system of nomenclature to these forms. There are parties to his important monographic studies. The first and second part were published in 1773 and 1774 respectively where in a section is devoted to the '*Infusoria'*. Muller presented a detailed analysis of this group and regarded members of the *Infusoria* as the simplest animal but included bacteria, diatoms, worms and rotifers in addition to Protozoa. In Muller's first treatise (1773) his earliest reference to *Paramecium* is characterized and spelled as follows-
"*Paramecium vermis* inconspicuous, simplex, pellucidus, complanatus, oblongus"

He listed two species, *P. aurelia* which is described as a *paramecium oblongum antice in longitudinem plicatum* and *Paramecium histrio* which he later removed from the genus in his final volume of 1786 not believing it to be a species of *Paramecium*.

The first description of *Paramecium* by Muller (1773) is not accompanied by figures but it identifies his *Paramecium aurelia* with Hill's *Paramecium* 'sp.3' which Hill apparently copied from the anonymous author of 1703. Here occurs the first change in spelling of the name *'Paramecium'* as given by Hill (1752) to *Paramaecium* this has led to consider able confusion in the literature even up to the present the insertion of the letter 'a' is it's etymologically incorrect since it is an error of transcription (Ludwig, 1930; Kalmus, 1931; Woodfuff, 1945). Since Muller made direct reference to Hill's *Paramecium* but miss-spelled it *Paramaecium* the latter is unacceptable according to article 19 of the "International Rules of Zoological Nomenclature".

This error of spelling was recognized by Herman (1784), Ehrenberg (1833, 1839) and Dujardin (1841). The species name of *Paramecium aurelia* appears to have been taken from the resemblance of the ciliate to a golden coloured or chrysalis of a butterfly; 'aureus' (Latin) gold or golden colour; 'chrysos' (Greek)= golden. It is the first species of the *paramecium* named under the Linnaean system of nomenclature that has come down to the present time as *Paramecium aurelia* O. F. Muller (1786).

Altogether, 56 species of *Paramecium* are listed by Ehrenberg (1833, 1838) as occurring in the literature. Of this number he believed 48 to be synonyms. Ehrenberg described the remaining eight species which he believed to be valid but out of this *P. aurelia* and *P. caudatum* are the only species are accepted today.
At the beginning of the 20th century, Jennings (1908) in his studies on heredity in *Paramecium* showed the existence of two main groups based statistically on mean length measurement of a considerable number of pure live cultures

1. *An aurelia group*
2. *bursaria group*

Woodruff (1921) called attention to the fact that the species of *Paramecium* fall naturally into two clearly defined groups when based on body shape. He listed them as the "*aurelia*" group and the "*bursaria*" group respectively on the basis of same specific characteristics.

1. "*Aurelia Group*":- individuals of this group characterized by a relatively long spindle or cigar-shaped body, a round or circular in cross section with somewhat pointed posterior end. The species which are included in this group are-

P. caudatum
P. aurelia
P. multimicronucleatum

2. "*Bursaria group*":- Body is foot shape and somewhat compressed. The posterior end is broadly rounded while the anterior end is somewhat obliquely truncate. Peristomal groove is long and broad. Compact macronucleus is present at the anterior side which is round to ovoid or elongated in shape Species of this group are-

P. trichium
P. calkinsi
P. polycaryum
P. woodruffi
P. bursaria

Within each group one finds two characteristics types of micronuclei of important taxonomic values as follows-

a. ***Caudatum* type**- individuals in which the micronucleus is relatively large and composed rather compact mass of chromatin bounded by nuclear membrane. This is a type of micronucleus found in *P. caudatum, P. bursaria and P. trichium.*

b. ***Aurelia* type**- Individuals in which the micronucleus is relatively small and vesicular. It consists of an extremely small concentrated mass of chromatin called the endosome centrally located with a distinct space between it and the nuclear membrane. This distinction is based on fixed and Steined specimens because in living ones it is difficult to identify micronuclei of the *aurelia* type, although micronucleus of the "*caudatum*" type may be seen easily in the living condition. This is a type of micronucleus found in *P. aurelia, P. multimicronucleatum, P. woodruffi, P. calkinsi* and *P. polycaryum.*

