

ON SOME CILIATE PARASITES OF FROGS AND TOADS OF KARNATAK, BOMBAY PRESIDENCY*

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INTRODUCTION.

The occurrence of binucleate opalinids in Indian Anura has been a subject of great controversy in the past. Bezenberger (1904), for the first time, described *Zelleriella macronucleata* (Bezz.) from an Asian toad, *Bufo melanostictus* Schneider, but his findings were later rendered doubtful by Metcalf (1923) who opened thirty-nine specimens of this toad to find no *Zelleriella* in them. Bhatia and Gulati (1927) who conducted extensive survey of the ciliate parasites of the Anura of the Punjab also reported a complete absence of both *Zelleriella* and *Protoopalina* in *Bufo melanostictus* as well as other Anurans they studied. The absence of these ciliates in Indian Anura was, thus, more or less accepted, until Nie (1935) again reported *Protoopalina caudata microhyla* Nie, from an Indian frog *Microhyla ornata* Dumeril and Bibron (*Ind. Mus. Reg. No. 17287*), a specimen of which collected at Harnai, Ratnagiri District, Bombay, was supplied to him by the Indian Museum, Calcutta (Metcalf, 1940; p. 472). This discovery of Nie evidently raised the question asked by Metcalf (p. 577) "Why are there no more Protoopalinids in these Indian Ocean Lands?", and, thus, led the writer to undertake this interesting piece of work.

The present investigation establishes, beyond doubt, the existence of binucleate opalinids in the Anura of Karnatak, and includes the description of five new forms, *i.e.*, *Protoopalina indica*, *P. karnatakensis*, *P. dharwarensis*, *Zelleriella microhylae* and *Z. froilanoi*. Since the locality is situated in South India which forms the most ancient part of the Asian continent, the presence of *Zelleriella* and *Protoopalina* in this region, may modify the present conclusions in the field of Zoogeography.

During the course of this work, the following twelve species of other ciliates found parasitic in the gut of the hosts examined have also been recorded: *Nyctotherus macropharyngeus* Bezz., *N. magnus* Bezz., *N. magnus malabarica* De Mello., *N. cordiformis* Stein., *Balantidium helenae* Bezz., *B. duodeni* Stein., *B. gracile* Bezz., *Opalina ranarum* Purk et Val., *Cepedea virgula* (Dobell) Metcalf., *C. philauti* sp. nov., and *C. dimidiata*

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naglavenensis subsp. nov. Most of the host species have been examined for the first time in India, and in the cases of those already studied more ciliates have been added to the list of their parasites.

The smears made on cover-glasses were either fixed in Schaudinn's sublimate alcohol and stained with Mayer's haemalum or they were fixed in Bouin's fluid and stained with Iron-haematoxylin. Some smears stained with Borax-carmine were also found to be very useful.

All drawings are made with the aid of camera lucida.

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NOTES ON HOSTS.

1. *Bufo melanostictus* Schneider.—The toad is very common in Dharwar and on account of its sluggishness, is easy to collect. Out of twenty-one specimens each measuring about 80 mm. from snout to vent, only seven were found infected.

Habitat: Gardens. Collected during December, 1944.

Ciliates recorded for the first time: *Nyctotherus macropharyngeus* Bezz.

*2. *Micrixalus opisthorhodus* Boulenger.—On account of its rarity, only five specimens each measuring about 63 mm. from snout to vent could be examined. All the five were well infected with parasites.

Habitat: Tank near Dharwar. Collected during October, 1944.

Ciliates found: *Nyctotherus macropharyngeus* Bezz., *N. magnus* Bezz., *Balantidium helenae* Bezz., *B. duodeni* Stein., *B. gracile* Bezz., *Opalina ranarum* Purk. et Val.

*3. *M. saxicola* Boulenger.—This is also a very rare frog. Only two specimens each measuring 40 mm. from snout to vent were obtained and examined. Both were found to be well infected with parasites.

Habitat: Tank near Dharwar. Collected during October, 1944.

Ciliates found: *Nyctotherus macropharyngeus* Bezz., *N. magnus* Bezz., *N. magnus malabarica* De Mello., *N. cordiformis* Stein., *Balantidium helenae* Bezz., *B. duodeni* Stein., *B. gracile* Bezz., *Opalina ranarum* Purk et Val., and *O. coracoidea* Bezz.

*4. *Microhyla ornata* Dumeril and Bibron.—This frog occurs in large numbers round about Dharwar. The young ones were generally found in day time in paddy fields during rains; but the adults due to their nocturnal and burrowing habits are rarely found during the day and usually leave their abode after sunset when large number of them may be met with. The best time to collect the young ones is during September and November. As many as 25 tadpoles and 10 froglings collected at Naglavi, a forest area about twelve miles from Dharwar, showed heavy infections of both *Zelleriella* and *Protoopalina*.

Habitat: Paddy fields. Collected during October, 1944 and August 1945.

* The host species preceded by an asterisk(*) have been examined for their ciliate parasites for the first time in India.

Ciliates found: *Nyctotherus cordiformis* Stein., *Protoopalina indica* n. sp. *P. karnatakensis* n. sp., *P. dharwarensis* n. sp. and *Zelleriella microhylae* n. sp.

*5. *Philautus* sp.—As stated by McCann (1932), it is one of the most elusive frogs and is rare and difficult to locate. As only young ones were obtained the species could not be ascertained. Some specimens were infected with *Zelleriella*. Fifteen juvenile frogs each about 16 mm. long and five tadpoles each measuring about 48 mm. long were examined. All the five tadpoles and ten out of the fifteen froglings were found with parasites.

Habitat: Paddy fields at Naglavi. Collected during September, 1944 and August, 1945.

Ciliates found: *Nyctotherus orcdiformis* Stein., *Cepedea virgula* (Dobell), *Zelleriella froilanoi* n.sp., and *Cepedea philauti* n.sp.

6. *Rana cyanophlyctis* Schneider.—The frog is most common in Dharwar. Out of thirteen specimens (each measuring about 43 mm. long from snout to vent) ten were found infected.

Habitat: Ponds. Collected during April, 1944.

Ciliates recorded for the first time: *Nyctotherus magnus* Bezz., *N. magnus malabarica* De Mello., *Balantidium gracile* Bezz., *Cepedea dimidiata naglavensis* n. sp.

*7. *R. leptodactyla* Boulenger.—The species is somewhat rare. Two specimens each measuring 50 mm. from snout to vent, were studied.

Habitat: Ponds. Collected during October, 1944.

Ciliates found: *Nyctotherus macropharyngeus* Bezz., *N. cordiformis* Stein., *Balantidium helenae* Bezz., and *B. duodeni* Stein.

8. *R. limnocharis* Wiegman.—Five specimens of this common frog, each measuring about 50 mm. long, were examined. All of them were found to be parasitized.

Habitat: Ponds. Collected during April, 1944.

Ciliates recorded for the first time: *Nyctotherus magnus malabarica* De Mello., *N. cordiformis* Stein., *Balantidium duodeni* Stein., *B. gracile* Bezz., *Opalina ranarum* Purk et Val and *O. coracoidea* Bezz.

