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Diversity of Zooplankton in Mountainous Organic based Paddy cum Fish Cultivation ecosystem in Ziro, Arunachal Pradesh

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Abstract

Zooplankton in the organic based mountainous paddy fields play an important role for the holistic development of fisheries and aquaculture sector, promoting livelihoods, food and nutritional security. Five major communities of zooplankton namely Cladocera, Copepoda, Rotifera, Protozooplanktonand Ostracoda were found in the study area where 34 species under Cladocera, 7 species under Copepoda along with some nauplii, 17 species under Rotifera and 1 species under Ostracoda and among protozooplankton 5 species under Protozooplankton, were recorded. Simpson dominance index revealed that *Bosmina*, *Chydorus*, *Cyclops*, *Diaptomus*, *Brachionus*, *Keratella*, *Arcella* were found as the most dominant zooplankton species. Shannon diversity index showed that Cladocera (2.45)> Copepoda (1.44)>Rotifera (1.30)>Protozooplankton (1.27). Margelef richness index showed that Cladocera (5.64)> Copepoda (1.65)> Rotifera (1.10)>Protozooplankton (1.33). The physico-chemical parameters of the rice field water as well as the structure and dynamics for the growth and abundance of zooplankton in the rice field also the productivity of rice and fish yield. It can be concluded that diversified zooplankton species has found in the organic nature paddy fields which have the reflection of the healthy ecosystem of Organic paddy fields. This type of ecosystems will be helped to attain of the three goals of sustainable development viz. **Goal 12** (Responsible consumption and production), **Goal 13** (Climate action), **Goal 14** (Life below water) by enhancement of blue revolution of the country.

Keywords: Diversity, paddy field, zooplankton, mountainous, SDG

Introduction

The mountainous paddy cum fish cultivation ecosystem in Ziro, Arunachal Pradesh is an organic based and eco-friendly culture practice (Noorhosseini and Bagherzadeh, 2013). The Apatani farmers stock mainly three strains of Common carp viz., *Cyprinus carpio specularis*, *Cyprinus carpio communis*, *Cyprinus carpio nudus* into the paddy fields (Das *et al*., 2007). The stocked fishes depend on the natural food sources like agricultural wastes, excreta of domestic animals like pig (*Sus scrofa scrofa*), cow (*Bos taurus*), Mithun (*Bos frontalis*) and goat (*Capra aegagrus hircus*) rather they use any supplementary fish feed (Ali, 1988; Saikia & Das, 2009). As the rice growing season starting from of May till end of September, the stocked fishes are harvested twice in a season. i.e. in the middle of July and October. They dependent on natural sources of water like diverted mountain streams and trickle down rain water of the monsoon season. Bamboo pipes are used to maintain the water level as well as dewatering the field at time of harvest (Saikia & Das, 2004).

Zooplankton, the free floating aquatic microorganisms are

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influencing the biogeochemical role towards the development of paddy field fishery. These organisms cope up with the frequently changing different growth phases of paddy and forms a congenial habitat for rich number of diversified species (Heckman, 1979; Simpson & Roger, 1995; Simpson *et al.*, 1994). Zooplankton enter into the paddy fields through both irrigation water and to form microhabitat underneath the paddy field water (Fernando, 1995 & 1996). Although, the paddy fields drastically change its limnology within a very short period of time, zooplankton can inhabit and flourish in such condition (Bambaradeniya *et al.*, 2004) and become readily available to the different categories of consumers in the paddy fields including stocked young carps (Shil *et al.*, 2013; Guangjun, 2013). Hence, zooplankton has immense role for the sustenance of the organic paddy practices.

Material and Methods

Study area: The mountainous paddy cum fish culture site is located in Ziro valley of Lower Subansiri district of Arunachal Pradesh, India (**Figure 1**). It is located between 26°50'-98°21' N latitude and 92°40'-94°21' E longitude with an altitude about 5000 ft. above mean sea level (asl). The total area of where paddy-fish culture is approximately 10,135 km^2 out of 592.0 ha of irrigated paddy lands (Saikia and Das, 2004).