Key to the species of *Paramecium*:-

1. Slender, Cylindrical, or cigar-shaped animals (*aurilia* group); bluntly rounded, anteriorly somewhat pointed or conic, posteriorly widest region about two- thirds of body length behind the anterior end.
2. Shorter and wider animals ("*bursaria*" group) somewhat dorsa-ventrally flattened with obliquely truncated anterior end and broadly rounded posterior end.
3. One large compact micronucleus ("*caudatum*" type); body pointed or conic postereiorly; two canol fed contractile vacuoles, length 170 to 290 µ ……*P. caudatum*.
4. More than one micronucleus and vesicular type…*aurelia* group
5. Usually less than 175µ in length two small vesicular micronuclei, two canal fed contractile vacuoles, smallest of the "aurelia" group less than 120 to 170µ in length ……*P. aurelia*
6. Usually large than 175µ three or four (occasionally up to seven) small vesicular micronuclei, commonly more than two (frequently three) canal fed contractile vacuoles, posterior end of body pointed or conic as *P. caudatum*, largest of *aurelia* group. 180 to 310µ in length ……*P. multimicronucleatum.*
7. Animals nearly coloured green because of zoochlorellae within cyclosis characteristically rapid, single large compact micronucleus, two canal-fed contractile vacuoles, length 85 to 150µ……*P. bursaria*
8. Two conspicuous vesicle-fed contractile vacuoles deeply set in endoplasm, each leading to exterior by means of convoluted outlet canal, radial canals absent, single compact micronucleus, smallest of *bursaria* group, length 70 to 90µ …… *P. trichium*
9. Without conspicuous vesicle-fed contractile vacuoles and convoluted outlet canal but with radial canals……*P. calkinsi*
10. Rotations of body on long axis mainly indirection right spiral, usually two (occasionally one to five) vesicular micronuclei, two canal-fed contractile vacuoles, fresh brackish water, length 110 to 140µ. …… *P. calkinsi*
11. Length generally 150µ, usually four (occasionally three to eight) small vesicular micronuclei, mouth near centre of body, two canal-fed contractile vacuoles, length 70 to 110µ ……*P. polycaryum*
12. Length generally greater than 115µ, mouth posterior to centre of body, three or four (occasionally up to eight) scattered vesicular micronuclei, two canal-fed contractile vacuoles, Brackish water, largest of '*bursaria*' group, length 120 to 210µ…….*P. woodruffi*

Wenrich (1928a) made the important observation that the position of the anus or cytopyge is different in two groups.

In member of "*bursaria*" group the anus is terminal and slightly to one side of the posterior end where as in the "*aurelia*" group it is subterminal, situated on the ventral side between the posterior to the oral groove and the posterior end of the body in *P. caudatum* and *P. multimicronucleatum*, the cytopyge lies between these two points or slightly nearer the end of the oral groove, in *P. aurelia* the cytopyge is nearer to the posterior end of the body.

In general *Paramecium* is large enough to be visible to the unaided eye. However, the internal detail is resolved only by the use of a microscope. A student is best able to observe the complex internal organization of the organism by using what is termed the hanging drop technique. Here a drop of water is suspended upside-down and on a coverslip that is position over a cavity on a microscope slide. The coverslip is sealed to prevent leakage.

Paramecium contains organized structures called vacuoles that are essentially a primitive mouth, stomach, and excretion system. As food enters the organism it is stored in specialized vacuoles. These can circulate through the cytoplasm of the organism, in order to provide food where needed. Characteristic of eukaryote, nuclear material is segregated by nuclear membrane.

Another characteristic feature of *Paramecium* is the so called contractile vacuole. The vacuole is able to store water and then by virtue expel the water out of the organism. In this way the amount of water inside the paramecia can be controlled. The observation of contractile vacuole is another feature that is visible by the light microscope observation of living paramecia.

On the exterior lies a membrane that is called the pellicle. The pellicle is both stiff, to provide support and to maintain the shape of the organism, and is flexible, to allow some flexing of the surface. Also on the surface are hundreds of tiny hairs called cilia. The cilia wave back and forth and act to sweep food particles (bacteria and smaller protozoa) towards the primitive mouth of the organism (the gullet). The cilia are also important in locomotion, acting analogous to the oars of a rowboat. The beating of the cilia is easily visible under light microscopic examination, especially if the movement of the organism has been retarded by the addition of a viscous compound such as glycerol/ fumes of acetic acid to the sample.