*9. *R. temporalis* Boulenger.—Only two specimens of this rare frog each 55 mm. long were examined.

Habitat: Ponds. Collected during October, 1944.

Ciliates found: *Nyctotherus macropharyngeus* Bezz., *N. magnus malabarica* De Mello., *N. cordiformis* Stein., *Balantidium helenae* Bezz., *B. duodeni* Stein., *B. gracile* Bezz., *Opalina ranarum* Purk et Val., and *O. coracoidea* Bezz.

SYSTEMATICS.

***Nyctotherus macropharyngeus* Bezz.**

This ciliate is very common in the frogs of Dharwar. Besides being present in the old hosts (*Rana limnocharis* Wieg. and *Rana cyanophlyctis* Schn.), the parasite was met with in a number of new hosts: *Micrixalus saxicola* Boul., *Micrixalus opisthorhodus* Boul., *Rana temporalis* Boul., *Rana leptodactyla* Boul., and *Bufo melanostictus* Schn. In *M. saxicola*, the form was slightly more ellipsoidal than oval, about two times as long as broad; the cytoplasm appeared very much alveolated; the contractile

vacuole situated at the posterior end was single; the macronucleus usually surrounded by a halo varied in its shape; the micronucleus, however, could not be detected. In other hosts, typical forms were found.

Measurements (in microns) of N. macropharyngeus Bezz.

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
<i>Micrixalus saxicola</i> —					
Host I	91	200—350 × 110—180	275 × 135	2.03 : 1	55 × 31
Host II	62	172—335 × 105—190	253 × 147	1.75 : 1	50 × 26
<i>Micrixalus opisthorhodus</i>	32	200—305 × 110—160	252 × 135	1.80 : 1	48 × 28
<i>Rana leptodactyla</i> ..	25	220—290 × 115—150	255 × 132	1.93 : 1	43 × 25
<i>Rana temporalis</i> ..	67	205—305 × 105—150	255 × 127	2.00 : 1	46 × 27
<i>Bufo melanostictus</i> * ..	11	200—255 × 120—150	227 × 135	1.66 : 1	55 × 30

*Parasites scanty in number.

Nyctotherus cordiformis Stein.

With the exception of *Rana temporalis* and *R. leptodactyla*, the parasite, though scanty in number, was found in all the hosts examined. In *Bufo melanostictus*, the ciliate reached a maximum body size of 138 × 88 microns, and appeared somewhat beanshaped. Those observed by Bhatia and Gulati (1927), in the same species of the host, were smaller. The cytopharynx in many individuals was not as much developed and curved as in the typical form described by Stein (1867). In *M. saxicola* and *M. opisthorhodus*, individuals having a somewhat longer cytopharynx were met with. De Mello (1932) observed a similar elongation of the cytopharynx in the forms studied by him from *Rana malabarica*. The macronucleus also showed variations in the shape and size from host to host.

Measurements (in microns) of Nyctotherus cordiformis Stein.

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
<i>Micrixalus saxicola</i> ..	17	70—110 × 50—70	90 × 60	1.50 : 1	44 × 9
„ <i>opisthorhodus</i>	10	70—100 × 40—60	85 × 50	1.70 : 1	45 × 15
<i>Rana cyanophytis</i> ..	18	90—130 × 50—80	103 × 60	1.71 : 1	55 × 15
<i>Rana limnocharis</i> —					
Host I	20	110—150 × 80—105	130 × 92	1.41 : 1	50 × 15
Host II	12	75—120 × 45—75	97 × 60	1.61 : 1	50 × 15
<i>Mirrohyla ornata</i> ..	8	85—125 × 65—85	105 × 75	1.40 : 1	50 × 25
<i>Philautus sp.</i> ..	5	115—140 × 60—80	127 × 70	1.81 : 1	55 × 30
<i>Bufo melanostictus</i> ..	14	110—155 × 65—90	132 × 77	1.71 : 1	55 × 30

***Nyctotherus magnus* Bezz.**

This giant *Nyctotherus* was met with only in four hosts, namely, *Rana limnocharis*, *R. temporalis*, *Micrixalus saxicola* and *Rana cyanophlyctis* of which the first three are new hosts for this ciliate. In all these infections the individuals were rather few in number. Their exceptionally large body measurements helped to distinguish them from other species such as *N. macropharyngeus* Bezz., *N. cordiformis* Stein., which were always found associated with it. The form though small in size as compared to Bezenberger's approached the typical in character. However, the cytoplasm in some individuals exhibited a much alveolated condition, and showed large food-vacuoles in which were found ingested specimens of *Balantidium helenae*. A similar instance was noted by Carini (1939) in *Nyctotherus vorax* Carini., in the body of which he found few specimens of *N. cordiformis* being ingested and digested there as food. Whether such food-habits are normal or the smaller ciliates fall as prey by chance during the process of feeding cannot definitely be stated here.

Measurements (in microns) for Nyctotherus magnus Bezz.

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
<i>Rana cyanophlyctis</i> ..	5	550—610 × 335—380	580 × 357	1·34 : 1	180 × 50
<i>Rana limnocharis</i> ..	1	485 × 340		1·42 : 1	180 × 45
<i>Rana temporalis</i> ..	4	340—518 × 230—340	429 × 285	1·50 : 1	186 × 60
<i>Micrixalus saxicola</i> * ..	1	620 × 450		1·37 : 1	200 × 60

* Showed cannibalistic character.

***Nyctotherus magnus malabarica* De Mello.**

Typical forms were observed in *Rana limnocharis*, *Rana temporalis*, *R. leptodactyla* and *Micrixalus saxicola*, all of which have been opened for this parasite for the first time. Individuals from *Rana leptodactyla* and *R. temporalis* showed considerable variations in the curvature of their cytopharynx. The inner end was not so bent as shown by De Mello (1932). The furrow running from the tip of the cytopharynx to the anal opening was very prominent. The finely granulated cytoplasm appeared somewhat thin and less alveolated. The micronucleus could not be traced throughout. In *Micrixalus saxicola*, the forms though small in size, were typical in character.

Measurements (in microns) for Nyctotherus magnus malabarica De Mello.

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
<i>Micrixalus opisthorhodus</i>	6	120—150 × 90—110	135 × 100	2.00 : 1	55 × 20
<i>Rana temporalis</i> ..	10	135—190 × 90—130	162 × 110	1.56 : 1	50 × 25
<i>Rana leptodactyla</i> —					
Host I	21	140—200 × 95—145	170 × 120	1.41 : 1	55 × 30
Host II	25	200—280 × 110—170	240 × 140	1.91 : 1	55 × 30
<i>Rana limnocharis</i> ..	17	105—170 × 75—110	137 × 92	1.48 : 1	60 × 30

Balantidium helenae Bezz.

Though *Microhyla ornata*, *Philautus sp.*, and *Bufo melanostictus* were entirely devoid of this ciliate, it was abundantly present in other host species. In *Micrixalus saxicola*, the form varied from elongately oval to broadly oval. The position of the macronucleus varied in many individuals. Out of 75 specimens 32 had their nucleus in about the middle of the body, while in the remaining 43, it was found to lie in the posterior half of the body. The cytoplasm contained some irregular bodies which were stained like the nucleus. The anal opening situated at the posterior pole was clearly visible. The boring apparatus as reported by Ray, (1932) and Chakravorti (1933) was not detected. In *M. opisthorhodus*, *Rana temporalis*, *R. leptodactyla*, *R. limnocharis*, and *R. cyanophlyctis* typical forms were found.