Sampling and analysis

Plankton samples were randomly collected by filtering 25 L of field water through 60 μm diameter mesh in the rice growing season of 2013 & 2014. The concentrated samples were preserved immediately in 4% formaldehyde solution. The preserved samples were identified by using binocular light microscope (Model: Nikon, ECLIPSE E200, Olympus CX4 and Leica DM 5000). Lackey's (1938) drop count method was used for quantification Zooplankton samples. Species of zooplankton was identified by following standard keys and monographs of Smirnov (1971); Needham & Needham, (1972); Tonapi, (1980); Battish, (1992); Edmonson, (1992); Kotov *et al.* (2012). The frequency of sampling whether it is monthly or yearly or seasonal to be mentioned, the details of the localities and how many localities collected also to be mentioned. Water samples collected monthly for physico-chemical parameters and analyzed by using APHA (2012). The yield records of rice and fish for each of the rice fields were obtained from the farmer (owner) through personal interview of the study plots.

Formula for calculation

$$\text{Number of individuals per liter} = \frac{N_1 \times V_1}{N_2 \times V_2}$$

Where,

N_1= Number of organisms per drop

V_1= Volume of concentrated sample (ml)

V_2= Volume of original sample (L)

N_2= Volume of 1 drop (ml)

Shannon Weiner index (H), Buzas Gibson index (e^H/S), Margelef index were used to estimate month wise and village wise species diversity, richness and evenness of the zooplankton community (**Table 3-8**). The equations are as follows.

(a) Shannon-Weiner diversity index

$$H' = -\sum_{i=1}^{s} \frac{ni}{N} ln \frac{ni}{N}$$

[Where, n_i= number of individuals of taxon i, n= Total number of individuals]

(b) Buzas-Gibson evenness index

$$e^{\wedge} = \frac{eH'}{S}$$

[Where eH' = Shannon-Weiner index, calculated using natural logarithms, S = Number of species]

(c) Margalef richness index

$$D_{mg} = \frac{S-1}{lnN}$$

[Where S= Number of species, N= Total number of individuals in the sample]

Results and Discussion

From the results, it was recorded that the village wise of water physico-chemical parameters (**Table 1**) were varied different sampling stations. Pine grobe has highest mean value of DO (7.87 mgl^{-1}), TDS (415.93 mgl^{-1}), TA (32.38 mgl^{-1}), CaH (12. 10 mgl^{-1}), SC (726.50 μScm^{-1}), NO_3-N (0.08 mgl^{-1}), PO_4-P (0.15 mgl^{-1}), WD (16.50 cm), TH (20.22 mgl^{-1}), pH (6.66). Mudang tage has highest WT (27. 13° C) and AT (28.99° C) was during 2013. Similarly, Pine grobe showed highest peak mean value of DO (9.90 mgl^{-1}), TDS (349.90 mgl^{-1}), TA (31.11 mgl^{-1}), CaH (20.26 mgl^{-1}), SC (642.84 μScm^{-1}), NO_3-N