There are many Ciliatologists, Protozoologists, Ecologists and Protistologists have worked on *Paramecium* and still doing. Following are the species of *Paramecia*, only few are described here;

- *Paramecium caudatum* (Ehrenberg 1833)
- *P. aurelia* (O. F. Muller, 1773)
- *P. multimicronucleatum* (Powers and Mitchell, 1910)
- *P. trichium* (Stokes, 1883)
- *P. calkinnsi* (Woodruff 1921)
- *P. polucaryum* (Woodfuff and Spencer, 1923)
- *P. bursaria* (Focke, 1836)
- *P. woodruffi* (Wenrich, 1928)

After comparing from above described species of *Paramecium*, present author has found *P. caudatum* (Ehrenberg 1833) and *P. bursaria* (Focke 1836).

Systematics of *Paramecium*

Domain: Eukaryota
Kingdom: Protozoa, Goldfuss, 1818, Rown, 1858
Subkingdom: Biciliata
Infrakingdom: Alveolata, Cavalier and Smith, 1991
Phylum: Ciliophora Doflein, 1901, Copeland, 1956
Subphylum: Intramacronucleata Lynn, 1996
Class: Oligohymenophorea de Puytorac et al., 1974
Subclass: Peniculia Fauré-Fremiet, in Corliss, 1956
Order: Peniculida Fauré-Fremiet, in Corliss, 1956
Suborder Parameciina Small and Lynn, 1985
Family: Parameciidae Dujardin, 1840
Genus: *Paramecium* O.F. Müller, 1773
Species: *P. caudatum* O.F. Müller, 1773
P. bursaria Woodruff

Genus *Paramecium* Hill, 1752

The name *Paramecium* is first time attempted by Hill (1752) to apply scientific names to microscopic animals and the first use the genus name, *Paramecium*. Hill probably used the Greek adjective, 'paramec' which means oblong and elongated to differentiate it from the rounded forms. He then added 'ium' to the term, 'paramec' to make it noun. He has done the characterization of the members in the group. The next great scholar student of microscopic organism was O.F. Muller, the first microbiologist who applied the Linnaean system of Nomenclature to these forms. They are three parts to his monographic studies. The first and second part were published in 1773 and 1774 respectively where in a section is devoted to the 'Infusoria'. Muller presented a detailed analysis of this group and regarded members of the infusoria as the simplest animals but included bacteria, diatoms, worms and rotifers in addition to protozoa. He listed two species, *Paramecium aurelia* and *P. histrio* but later he removed the *P. histrio* from the genus in his final volume of 1786 not believing it to be a species of *Paramecium.*

The organism belongs to the genus *Paramecium* are having long spindle, cigar or foot shape body. It is circular or ellipsoidal in cross section. The posterior end is bluntly pointed to round. In 'Bursaria' group, body is somewhat dorsoventrally flattened with obliquely truncated anterior end and broadly rounded posterior end. Single macronucleus present and one to several vesicular or compact micronuclei are found. Peristome is long, broad and slightly oblique. 1 to 2 contractile vacuoles are presented at anterior or the posterior ends. Rotation of body is along the axis in direction of left or right spiral. Some of the organisms are green in colour because of zoochlorella within, while some of the species are golden coloured or crystals of butterfly 'aureus' (Latin) gold or golden colour; 'chrysos' (Greek) means golden.

Altogether 56 species of *Paramecia* are listed by Ehrenberg (1833, 1838) as occurring in the literature. Out of these he believed 48 species to be homonyms. Ehrenberg described the remaining 8 species which he believed to be valid but out of these *P. aurelia* and *P. caudatum* are the only species accepted today.

At the beginning of the 20th century, Jennings (1908) in his studies on heredity in *Paramecium* showed the existence of two main groups based statistically on mean length measurements of a considerably number of pure live cultures. Woodruff (1921) called attention to the fact that the species of *Paramecium* fall naturally into two clearly defined groups when based on body shape. The one group is 'Aurelia' group and the individuals of this group characterized by a relatively long spindle or cigar shaped body, round or circular in cross section with a somewhat pointed posterior end. This group includes three species viz; *P. caudatum, P. aurelia* and *P. multimicronucleatum*.