The broadly oval forms have been described under a new species *B. ovale* (Dobell 1910, p. 74). After studying these forms in the Lahore frogs, Bhatia and Gulati (1927, p. 107) came to the conclusion that they were identical in structure with *B. helenae* and differed only in size; and should, therefore, be treated as one and the same species. Similar forms having been met with in the hosts of Dharwar, the writer is of the opinion that Bhatia and Gulati are probably correct.

Measurements (in microns) for Balantidium helenae Bezz.

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length: breadth) average.	Average nucleus.
		Range.	Average.		
<i>Micrixalus saxicola</i> ..	75	80-140 × 40-150	110 × 95	1.10 : 1	30 × 12
<i>M. opisthorhodus</i> ..	10	45-60 × 28-32	52 × 30	1.73 : 1	20 × 10
<i>Rana temporalis</i> ..	22	55-115 × 30-50	85 × 40	2.12 : 1	30 × 10
<i>R. leptodactyla</i> ..	34	50-105 × 30-65	77 × 47	1.50 : 1	25 × 10
<i>R. limnocharis</i> ..	20	40-90 × 30-45	65 × 37	1.71 : 1	30 × 9
<i>R. cyanophlyctis</i> ..	49	50-85 × 25-50	67 × 37	1.81 : 1	30 × 10

Balantidium gracile Bezz.

With the exception of *Microhyla ornata*, *Bufo melanostictus* and *Philautus* sp. the parasite occurred in all the hosts examined at Dharwar. It was usually located in the intestine. Bezenberger (1904) found the macronucleus lying mostly at the hinder end and seldom in the middle. In Dharwar forms it was usually in the middle.

Measurements (in microns) for Balantidium gracile Bezz.

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
<i>Micrixalus saxicola</i> * ..	27	145-210 × 25-30	177 × 27	6.55 : 1	20 × 10
<i>M. opisthorhodus</i> ..	46	95-185 × 20-35	140 × 27	5.18 : 1	20 × 9
<i>Rana temporalis</i> † ..	4	130-155 × 20-35	142 × 25	5.60 : 1	20 × 11
<i>Rana leptodactyla</i> ..	44	170-285 × 20-35	227 × 27	8.40 : 1	36 × 10
<i>Rana limnocharis</i> ..	65	90-195 × 30-40	142 × 35	4.05 : 1	20 × 10
<i>Rana cyanophlyctis</i> ..	24	120-260 × 20-25	190 × 22	8.60 : 1	30 × 10

* Pure culture in small intestine.

† Parasites scanty in number.

Balantidium duodeni Stein.

The ciliate occurred in the new hosts, *Rana temporalis*, *R. leptodactyla*, *Micrixalus saxicola*, and *M. opisthorhodus* as well as in the old hosts *R. limnocharis* and *R. cyanophlyctis*. Typical specimens were met with in all the hosts.

Comparing the characters of *B. rotundum* Bezz. with *B. duodeni* Stein, it is found that the former differs from the latter in having a straight dorsal surface (which, perhaps, is due to the much rounded sides) that gives the parasite an appearance of an egg. In other characters like the nucleus, the triangular area in the cytoplasm and the peristome they are quite identical. In the specimens studied at Dharwar, it was noted that both oval and egg-shaped forms were present. Those that were small in size appeared egg-shaped, while the larger forms appeared longer and oval. *B. rotundum*, therefore, may well be compared to these smaller forms of *B. duodeni*. And since *B. rotundum* is not structurally very different from *B. duodeni*, I am inclined to think that both these duodenal forms are identical.

Measurements (in microns) for Balantidium duodeni Stein.

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus.
		Range.	Average.		
<i>Micrixalus saxicola</i> * ..	19	25-43 × 14-30	34 × 22	1.54 : 1	10 × 7
<i>M. opisthorhodus</i> ..	53	30-55 × 20-30	42 × 25	1.68 : 1	11 × 8
<i>Rana temporalis</i> ..	23	30-48 × 20-24	39 × 22	1.77 : 1	10 × 8
<i>R. limnocharis</i> † ..	7	40-50 × 20-30	45 × 25	1.80 : 1	9.5 × 9
<i>R. cyanophlyctis</i> ..	10	35-45 × 25-30	40 × 27	1.58 : 1	10 × 8

* Abundant in duodenum.

† Parasites scanty in number.

Opalina ranarum Purk and Val.

The parasite occurred both in the new hosts (*Rana temporalis*, *Micrixalus saxicola* and *M. opisthorhodus*) and in the old ones (*Rana limnocharis* and *Bufo melanostictus*). In all these infections the parasites were abundant and were usually lodged at the anterior end of the rectum. In the same infection, both oval and truncated forms were noticed. Metcalf (1923) has considered these forms as two separate subspecies. Since all these forms are common in all the infections studied at Dharwar, it seems that they are only the variations, of one and the same species. The parasite resembled the typical form in all other characters.

Measurements (in microns) for Opalina ranarum Purk & Val.

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus (diameter).
		Range.	Average.		
<i>Micrixalus saxicola</i> * ..	21	170-210 × 75-200	190 × 137	1.84 : 1	3-4
<i>M. opisthorhodus</i> ..	61	225-410 × 110-185	317 × 147	2.13 : 1	3-4
<i>Rana temporalis</i> ..	44	170-280 × 70-175	225 × 122	1.84 : 1	3-4
<i>R. limnocharis</i> ..	21	130-190 × 70-90	160 × 80	2.00 : 1	3.5-4
<i>Bufo melanostictus</i> ..	31	110-180 × 55-100	147 × 77	1.90 : 1	3-4

* Truncated forms.

Opalina coracoideo Bezz.

In Dharwar, the species occurred in three hosts, *Rana limnocharis*, *R. temporalis* and *Micrixalus saxicola*. Of these the latter two are recorded here as new hosts for this parasite. The ciliate showed a number of shapes especially in the length of the beak which varied from individual to individual. In some, the beak was considerably reduced while in others it was exaggerated into a well developed tail. Bhatia and Gulati (1927) have described these forms with elongated beaks under a new species, *Opalina coracoidea lahorensis*. Metcalf (1940) while studying three infections of *O. coracoidea* from *R. cyanophlyctis* of Bogawan talava, Ceylon, found the beak to be either long or short or absent. These differences in the length of the beak were also present in the infections studied at Dharwar.

Measurements (in microns) for Opalina coracoidea Bezz.

Name of Host.	No. of parasites studied.	Body : length × breadth		Body (length : breadth) average.	Average nucleus (diameter).
		Range.	Average.		
<i>Micrixalus saxicola</i>					
Host I*	20	190-270 × 100-250	230 × 175	1.31 : 1	4-5
Host II†	27	150-240 × 90-155	195 × 122	1.51 : 1	4
<i>Rana temporalis</i> ‡ ..	31	125-325 × 70-200	225 × 135	1.65 : 1	4
<i>R. limnocharis</i> § ..	12	130-210 × 75-120	170 × 97	1.74 : 1	3-4

* Length of beak (average) 30-40.