(0.76 mgl^{-1}), PO_4-P (0. 16 mgl^{-1}), WD (15.52 cm), Cl^{-1} (46.15 mgl^{-1}), TH (31.36 mgl^{-1}), pH (7.63) in 2013. The WT (27.83° C) and AT (28.19° C) was maximum in Mudang tage during 2014. However, in 2013, Cl^{-1} (48.98 mgl^{-1}) was maximum respectively in Mudang tage while minimum value of 2013 and 2014 was respectively in Tajang (28.94 mgl^{-1}) and Dutta (35.59 mgl^{-1}). The CaH (5.45 mgl^{-1}), NO_3-N (0.06 mgl^{-1}), pH (5.10) was lowest in Nenchalya, 2013. Mudang tage showed the lowest value of SC (398.67 μScm^{-1}) and WD (8.53 cm) where PO_4-P (0.05 mgl^{-1}) was lowest in Dutta in 2013. In 2014 also SC (400.23 μScm^{-1}) and WD (9.39 cm) was lowest in Mudang tage and PO_4-P (0.12 mgl^{-1}) was lowest in Dutta. The TDS (219.00 mgl^{-1}), TA (24.75 mgl^{-1}), NO_3-N (0.30 mgl^{-1}), TH (22.83 mgl^{-1}) and DO (5.59 mgl^{-1}) was also lowest in Mudang tage during 2014 only. In 2013, the lowest value of FCO_2 (12.97 mgl^{-1}), WT (25.51° C) and AT (27.69° C) was in Pine grobe and DO (5.60 mgl^{-1}) and PO_4-P (0.05 mgl^{-1}) was lowest in Dutta. In 2014, the lowest value of FCO_2 (7.74 mgl^{-1}), WT (23.08° C), AT (25.78° C) and PO_4-P (0.12 mgl^{-1}) followed similar trend. CaH (14.95 mgl^{-1}) and Cl^{-1} (35.59 mgl^{-1}) depicted their minimum value in Dutta during 2014. It was also observed that the TDS (266.36 mgl^{-1}), TH (9.71 mgl^{-1}), Cl^{-1} (28.94 mgl^{-1}) was lowest in Tajang, 2013. The minimum value of both pH (5.10) and TA (28.43 mgl^{-1}) as well as the maximum value of FCO_2 (19.68 mgl^{-1}) was in Nenchalya during 2013. The low pH (6.05), TA (22.83 mgl^{-1}) and high FCO_2 (12.97 mgl^{-1}) of Nenchalya was again noticed in 2014. Hossain *et al.* (2013) reported that the WT, 18.30˚C to 37.90˚C is suitable for growth of planktonic organisms. The low pH in April have occurred due to sudden submergence and decomposition of dry land flora and fauna and leftover rice stalks including metabolic wastes of the stocked fishes (Chowdhary *et al.*, 2000; Siddhartha *et al.*, 2012). Apatani farmers most frequently used to clear weeds in their wet rice fields that allowed sufficient solar influx into field water enhancing the multiplication of zooplankton.

It was also observed that Cladocera, Copepoda, Rotifera, Protozooplankton and Ostracoda under Zooplankton were recorded in the mountainous paddy fields of Ziro valley (**Figure 2**). A total of 34 species of Cladocera, 7 species of Copepoda with larval stages of nauplii, 17 species of Rotifera and 5 species of Protozooplankton, and only one species of Ostracoda (**Table 2**) were observed in the study period. Copepod nauplii were frequently occurring during the whole sampling periods indicated their active reproductive phases (Sharma, 2011; Bhat *et al.*, 2014) in the flooded fields. Zooplankton community structure showed significant variability in terms of diversity, richness and evenness within a very short period of time which probably governed by the cumulative effect of physico-chemical and biological parameters. Shannon diversity index (**Table 3**) showed that Cladocera (2.45)>Copepoda (1.44)>Rotifera (1.30)>Protozooplankton (1.27). Margelef richness index (**Table 4**) showed that Cladocera (5.64)>Copepoda (1.65)>Rotifera (1.10)>Protozooplankton (1.33). The diversity and richness indices indicated that Cladocera has the highest diversity which was matched with the findings Ali (1990) in the flooded paddy fields.

Cladocera (0.515) and Copepoda (0.404) showed highest evenness in Pine grobe and lowest (0.226, 0.297) in Tajang (**Table 3** & **4**). However, Protozooplankton showed its peak (0.980) value in Tajang and dip (0.926) value in Dutta (**Table 6**). Rotifera was highest (0.671) evenness in Nenchalya and lowest (0.509) in Mudang tage (**Table 7**). The species (*Cypris* sp.) under Ostracoda had equal value of evenness in the sampling villages (**Table 8**). Zooplankton and some other invertebrates select phytoplankton and periphyton as the most preferable source of trophic resource for their growth and survival (Feminella & Hawkins, 1995). So, the abundance and diversity of both phytoplankton and periphyton are greatly influenced by the population fluctuation of Zooplankton, the herbivore grazers. The predatory action of Copepods might have decreased the abundances of Rotifers in the end phase of rice (Badsi *et al.*, 2010).