Another group is 'Bursaria' group in which the organisms are shorter and broader, dorsoventrally flattened and more rounded posterior end with somewhat obliquely truncated anterior end. This group includes four species viz; *P. trichium, P. calkinsi, P. polycaryum, P. woodruffi* and *P. bursaria.* Wenrich (1928) made the important observation that the position of the anus or cytopyge is different into two groups.

In general *Paramecium* contains vacuoles through which digestion and excretion takes place. As food enters the organism, it is stored in specialized vacuoles known as food vacuoles. These can circulate through the cytoplasm of the organism in order to provide food where needed. Another characteristic feature of *Paramecium* is the contractile vacuole. This vacuole stores water and then by compression of the side arms that radiate from the central vacuole to expel the water out of the organism. They also play an important role in osmoregulation.

A membrane lies on the exterior called the pellicle. The stiff pellicle provides support and maintains the shape of organism and the flexible pellicle gives flexibility to the surface, there are hundreds of tiny hairs called cilia. The cilia are important in locomotion, acting analogous to the oars of rowboat. The cilia also help in sweeping food particles (bacteria and smaller protozoa) towards the mouth by moving back and forth. Following are the species of *Paramecium* and out of these two are redescribed here.

P. aurelia Muller, 1773
P. caudatum Ehrenberg, 1833
P. trichium Stokes, 1885
P. multimicronucleatum Power and Mitchell, 1910
P. calkinsi Woodruffi, 1921
P. polycaryum Woodruff and Spencer, 1923
P. bursaria Wenrich, 1928

Percentage of prevalence of free living fresh water ciliates:
During the period of two years (Jan.2007 to Dec. 2008) a total number of water samples 1624 were examined, 879 of these were positive with free living ciliates.

In the first year (Jan. 2007 to Dec. 2007) 677 fresh water samples were examined, 361 of these were positive with free living ciliates. The percentage of prevalence of free living ciliates was about 53.32%.

In the second year (Jan. 2008 to Dec. 2008) 947 fresh water samples were examined, 518 of these were positive with free living ciliates. . The percentage of prevalence of free living ciliates was about 54.70%.

A month wise analysis in first year (Jan.2007 to Dec.2007) shows the maximum percentage of prevalence of free living ciliates during August and September (73.68%, 70.69%), lowest in May (31.15%) and minimum to moderate in remaining months.

In second year (Jan.2008 to Dec.2008) maximum percentage of prevalence of fresh water free living ciliates was showed again during August and September (74.47%, 71.25%), lowest in February, March and April (38.10%,36.71%,39.13 %) and minimum to moderate in remaining months.

Comparatively percentage frequency of *Paramecium caudatum* is seen more than the various ciliates. Only it has been found that the population of present species is slightly decrease in the month of May in both the years.
The pattern in both the years suggests that the peak is soon after the monsoon rain. The percentage then gradually reduces at the end of the winter months and reaches a low with the onset of summer. The details of the number of animals examined and the month wise prevalence is shown in Table 1 and 2.

Table 1. Showing the month wise prevalence of free living fresh water Ciliates, during the period from Jan. 2007 to Dec. 2007.

Sr No	Month	No. of water samples examined	No. of +ve water samples	% of Total Prevalence	% of Paramecium species in the total ciliate positive samples
1	Jan-07	45	22	48.89	40.76
2	Feb-07	55	23	41.82	40.00
3	Mar-07	47	20	42.55	40.00
4	Apr-07	60	21	35.00	34.00
5	May-07	61	19	31.15	11.02
6	Jun-07	67	32	47.76	46.55
7	Jul-07	54	36	66.67	59.50
8	Aug-07	57	42	73.68	64.00
9	Sep-07	58	41	70.69	64.00
10	Oct-07	60	39	65.00	50.00
11	Nov-07	64	41	64.06	49.00
12	Dec-07	49	25	51.02	42.00
	Total	**677**	**361**	**53.32**	**44.15**

Table 2. Showing the month wise prevalence of free living fresh water ciliates during the period from Jan.2008 to Dec. 2008.