† Length of beak (average) 30-40.

‡ Length of beak (average) 30-42.

§ Length of beak (average) 30-40

***Cepedea virgula* (Dobell) Metcalf.**

The ciliate was met with in *Philautus* sp. which was heavily infected. The horizontally placed endospherules were well stained with iron-haematoxylin.

Measurements in microns.—35 parasites.

Body (length \times breadth) : range, 80-125 \times 35-50 ; average, 102 \times 42 ; length : breadth (average), 2.33 : 1 ; average nucleus (diameter), 5.

***Cepedea philauti*, sp. nov.**

The body, clothed with short cilia, is cylindrical and somewhat fusiform with the posterior middle of the body having the greatest width. The anterior and the posterior ends are broadly rounded. The coarsely alveolated cytoplasm is not differentiated into ectosarc and endosarc and appears somewhat compact near the anterior pole. The features that are characteristic in this new species are the numerous large and oval nuclei spread irregularly in the cytoplasm. Incomplete transverse constrictions similar to those seen in *C. formosae* Met. were observed in some individuals.

Host.—*Philautus* sp.

Measurements in microns.—19 individuals.

Body (length \times breadth) : range, 255-360 \times 50-80 ; average, 307 \times 65 ; Average nucleus (diameter), 4-5. Dividing nucleus (oval), 10 \times 7. Cilia line interval, anterior region 1, posterior region, 2. Diameter of endospherule, 3-4.

Key to the species of Cepedea.

1 (3) Anterior end with a spine-like projection ..	2	
2 Body triangular in cross-section. Posterior end bluntly rounded. Length, 82 μ ..		<i>C. punjabensis</i> Bh. & G.
3 (1) Anterior end without a spine-like projection ..	4	
4 (15) Body greatly elongated	5	
5 (10) Body with transverse constrictions	6	
6 (9) With one or two incomplete constrictions ..	7	
7 (8) Spindle-shaped body with elliptical nuclei. Length, 170 μ		<i>C. formosae</i> Met.
8 (7) Fusiform body with spherical nuclei. Length, 307 μ ..		<i>C. philauti</i> sp. n.
9 (6) With many complete constrictions. Length, 365 μ ..		<i>C. segmentata</i> . Met.
10 (5) Body without any constrictions	11	
11 (12) Nuclei ellipsoidal. Length, 680-1000 μ ..		<i>C. longa</i> Bezz.
12 (11) Nuclei spherical	13	
13 (14) Cilia short. Length, 848		<i>C. dolicosoma</i> Met.
14 (13) Cilia long. Length, 500 μ		<i>C. ophis</i> Met.
15 (4) Body not greatly elongated .. .	16	
16 (25) Body cylindrical	17	
17 (24) Sides of the body curved, anterior end rounded and posterior tapering to a point	18	
18 (19) With a naked spine at the posterior pole small round nuclei (diameter) 3.8 μ , Length, 124 μ ..		<i>C. spinifera</i> Met.
19 (18) Without a naked spine at the posterior pole ..	20	
20 (23) Nuclei spherical	21	
21 (22) Endospherules round and irregularly placed Length, 180 μ		<i>C. dimidiata</i> Stein.
22 (21) Endospherules elongated and transversely placed Length, 98 μ		<i>C. virgula</i> (Dobell)

23 (20) Nuclei dumbell-shaped. Length, 131 μ	<i>C. celebensis</i> Met.
24 (17) Sides of the body straight. Anterior end presenting a vacuolated appearance. Posterior end rounded, sometimes pointed. Length, 125—440 μ ..	<i>C. thiagi</i> De Mello.
25 (16) Body lanceolate. Anterior end broad and rounded. Posterior, slender and tapering to a point. Nuclei only 4 or 5, Length, 82 μ ..	<i>C. lanceolata</i> Met.
26 (25) Body obovate. Length, 315 μ	<i>C. obovoidea</i> Met,
27 (26) Body globose ..	28
28 (29) Nuclei elliptical. Cilia dense and long. Length, 170 μ ..	<i>C. globosa</i> Met.
29 (28) Nuclei spherical. Cilia sparse and short. Length, 87 μ ..	<i>C. bandivii</i> Met.
30 (27) Body sub-cylindrical ..	31
31 (32) Both ends rounded or anterior end less pointed than the posterior. Length, 35—250 μ	<i>C. subcylindrica</i> De Mello.
32 (31) Both ends pointed. Length, 64—89 μ	<i>C. sialkoti</i> Bh. & G.

***Cepedea dimidiata naglavensis* subsp. nov.**

Description and discussion.—

Cepedea dimidiata has a number subspecies. They are generally described as slender, more slender, stocky and Zelleriella forms. De Mello (1944) found more slender forms in the present host (*R. cyanophlyctis*) from Nova Goa, and named them as *C. dimidiata cottoniana*. The forms found in *R. cyanophlyctis* from Dharwar differ from *cottoniana* in having a much attenuated posterior end, and also in having a greater number of nuclei. The present sub-species is named as *Cepedea dimidiata var. naglavensis* after the locality from where the host was collected.

Host.—*Rana cyanophlyctis*

Measurements in microns.—28 parasites.

Body (length \times breadth): range, 180-255 \times 15-30; average 207 \times 22, length: breadth (average), 9.40:1. Average nucleus (diameter): 3-4.