The Margelef index of Cladocera (5.111) and Copepoda (1.930) showed maximum richness in Pine grobe (**Table 3** & **4**). The minimum (4.201) richness of Cladocera was in Dutta and Copepoda (1.840) was in Nenchalya and Mudang tage (**Table 2** & **3**). Again, Rotifera (3.892) and Protozooplankton (0.814) respectively showed their highest richness in Tajang and Dutta (**Table 6** & **7**). The rich diversity of both Protozooplankton and Rotifera perhaps due to the higher population of bacteria and low water flow which caused decomposition of household sewages that ultimately enhanced the production rate of organic materials (Sharma *et al.*, 2014). But lowest richness of Rotifera (3.607) was in Mudang tage and Protozooplankton (0.785) was in Pine grobe (**Table 6** & **7**). It was observed that Ostracoda had no richness value (**Table 8**).

The Shannon diversity index of Cladocera (2.670) and Copepoda (1.397) showed the highest diversity in Pine grobe (**Table 4** & **5**) whereas lowest diversity was observed in Tajang (1.846, 1.090). The highest diversity and species richness of

Cladocera and Copepoda in Pine grobe may be because of higher density of suspended algal population, relatively higher level of paddy field water depth, total dissolved solids, specific conductivity, nutrient contents like chloride, nitrate-nitrogen, phosphate phosphorus (Saikia *et al.* 2017). Idris (1983) observed that there was rich species diversity of Cladocera in rice fields and other wetlands of East and West Malaysia where 24 species were the newly recorded. Rotifera and Protozooplankton had the highest (2.398) diversity in Nenchalya and Tajang (1.590) respectively (**Table 6** & **7**) may be due to the higher population of bacteria and low water flow which caused decomposition of household sewages that ultimately enhanced the production rate of organic materials (Majagi and Vijaykumar, 2009; Dhembare, 2011; Bhat *et al.*, 2014, Sharma *et al.*, 2014). The lowest diversity of Rotifera (2.099) was in Mudang tage and Protozooplankton (1.533) was in Dutta. Ostracoda (**Table 8**) did not have any value in all the sampling villages. Ali (1990) found that the shallow littoral nature of rice fields is the suitable habitat of abundant Cladocera and Rotifer species, although copepods were also numerically more abundant. Presence of diversified species of Zooplankton make it assured that the high altitude paddy cum fish culture system of Ziro valley provides their congenial where certain species were in an advantageous position to be distributed equally in the paddy fields. But, sometimes frequent deweeding and agronomic activities caused low evenness of some species within the flooded rice field.

This ecofriendly and economically beneficial farmer's practice has made the paddy cum fish culture in the context of aquatic resource utilization (Singh *et al.*, 2011). The total productivity for fish ranges 300-500 kg/ha/season and 3000-4000 kg/ha/season (**Table 9** & **10**). Fish enhanced 10-15% of rice productivity (10-15%) by maintaining the growth of algae, weeds and injurious insects, providing nutrient input through fish excreta and promoting tillering of the rice through movement of fish inside the field. It is also to be mentioned that the mineralization process of organic matter, puddling of mud and soil aeration by other benthos caused better yield of rice (Mondal *et al.*, 2005) in such a fish co-cultural mountainous organic based Paddy cum Fish Cultivation ecosystem. The field dyke (height 0.9 m-1.5 m) used to cultivate with various nitrogen fixing vegetables and millets for enhanced productivity of rice. Additionally, the dyke is also use for complete drying of field water during harvesting of rice and fish. Bamboo fencing is done to avoid the runaway of fishes through the pipes. For sustainable utilization of the paddy fields. farmers basically use agro inputs like household and agricultural wastes, excreta of domestic animals like pig (*Sus scrofa scrofa*), cow (*Bos taurus*), Mithun (*Bos frontalis*), and goat (*Capra aegagrus hircus*) as energy subsidy (Saikia & Das, 2004). Moreover, Azolla and Lemna are allowed to grow in the field water as a nitrogen fixer (Saikia and Das, 2008b). Such mentioned organic foods formed in the field may play an important role in the detritivorous habitat of the stocked fishes.