Sr No	Month	No. of water samples examined	No. of +ve water samples	% of Total Prevalence	% of Paramecium species in the total ciliate positive samples
1	Jan-08	68	37	54.41	35.00
2	Feb-08	84	32	38.10	35.00
3	Mar-08	79	29	36.71	34.12
4	Apr-08	69	27	39.13	32.19
5	May-08	62	27	43.55	22.21
6	Jun-08	89	49	55.06	21.00
7	Jul-08	94	70	74.47	59.55
8	Aug-08	80	57	71.25	69.15
9	Sep-08	89	58	65.17	65.14
10	Oct-08	87	60	68.97	64.19
11	Nov-08	69	32	46.38	45.00
12	Dec-08	77	40	51.95	39.10
	Total	**947**	**518**	**54.70**	**46.68**

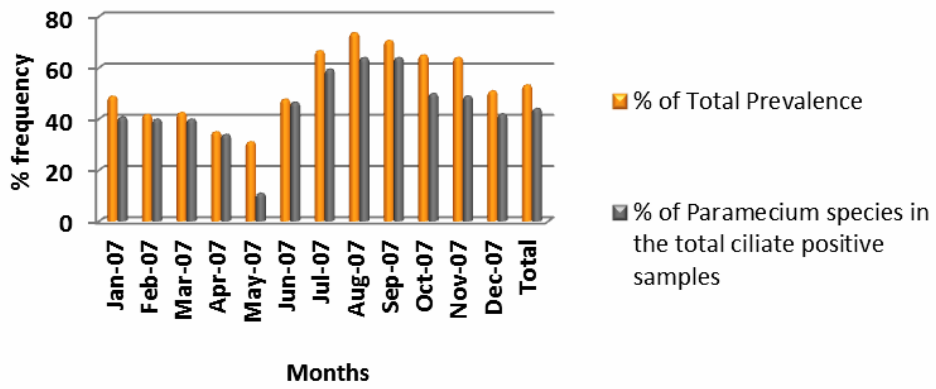


Figure 2. Showing the month wise prevalence of free living freshwater Ciliates, during the period from January 2007 to December 2007.

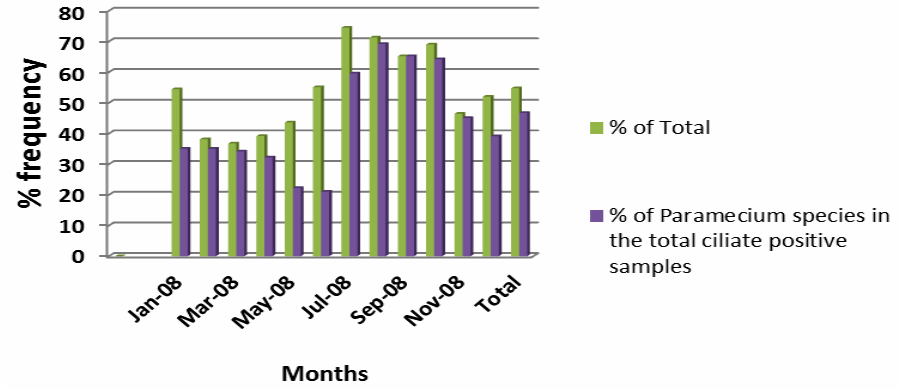


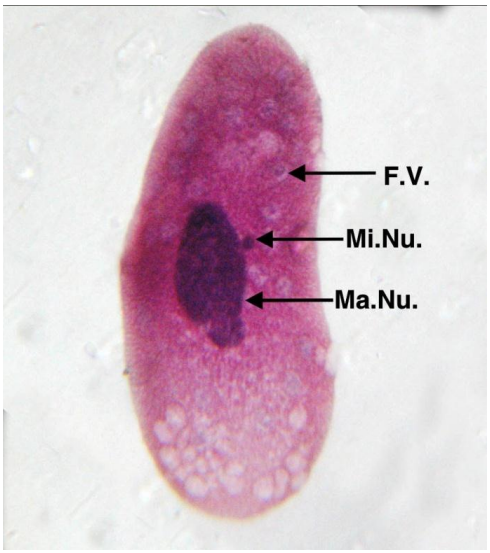
Figure 3. Showing the month wise prevalence of free living freshwater Ciliates, during the period from January 2008 to December 2008.