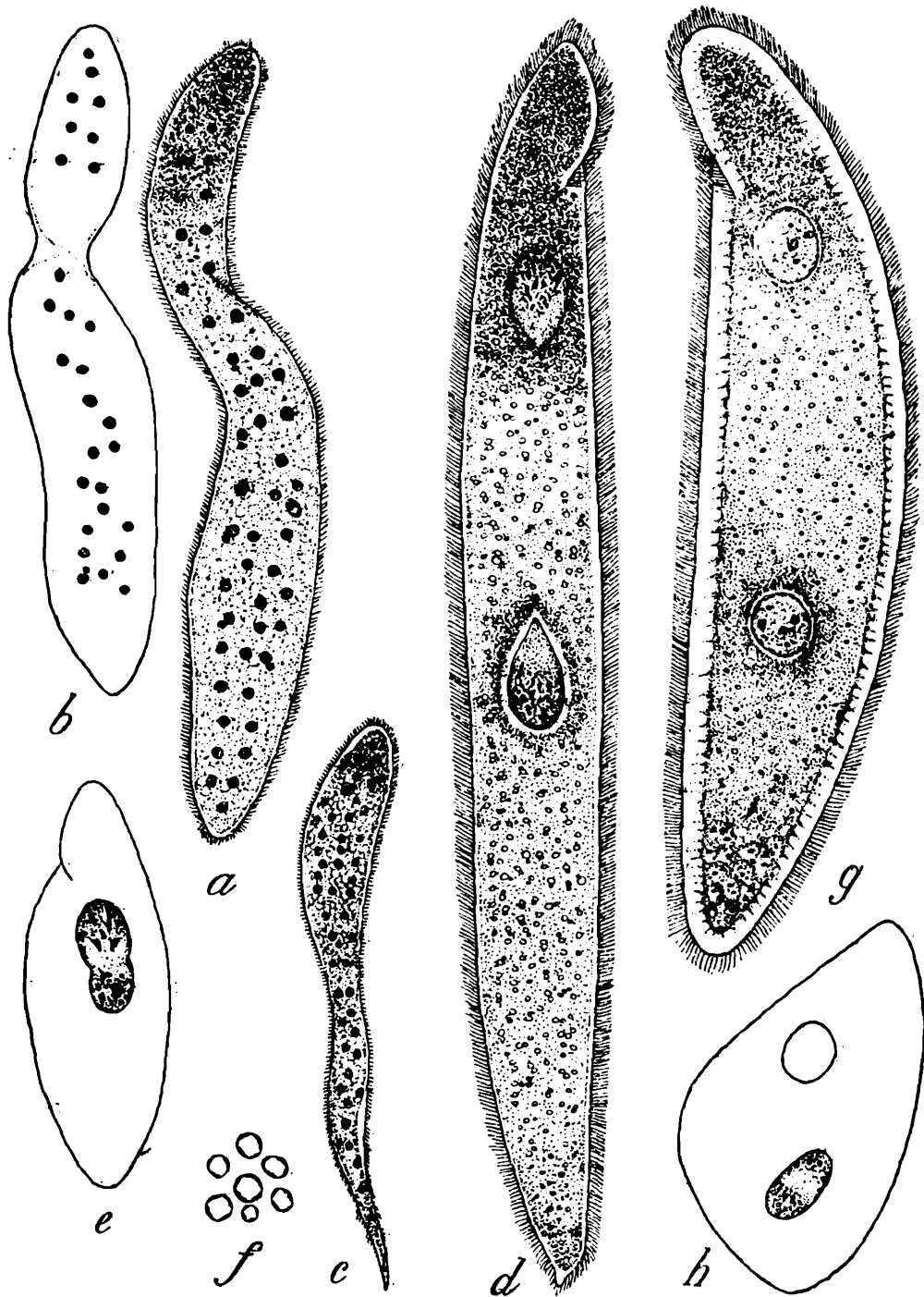
Key to subspecies of C. dimidiata

1 (2) Anterior end broadly rounded with a narrow posterior end ..	3
3 (4) Posterior pole rounded. Body (length \times breadth), 138 \times 45 μ , nucleus diameter 4 μ ..	<i>C. d. paraguensis</i> Met.
4 (3) Posterior end slender and rounded. Cilia longer. Body (L \times B), 180 \times 45 μ . Nucleus diameter 4 μ	<i>C. d. orientalis</i> Met.
2 (1) Body lanceolate. Anterior end slender and posterior end attenuated to a pointed end ..	5
5 (6) Posterior tip pointed. Body (L \times B), 120—140 \times 25 μ . Nucleus large 4-5 μ ..	<i>C. d. cottoniana</i> De Mello.
6 (5) Posterior end much attenuated ending in a sharp point. Nuclei small and spherical, 3—4, μ , in diameter, Body (L \times B). 207 \times 22 μ	<i>C. d. naglavensis</i> , subsp. nov.

***Protoopalina indica*, sp. nov.**

Description.—The body is cylindrical, broadest near the anterior end and gradually tapering towards the posterior. The anterior pole is bent to one side while the posterior narrowing into a rounded point appears somewhat mamilliated. The cytoplasm is not well differentiated into cortical and medullary zones. Numerous large oval endospherules (stained well with iron-haematoxylin) were seen in the medullary zone. Towards the anterior pole these endo-spherules aggregate, so

that, a more compact and denser region is formed. It is somewhere in this compact region that the anterior nucleus is usually located while the posterior nucleus is almost always in the middle of the body. The two pear-shaped nuclei are so placed that they lie with their pointed ends facing one another. The so called nuclear thread (consisting of attenuated nuclear membrane) connecting the two nuclei was not



TEXT-FIG. 1. *a* and *b*.—*Cepedea philauti*, sp. nov. *a*. Normal individual showing general structure : $\times 215$; *b*. Dividing individual : $\times 215$; *c*. *Cepedea dimidata naglavensis*, sub sp. nov. : $\times 430$. *d-e*.—*Protoopalina indica* sp. nov. *d*. Normal individual showing general structure : $\times 430$; *e*. Daughter individual from a recent division; *f*. Endospherules under oil-immersion objective; *g* & *h*.—*Protoopalina karnatakensis*, sp. nov. *g*. Full grown slender individual showing general structure : $\times 430$; *h*.—A stooky (Zelleriella) form in division : $\times 430$.

visible. The chromatin element of the nucleus in the normal individual is broken up into numerous bits (the nucleoli) the exact number of which could not be determined. In some the number was more than

twenty. The cilia were long and thick. Individuals undergoing division (both transverse and longitudinal), were present. The daughter cells come from transverse division were all uninucleated.

Host.—*Microhyla ornata*

Measurements in microns.—61 individuals.

Body (length \times breadth): range, 135-415 \times 40-75; average (L \times B) 275 \times 57; length: breadth (average) 4.82 : 1; nucleus (length \times breadth): range, 27-33 \times 14-17. Endospherule (length \times breadth): range, 2.5-3.5 \times 1.5-2. Cilia line interval, anterior region, 1.8; middle region 2.10; posterior region, 3.00. Width of ectosarc, 3.00.

Comparison.—On account of its slender pointed posterior end, as well as the body measurements and the shape of the nucleus, *P. indica* is classed under the sub-generic group II (Metcalf 1940, p. 571-576).

The following table shows the specific differences of the group.

Key to subgeneric group II.