Conclusion

The diversified population of zooplankton serves as natural food sources for the fishes which enhance unit land of aquatic productivity in paddy fields and better livelihood option for tribal framers. All the mentioned agro inputs with organic manures, decomposed rice stubbles and macrophytes impact on growth and abundance of such natural fish which in turn to attain sustainable development **Goal 12** (Responsible consumption and production), **Goal 13** (Climate action), **Goal 14** (Life below water) by greater profitability in blue revolution of unique Integrated Aquaculture Agriculture system. Therefore, this unique system needs special attention to develop mass culture for enhancement of Zooplankton which has greater contribution in blue revolution of India.

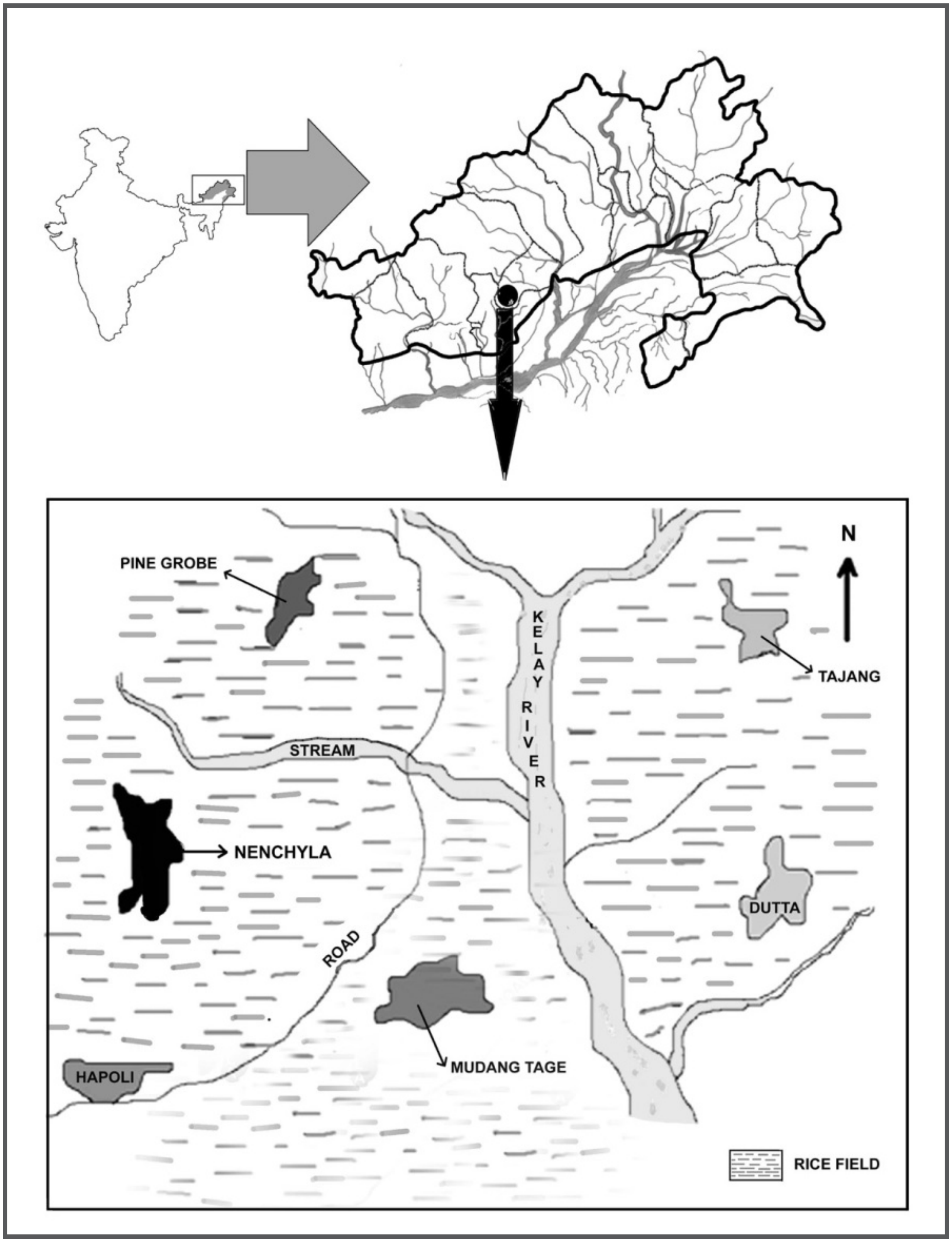

Figure 1: Sampling sites of the study area

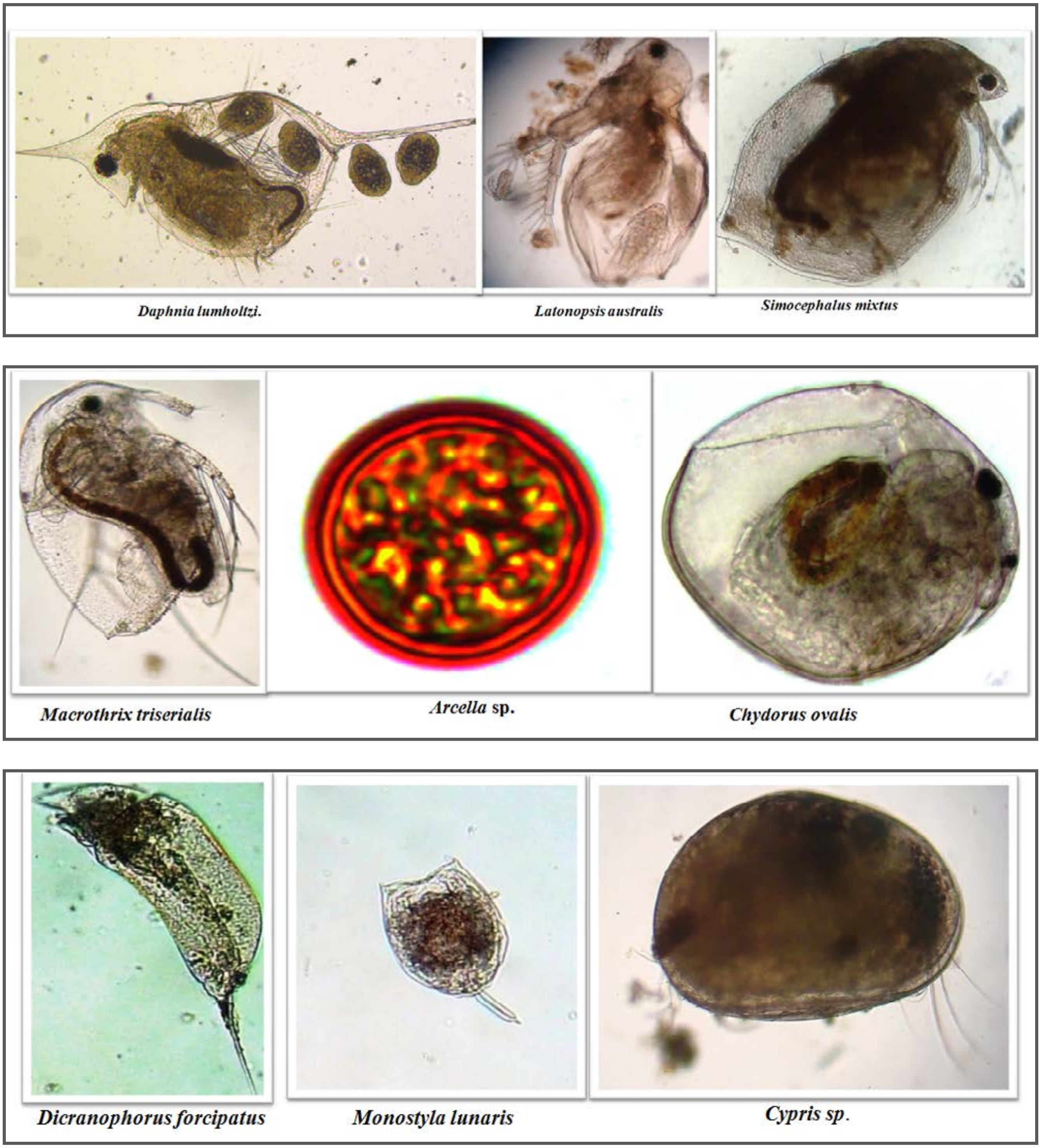

Figure 2: Some identified Zooplankton