***Paramecium caudatum* Ehrenberg (1833)**

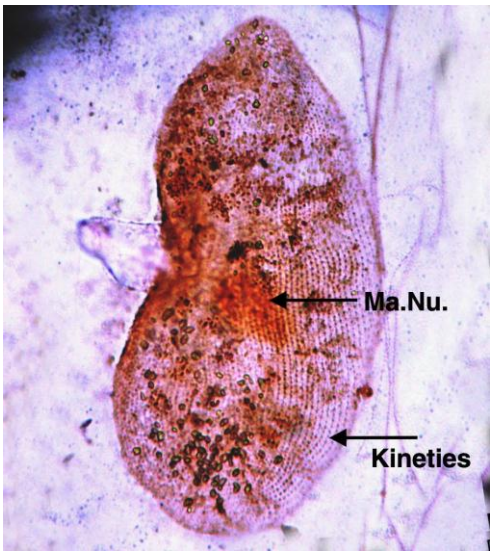
Description of the species

This species is first reported by Ehrenberg (1833). Body of this ciliate is cylindrical, cigar or foot shaped, or slipper shaped. It is an active animalcule that is widely distributed and extensively studied organism. The anterior end of the body is bluntly rounded whereas the posterior end is pointed. *Paramecium* swims the anterior end forward in a helix because its ciliary beat is oblique to the long axis of the body. *Paramecium* can reverse the direction of its ciliary beat and move backwards.

It measures 125 to 227.5µ in length and 65 to 120µ in width. Body ciliation is uniform, but caudal cilia are elongated. The anterior region is relatively broader than the posterior end. The body size and shape studied and recorded in living condition. The ventrally located ventral groove or vestibulum extends slightly more than half of the body length in the direction of the right spiral. The groove oriented obliquely across the cell and opens anteriorly. Buccal cavity is with one endoral membrane and two piniculi (peniculus- a group of specialized cilia characteristic of peniculina). The entrance of the groove faces anteriorly and the cytostome is reaches to the posterior end. The cytostome opens into a fluid region of the cytoplasm known as cytopharynx (*P. caudatum*, Shaikh, 2006). The cilia of the peristomal groove move food particles (bacteria, small protozoan or organic particles) in to the cytopharynx to make food vacuoles in the cytopharynx. After formation, the vacuoles move in a circuitous route through the cell while the various events of digestion occur subsequently. Macronucleus is large, compact, elongated, and centrally placed. It measures about 30 to 75µ in length and 17.5 to 37.5 µ in width. Micronucleus is single spherical to ovoid in shape, situated close to the macronucleus. There are two contractile vacuoles observed with radial canals in living condition. These vacuoles are located in about first and last quarters of the body and empty to the outside by means of excretory pores. The cytopyge is present on ventral side and sub terminal and rather close to the posterior tip of the body, through which the indigestible residue of the food is extruded from the body. See in microphotographs.

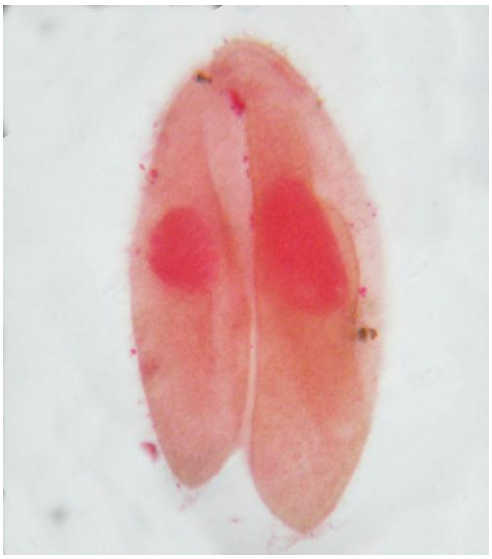


***Paramecium caudatum* W.M.**



***P. caudatum*, Silver staining**

***P. caudatum* Binary fission**



***P. caudatum*, Conjugation**

Figure 4. ***Paramecium caudatum*** ***a)*** **W.M. b) Silver staining c) Binary fission d) Conjugation**

Comments

The cigar or foot shaped or slipper shaped body of this organism matches to genus *Paramecium* and hence it is a member of this genus. Hill (1752) first time reported this genus. After that many other workers such as Muller (1713), Ehrenberg, (1833), Stokes (1885), Power and Mitchell (1910), Woodruff (1921), Woodruff and Spencer (1923), Wenrich (1928), Kudo (1966), Bick (1972), reported various species of this genus.