- | | |
|--|-----------------------------------|
| 1 (2) Posterior pole tapering to a sharp point and sometimes with a posterior process | 3 |
| 3 (6) Posterior end broad and abruptly ending in a point | 4 |
| 4 (5) Posterior end not curved. Nucleoli 6 in number
Nucleus (L \times B) 40 \times 26 μ . Body (L \times B) 200 \times 95 μ | <i>P. caudata</i> (Stein). |
| 5 (4) Posterior end curved. Tail large and blunt. Nucleoli 8 in number. Nucleus (L \times B) 30 \times 14 μ .
Body (L \times B) 90 \times 74 μ | <i>P. macrocaudata</i> Met. |
| 6 (3) Posterior end elongated and gradually tapering to a narrow point | 7 |
| 7 (10) Posterior pole rounded or sometimes pointed | 8 |
| 8 (9) Nucleoli 8 in number. Nucleus pear-shaped (L \times B) 32 \times 10 μ . Body (L \times B) 330 \times 68 μ | <i>P. intestinalis</i> . (Stein). |
| 9 (8) Number of nucleoli undetermined. Oval nucleus, (L \times B) 23 \times 13 μ Body (L \times B) 288 \times 63 μ | <i>P. orientalis</i> Met. |
| 10 (7) Posterior pole mamilliated. Nucleoli 20 in number. Nucleus pear-shaped, (L \times B) 27 \times 14 μ .
Body (L \times B) 275 \times 57 μ | <i>P. indica</i> sp. nov. |
| 2 (1) Posterior pole tapering to a broadly rounded point | 11 |
| 11 (12) Nuclei close together in centre. Nucleus oval (L \times B) 18 \times 10 μ . Body (L \times B) 230 \times 46 μ .
Nucleoli number not mentioned | <i>P. yunnanensis</i> Met. |
| 12 (11) Nuclei far apart | 13 |
| 13 (14) With definite number of nucleoli.— | |
| (a) Nucleoli 6 in number. Body (L \times B) 170 \times 24 μ .
Nucleus (L \times B) 14 \times 9 μ | <i>P. stejnegeri</i> Met. |
| (b) Nucleoli 8 in number. Slender Body (L \times B) 97 \times 18 μ . Nucleus ellipsoidal (L \times B), 10 \times 6 μ | <i>P. pelobatides</i> Met. |
| (c) Nucleoli 4 in number. Body (L \times B) 240 \times 68 μ .
Nucleus (L \times B) 25 \times 8.9 μ | <i>P. dorsalis</i> (Raff). |
| (d) Nucleoli 3 in number. Nucleus (L \times B) 6 \times 2 μ ,
(anaphase). Body (L \times B) 63 \times 11 μ | <i>P. caccosterni</i> Fantham. |
| 14 (13) With an undetermined number of nucleoli | 15 |
| 15 (16) Nucleus ellipsoidal (L \times B) 10 \times 6 μ . Body (L \times B) 160 \times 32 μ | <i>P. peronii</i> Met. |
| 16 (15) Nucleus rounded | 17 |
| 17 (18) Nucleus smaller (diameter) 10 μ . Body (L \times B) 572 \times 70 μ | <i>P. hylarum</i> (Raff). |
| 18 (17) Nucleus large (diameter) 19 μ . Body (L \times B) 313 \times 70 | <i>P. luzonensis</i> Met. |

Protoopalina karnatakensis, sp. nov.

Description.—The body is somewhat cylindrical with its anterior end elongated and bent to one side. One side of the body is slightly curved while the other is nearly straight. The posterior and the anterior poles are broadly rounded.

Two forms, namely, (i) slender and long, and (ii) stocky and broad were recognised. The cytoplasm is very well differentiated into the cortical and the medullary zones. The medulla is dense and contains endospherules which are small and sparse. The two nuclei almost spherical in shape, are placed quite apart along the vertical axis of the body. The posterior nucleus is situated somewhat away from the middle of the body, while the anterior nucleus is located more or less near the compact anterior region as in *P. indica*. The nuclear strand could not be traced at all. The chromatin of the nucleus consists of 4-6 nucleoli. The cilia are long and fine, but are shorter as compared to those of *P. indica*.

Host.—*Microhyla ornata*.

Measurements in microns.—16 individuals. (slender and elongated) : length \times breadth (average), 167×47 . 14 Zelleriella forms measured : length \times breadth (average), 85×35 . Diameter of the nucleus, 13.5. Endospherules (diameter) 1-2. Cilia line interval, 1.5-3.2.

Width of ectosarc 5.5.

Comparison.—Because of its flattened body form and dumbbell-shaped nuclei, *P. karnatakensis* belongs to the sub-generic group V of Metcalf.

The species of this group are arranged in key below :—

- | | | |
|---------|--|------------------------------------|
| 1 (8) | Nuclei spindle-shaped or elliptical .. | 2 |
| 2 (5) | Body elliptical | 3 |
| 3 (4) | Nuclei connected by a thread, elliptical (L \times B)
13 \times 3 μ . Body (L \times B) 106 \times 26 μ .. | <i>P. mossambicensis</i> Met. |
| 4 (3) | Nuclei not connected by a thread, Long nucleus
(L \times B) 17 \times 6 μ . Body (L \times B) 76 \times 30 μ .. | <i>P. longinucleata</i> Met. |
| 5 (2) | Body broadened anteriorly and sharply pointed
behind | 6 |
| 6 (7) | Nucleoli 8 in number. Body (L \times B) 196 \times 30 μ .
Nucleus (L \times B), 30 \times 13 μ .. | <i>P. regularis</i> Met. |
| 7 (6) | Nuclei 6 in number. Body (L \times B) 119 \times 30 μ .
Nucleus (L \times B) 22 \times 8 μ .. | <i>P. rhinodermatos</i> Met. |
| 8 (1) | Nuclei ovoidal or dumbbell-shaped .. | 9 |
| 9 (12) | Posterior pole with a narrow posterior process .. | 10 |
| 10 (11) | Nuclei 4 in number. Body (L \times B) 90 \times 40 μ .
Nucleus (L \times B) 27 \times 6.2 μ .. | <i>P. xamachana</i> Met. |
| 11 (10) | Nucleoli 6-10 in number. Body (L \times B) 102 \times 42
μ . Dumbell-shaped nucleus, (L \times B) 17 \times 12 μ | <i>P. bufonis</i> Met. |
| 12 (9) | Posterior pole broadly rounded. Nucleoli 4-6 in
number. Slender forms (L \times B) 167 \times 47 μ .
Zelleriella forms (L \times B) 85 \times 35 μ . Nucleus
ovoidal 13.5 \times 13 μ | <i>P. karnatakensis</i> , sp. nov. |

Protoopalina dharwarensis, sp. nov.

Description.—The body as compared to the previous species (*P. indica* and *P. karnatakensis*) is much elongated and more slender. The anterior and the posterior poles are broadly rounded and look alike. The granular cytoplasm is not well differentiated into ectosarc and endosarc as in *P. indica* and *P. karnatakensis*. The spherules in the endosarc are fine and appear somewhat elliptical in form. Often, some minute chromatinlike bodies appear to group together towards the posterior end of the body. A group of vacuoles (constituting the excretory system) are also seen at this region. The two round nuclei are placed in the anterior half of the body. In some individuals, a halo is often present round the nuclei. The chromatin consists of small and irregular bits. Approximately 6 nucleoli were observed in one of the dividing nuclei. The nuclear thread was absent.

Host.—*Microhyla ornata*.

Measurements in microns.—15 individuals. Body (L×B) : average, 207×25 ; L : B 8·02 : 1. Nucleus (i) 11·5×9, (ii) 13·5×11, (iii) 12·5×9·5.

Diameter of endo-spherule, anterior region 1·5 ; posterior region 2·2. Cilia line interval, anterior region 1·5-2 ; posterior region, 3·3. Width of ectosarc 2.

Because of the bodyform, the species is referred to the subgeneric group IV, the key to the species of which is given below.