Table: 1. Village wise variation of physico-chemical parameters (Mean ± SD) of the rice field water in during the study season

Parameters	Year	Pine grobe	Tajang	Nenchalya	Dutta	Mudang tage
FCO_2 (mgl^{-1})	2013	12.40±1.82	15.79±7.74	19.68±6.93	16.54±11.94	12.97±1.77
	2014	7.74±4.46	8.08±4.69	10.02±4.28	9.49±3.29	9.14±4.36
DO (mgl^{-1})	2013	7. 71±3.71	7.34±4.52	6.19±2.70	5.49±3.38	6.83±4.31
	2014	9.90±2.23	8.84±1.48	5.77±2.22	5.74±2.22	5.59±2.90
TDS (mgl^{-1})	2013	415.93±79.70	266.36±77.60	266.85±77.44	304.43±103.79	326.85±60.40
	2014	349.90±97.27	308.95±50.30	253.09±65.63	307.53±93.09	219.00±70.68
TA (mgl^{-1})	2013	32.38±7.19	29.25±6.32	28.43±9.27	32.11±7.39	30.40±7.66
	2014	31.11±5.51	28.29±6.34	24.75±11.24	26.13±5.41	27.58±6.52
CaH (mgl^{-1})	2013	12.10±2.83	6.16±1.88	5.45±1.00	11.94±9.49	8.68±4.64
	2014	20.26±3.52	16.52±5.72	16.77±3.94	14.95±3.93	15.12±7.58
SC (μScm^{-1})	2013	726.50±189.68	549.36±129.24	468.27±106.54	555.98±195.65	398.67±60.48