The body shape shows rounded anterior end and narrow posterior end matches to all the species of *Aurelia* group of *Paramecium* and differs from *Bursaria* group in which the individuals have flattened anterior end hence present author compares this species with *aurelia* group only which includes *P. aurelia*, *P. caudatum*, and *P. multimicronucleatum.*

Posterior end of the present species is bluntly pointed which is differ from *P. aurelia* and *P. multimicronucleatum* because the posterior end in both of these species is usually more rounded. This character matches with *P. caudatum.* The contractile vacuoles in the present species are two in number and are situated, one is at anterior end and another is at posterior end on aboral surface of the body. This character matches to *P. caudatum* (Shaikh, 2006), and *P. aurelia* (Deshmukh, 2010) but Muller (1773) described two contractile vacuoles in P. *aurelia* and both of them are located at

the anterior end of aboral side. Present species also separates from *P. multimicronucleatum*, which possesses three to seven contractile vacuoles scattered in anterior and posterior region.

Macronucleus in present case is centrally placed, which is elongated and occasionally triangular while the macronucleus in *P. aurelia* and *P. multimicronucleatum* is usually compact, round to ovoid and located just above the middle of the body, hence found to be different from *P. aurelia* and *P. multimicronucleatum*, but closer to *P. caudatum* (Ehrenberg, 1833), which has centrally placed macronucleus. Shaikh, (2006) reported macronucleus in *P. caudatum* which is situated anterior to middle, compact, smoothly ellipsoidal or kidney shaped.

Present species shows single compact micronucleus close to the macronucleus which matches to *P. caudatum* described by Ehrenberg, 1833, Shaikh, 2006 while Muller (1773) reported two small, vesicular micronuclei in *P. aurelia*. Recently in *P. aurelia*, Deshmukh (2010) reported single vesicular micronucleus, 4 or more micronuclei described by Power and Mitchell, (1910) in *P. multimicronucleatum*. Hence this species separates from both the above species. But it resembles to *P. caudatum* (Ehrenberg, 1833; Shaikh 2006) in which they also reported single vesicular micronucleus. Body dimensions of the present species are closer to the *P. caudatum* (Ehrenberg and Shaikh) but smaller than *P. multimicronucleatum* while the body is larger than *P. aurelia*. After the discussion and comparison of the present species with the species of *Aurelia* group it is found similar to *P. caudatum* in body dimensions, shape, position of macronucleus and single vesicular micronucleus matches to the *P. caudatum* described by Ehrenberg, (1833) while the position of two contractile vacuoles matches to the *P. caudatum* described by Shaikh, (2006) and hence redescribed here as a *Paramecium caudatum* (Table 3).

Table 3. Comparison of the present species with the species of Aurelia group of Paramecium

Sr. No.	Particulars	*P. aurelia* Muller, 1773	*P. caudatum* Ehrenberg, 1833	*P. multimicronucleatum* Power and Mitchell, 1910	*P. caudatum* Shaikh, 2006	*P. aurelia* Deshmukh, 2010	*P. caudatum* Present author
1	Body shape	Cigar or foot shaped, posterior end is more rounded than anterior end.	Cigar or foot shaped, posterior end is bluntly pointed	Cigar or foot shaped, posterior end is rounded	Cigar or foot shaped, posterior end is bluntly pointed	Cigar or foot shaped. Posterior end is more rounded than anterior end.	Cigar or foot shaped, posterior end is bluntly pointed
2	Body dimensions	120µ-180µ long	180µ-300µ long	200µ-330µ long	171 to 245µ long	74.64µ-111.23µ by 24.97µ-38.59µ	125 to 227.5um By 65 to 120um
3	Contractile vacuole	2, anterior, on aboral surface	2, posterior, on aboral surface	3-7, anterior and posterior	2, one posterior and one anterior on aboral surface,	2, one posterior and one anterior, on aboral surface.	2, one anterior and one posterior, on aboral surface
4	Macronucleus	Ovoid to elongated, just above the middle of body	Compact, elongated, centrally placed	Ovoid to elongated, obliquely placed just above the middle of body	Anterior to middle, compact, smoothly ellipsoidal or kidney shaped.	Compact, round to ovoid or triangular, just above the middle of the body	Compact, elongated, centrally placed 30 to 75um by 17.5 to 37.5um
5	Micronucleus	2, small vesicular	1, compact	4 or more, vesicular	1, compact	1, vesicular	1, compact
6	Habitat	Fresh water	Fresh water	Fresh water	Fresh water	Fresh water	Fresh water

REFERENCES

Corliss J. O. (1977). Annotated assignment of families and to the order and classes currently comprising the Corlissan scheme of higher classification for the Phylum Ciliophora. *Trans. Am. Micros. Soc*. **96**: 104-140.