Key to the species of Group IV

- | | | |
|--|---------|-----------------------------------|
| 1 (4) Nuclei pear-shaped | .. .. . | 2 |
| 2 (3) Nucleoli apparently 6 in number. Body filiform (L × B) 300 × 35 μ. Nuclei connected by a thread, Nucleus (L × B) 25 × 6 μ | .. .. . | <i>P. filiformis</i> Met. |
| 3 (2) Nucleoli 10 in number. Body flattened (L × B) 238 × 22·8 μ. Nuclei (L × B) 22·8 × 9·5 μ | .. .. . | <i>P. limnocharis</i> , Nie. |
| 4 (1) Nuclear shape otherwise | .. .. . | 5 |
| 5 (6) Nuclei elliptical. Body very much attenuated. "Nucleoli in the form of 16 small chromatin masses." Body (L × B) 530 × 36 μ. Nucleus (L × B) 24 × 9 μ | .. .. . | <i>P. tenuis</i> (Raff) |
| 6 (5) Nuclei oval or round. Body elongated and slender. Nucleoli apparently 6 in number. Nucleus reticulate (L × B) 11·5 × 9 μ. Body (L × B) 207 × 25 μ | .. .. . | <i>P. dharwarensis</i> , sp. nov. |

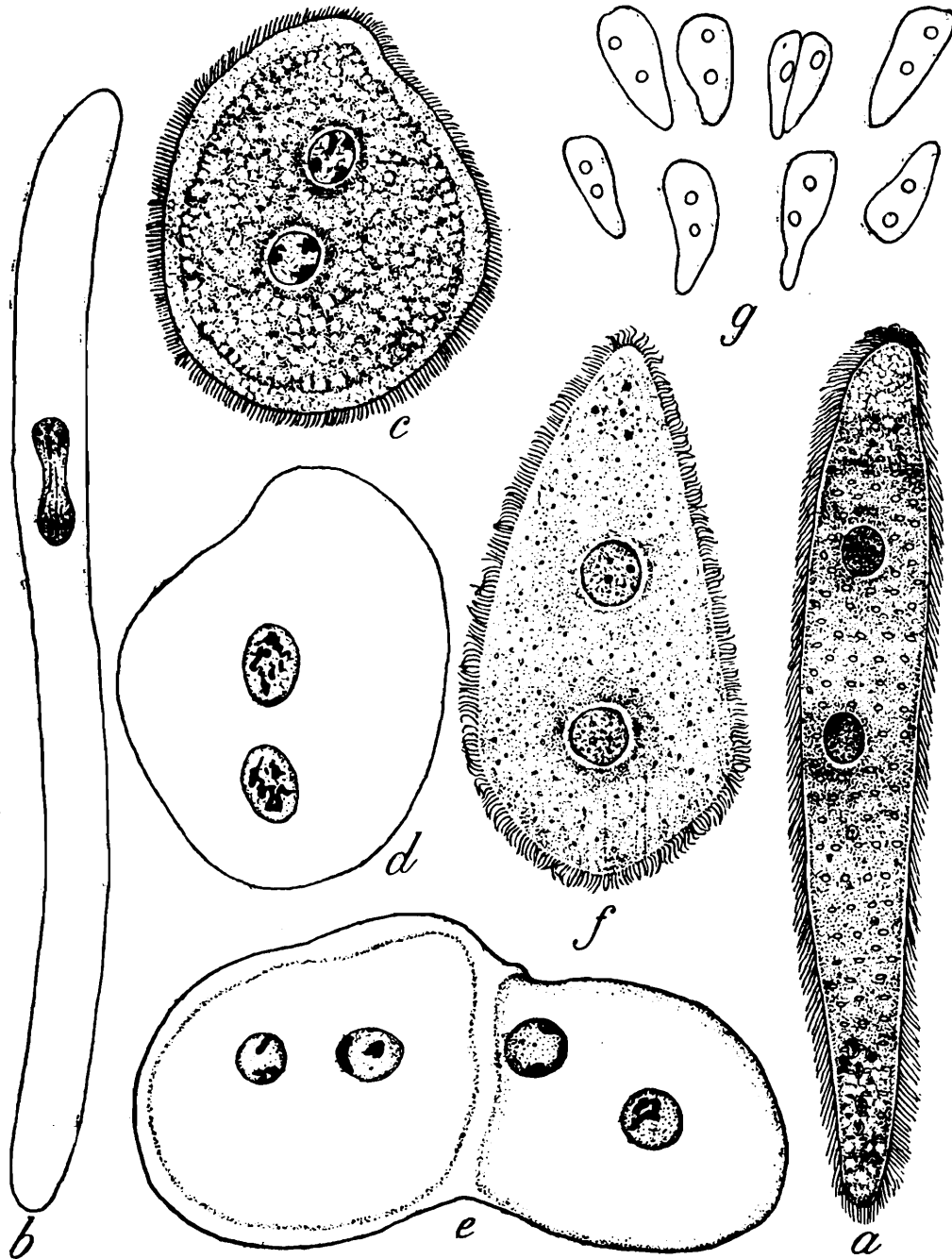
Zelleriella microhylae, sp. nov.

Description.—The body is round and flat. The posterior projection as reported by Nie (1935) in *Z. orientalis* is not present. The coarsely alveolated cytoplasm is differentiated into a thin ectosarc and a dense endosarc. The small, oval and well stained endospherules give the endosarc a dense appearance. The two nuclei almost spherical are obliquely placed over one another in the cytoplasm. In the normal state, the nucleoli (4-6 in number) appear as large irregular bits of chromatin hanging from the surface of the nucleus. The cilia are short, fine and uniformly distributed all over the body. Various stages of mitotic divisions of the nucleus were observed

Host.—*Microhyla ornata.*

Measurements in microns.—34 individuals.

Body (length \times breadth) : range 70-110 \times 60-80 ; average (L \times B) \times 70, Length : Breadth (average) 1.28 : 1 ; Dividing individual (L \times B),



TEXT-FIG. 2. *a* and *b*.—*Protoopalina dharwarensis* sp. nov. *a*. Normal individual showing general structure : \times 430 ; *b*. Daughter cell from a longitudinal division showing dumbbell-shaped nucleus : \times 430. *c-d.*—*Zelleriella microhylae*, sp. nov. *c*. Normal individual showing general structure : \times 430 ; *d*. Nuclei in prophase : \times 430 ; *e*. Dividing individuals with nuclei in telophase : \times 430. *f. & g.*—*Zelleriella froilanoi*, sp. nov. *f*. Normal individual showing general structure : \times 430 ; *g*. Dividing individuals under low power : \times 100.

150 \times 90. Diameter of the resting nucleus, 10-13. Cilia line interval : anterior region, 3 ; posterior region, 4. Length of the cilia, 8. Width of ectosarc, 4-4.5.

Zelleriella froilanoi, sp. nov.

Description.—The body is thin, flat and bluntly rounded at the posterior end. The anterior pole is broad and round. The posterior one is tapering to a rounded point. The small and stocky forms have somewhat a wedge-shaped body. Unlike *Z. microhylae*, the cytoplasm is not well differentiated into the usual zones. The protoplasm is very finely granulated and is evenly distributed. Cytoplasmic inclusions in the form of very fine granules which stain like chromatin were seen in some individuals. The oval endospherules are small and sparsely distributed in the cytoplasm. Some small and large vacuoles are often seen to group together at the posterior pole of the body. The two spherical nuclei are placed one over the other in the vertical axis of the body. The chromatin is found to be in the form of minute granules and not in large bits as seen in *Z. microhylae*. In the dividing nucleus the nucleoli were approximately 8 in number but usually varied from 6-8.

Host.—*Philautus* sp.

Measurements in microns.—71 individuals.

Body (length \times breadth) : range 80-150 \times 25-55 ; average (L \times B), 115 \times 40 : Length : Breadth (average) 2.87 : 1 ; diameter of the nucleus 10-12. Distance between the two nuclei 15-30. Length of the cilia, 12. Cilia line interval, 3.