Corliss J. O. (1978). A salute to fifty- four great microscopist of the past: a pictorial to the history of Protozoology. Part 1. *Trans. Amer. Micros. Soc.* **97**: 419-458.

Corliss J. O. (1978). Protozoan ecology: a note on its current status. *Amer Zool.* **13**: 145-148.

Corliss J. O. (1979). The Ciliated Protozoa: characterization classification and guide to the literature 2nd ed. *Pergtamon Press* Oxford.

Corliss J. O. (1991). Historically important events, discoveries and works in Protozoology from the mid-17th to mid-20th century. *Rev. Soc. Mex. Hist. Nat*. **42**: 45-81.
Corliss J. O. (1997). Some important anniversaries in the history of Protozoology. *Rev. Soc. Mex. Hist. Nat*. **47**: 5-17
Ehrenberg C. G. 1833. Dritter beitrag zur erkenntniss grosser organisation in der richtung des kleinsten raumes. Abh. Konig. *Akad. Wissensch. Berl.* 145-336.
Deshmukh (2010). Studies on some aquatic and soil protozoa from Aurangabad vicinity Ph. D. thesis of Dr. B.A.M. University Aurangabad.
Dobell C. (1932). Antony van Leeuwenhoek and his "little animals." Staples Press, London
Hall R. P. (1937): Growth of free-living protozoa in pure cultures. In Needham et al. Culture methods for invertebrate animals.
Hall R. P. and Nigrelli, **R. F. (1937).** A note on the vauome of *Paramecium bursaria* and the contractile vacuole of certain ciliates. *Tr. Am. Micr. Soc.* **56**:185.
King R.L. (1935). The contractile vacuole of *Paramecium multinucleatum*. *J. Morphol.* **58**:555.
King R.L. (1954). Origin and morphogenetic movements of the pores of the contractile vacuoles in *Paramecium aurelia*. *J. Protozool.* **1**:121.
Kudo R. R. (1975). Protozoology 5th ed. Charles C. Thomas Springfield, Illinios; 1174
Kudo R. R. (1977). Protozoology 5th ed. Springfield, III: Chane, C.C. Thomas (1774).
Ludwing W. (1930). Zur Nomenclatur und Systematick der Gattung *Paramecium. Zool. Anz*., **92**: 33–41
Lynn D. H. and Small, E. B. (2000). Phylum Ciliophora In An illustrated guide to the protozoa.2-nd ed. (Eds. Lee J. J. Hunter S. H. and Bovee E. C.) Allen press, Lawrence. 371-655.
Műller O. F. (1773). Vermium terrestrium et fluviatilium, Historia
Powers J. H. and Mitchell C. (1910). A new species of *Paramecium* (*P. multimicronucleata*) experimentally determined. *Biol. Bull.* **19**: 324-332.
Puytorac (1974). Proposition d'une. Classification du phylum *Ciliophora* Doflein, 1901. C. R. *Acad. Sci. Paris*. **278**: 2799-2802.
Wenrich D.H. (1928). *Paramecium woodruffi* n. sp. Tr. Am. Micr. Soc. **47**:256.
Wenrich D.H. (1928a). Eight well defined species of Paramecium. *Ibid.* **47**:275.
Wiley N.Y. Wenrich D.H. (1928a). Eight well defined species of *Paramecium. Ibid.* **47**:275.
Woodruff L. L. (1921). The structure, life history, and intrageneric relationships of *Paramecium calkinsi*, sp. nov. *Biol. Bull.* **41**:171-180.
Woodruff L. L. and Spencer H. (1923). *Parameciumpolycaryum* sp. nov. *Proc. Soc. Exp. Biol. Med.* 20:338-339.
Woodruff L.L. (1931). Micronuclear variation in *Paramecium bursaria*. *Quart. Micr. Sci.* **74**:537.