Key to the species of Zelleriella.

- | | | | |
|--------|---|-------|--------------------------------|
| 1 (13) | Body without a posterior curved process | .. | 2 |
| 2 (7) | Body with a posterior end narrowly elongated and pointed.— | | |
| | (a) Body, trumpet-shaped, posterior end elongated. | | |
| | Body (L \times B), 180—220 \times 75—100 μ . | | |
| | Nucleus spherical, 20-22 μ diameter | .. | <i>Z. cornucopia</i> Carini. |
| | (b) Body cone-shaped. Posterior pole rounded. | | |
| | Nucleus spherical 15-17 μ in diameter ; | | |
| | distance between two nuclei 20-25 μ . Body | | |
| | (L \times B), 100 \times 30 μ | .. | <i>Z. falcata</i> Carini. |
| | (c) Body comma-shaped. Posterior pole pulled to a point. Body 70-90 μ in length. Diameter of the spherical nuclei, 8-10 μ ; distance between two nuclei, 10 μ | .. .. | <i>Z. corniola</i> Carini. |
| | (d) Body wedge-shaped | .. .. | 3 |
| 3 (4) | Nuclei ellipsoidal or pear-shaped (number of nucleoli not mentioned) ; Body (L \times B) 207 \times 130 μ . Nucleus (L \times B) 32 \times 22 μ | .. .. | <i>Z. magna</i> Met. |
| 4 (3) | Nuclei spherical | .. .. | 5 |
| 5 (6) | Body very thin and broadly wedge-shaped ; L \times B, 115 \times 40 μ . Nucleus diameter 10-12 μ . Nucleoli 6-8 in number. Distance between two nuclei, 15-30 μ | .. .. | <i>Z. froilanoi</i> , sp. nov. |
| 6 (5) | Body narrowly wedge-shaped. Body (L \times B), 93 \times 50 μ . Nucleoli 4 in number. Nucleus diameter 10 μ | .. .. | <i>Z. intermedia</i> Met. |
| 7 (2) | Body with a posterior end broadly rounded.— | | |
| | (a) Body irregularly rounded, thin and leaf-like. | | |
| | L \times B, 300 \times 200 μ . Nucleoli 8 in number. | | |
| | Spherical nucleus 25 μ | .. | <i>Z. foliacea</i> Carini. |

- (b) Body triangular with a truncated posterior end.
Spherical nuclei 10-12 μ . Body (L \times B),
80-150 \times 45-65 μ *Z. truncata* Carini.
- (c) Body oval and greatly flattened .. 8
- 8 (12) Nuclei rounded—
- (a) Nuclei large, 20 μ in diameter *Z. binucleata* (Raff.
- 9 (8) Nuclei smaller 10
- 10 (11) Nucleus 12 μ . in diameter. Nucleoli 3-4 number .. *Z. macronucleata* Bezz.
- 11 (10) Nucleus 10-13 μ in diameter. Body thick (L \times B),
70-110 \times 60-80 μ . Nucleoli 4-6 in number .. *Z. microhylae*, sp. nov.
- 12 (8) Nuclei ovoidal (L \times B) 15 \times 10 Nucleoli 4 in
number. Body (L \times B) 130 \times 82 μ *Z. brasiliensis* (Pinto).
- 13 (1) Body with a posterior curved process .. 14
- 14 (15) Posterior tail long and distinct, Nuclei (L \times B)
23 \times 13.9 μ . Body (L \times B) 100 \times 60 μ .. *Z. antanesi* Pessoa.
- 15 (14) Posterior tail otherwise .. 16
- 16 (17) Posterior end terminates to a minute sharp point.
Nucleoli 8 (?) in number. Body leaflike, (L \times B)
87.5-120 \times 45-70 μ . Nucleus 12.5 μ in diameter .. *Z. orientalis* Nie.
- 17 (16) Body broad anteriorly. Nucleoli 3 in number.
Nucleus 10 μ in diameter. Body (L \times B) 105 \times 80
 μ *Z. bufonix* Met.

SUMMARY.

1. The ciliate parasites of about one hundred and twenty-five specimens of frogs and toads of Karnatak, Bombay Presidency, comprising nine different species have been studied particularly with a view to ascertain the presence of binucleated opalinids in them.

2. Five new species of *Zelleriella* and *Protoopalina* have been described, thus establishing, beyond doubt, the presence of binucleated opalinids in these anurans.

3. Ciliate parasites of six of the host species have been recorded for the first time in India; and some more ciliates have been added to the list of parasites of the hosts already examined. Besides one new species and one new sub-species of the genus *Cepedea*, ten old species of ciliates found parasitic in the gut of these anura have also been recorded.

REFERENCES.

- BEZZENBERGER, E., 1904.—*Über Infusorian aus asiatischen Anuren.*
Arch. Protistenkd. III, pp. 138-174.
- BHATIA, B. L., 1936.—*Faun. Brit. Ind., Protozoa : Ciliophora.*
- BHATIA, B. L., and GULATI, A. N., 1927.—On some parasitic ciliates from
Indian frogs, toads, earthworms and cockroaches. *Arch. Protis-*
tenkd. XVII, pp. 85-120.
- CARINI, A., 1939.—Contribuica ao estudo dos nictoteros dos batraquos
of Brazil. *Archios de Biologia ano, S. paulo* XXIII, pp. 202
-203.
- CHAKRAVORTI, M. M., (1933).—Boring apparatus in *Balantidium.* *Curr.*
Sci. I, pp. 345-346, figs. 1-3.

- DE MELLO, A. F., 1944.—Further additions to the list of ciliates living in the intestine of *Rana cyanophlycits*. *Journ. As. Soc. Beng.* X, pp. 1-7.
- DOBELL, C. C., (1910).—On some parasitic Protozoa from Ceylon. *Spolia Zeylan.* VII, pp. 65-87.
- DE MELLO, I. F., 1932.—Contribution ale etude infusorie parasites des anure du malabar. *Rec. Ind. Mus.* XXXIV, pp. 89-124.
- MCCANN, C., 1932.—Notes on Indian Batrachians. *Journ. Bomb. Nat. Hist. Soc.* XXXVI, pp. 152-180.
- METCALF, M. M., 1923.—The Opalinid ciliate infusorians. *U. S. Nat. Mus. Bull.* CXX, pp. 1-484.
- , 1940.—Further studies on the Opalinid ciliate infusorians and their hosts. *Ibid.* LXXXVII, pp. 465-634.
- RAY, H., 1932.—On the Morphology of *Balantidium sushillii* n. sp. from *Rana tigrina*, Daud. *Journ. Roy. Micr. Soc.* LII, pp. 374-82, 1 pl., 5 text-figs.
- NIE DA SHU, 1935.—Intestinal ciliates of Amphibia of Nanking *Contr. Biol. Lab. Sci. Soc. China, Zool. Ser.* II, pp. 66-95.
- STEIN F., 1867.—Der organismus der infusoriere nach eigenen forschungen in systematische Reihenfolge bearbatet. *Algemeine u Heterio Leipzig.* II, pp. 309-327.