	2014	642.84±148.34	500.15±103.06	524.17±118.83	535.64±143.25	400.23±139.19
PO_4-P (mgl^{-1})	2013	0.15±0.07	0.13±0.02	0.14±0.01	0.05±0.04	0.09±0.01
	2014	0.16±0.09	0.14±0.05	0.15±0.02	0.12±0.08	0.14±0.05
NO_3-N (mgl^{-1})	2013	0.08±0.03	0.08±0.03	0.06±0.01	0.07±0.02	0.07±0.02
	2014	0.78±0.28	0.44±0.08	0.64±0.02	0.54±0.03	0.30±0.01
WD (cm)	2013	16.50±3.79	13.53±4.35	14.17±4.07	9.12±5.99	8.53±3.46
	2014	15.52±4.47	10.08±4.44	10.29±4.45	9.52±5.27	9.39±4.72
Cl^{-1} (mgl^{-1})	2013	44.43±25.06	28.94±9.49	31.42±12.44	29.53±11.96	48.98±31.21
	2014	46.15±17.34	45.79±13.08	39.41±10.69	35.59±8.42	39.14±13.03
TH (mgl^{-1})	2013	20.22±7.42	9.71±2.73	11.25±8.62	13.08±4.33	10.13±2.65
	2014	31.36±6.63	27.16±6.26	26.40±7.67	24.18±5.68	22.83±6.63
pH	2013	6.66±0.40	6.42±0.41	5.10±0.74	6.10±1.38	6.23±0.52
	2014	7.03±0.51	6.26±0.77	6.05±1.39	6.49±0.48	6.53±0.31
WT (°C)	2013	25.51±4.64	26.61±2.91	26.69±2.64	27.08±3.44	27.13±3.17
	2014	23.08±2.42	23.94±4.80	25.24±1.56	25.83±3.26	27.83±2.73
AT (°C)	2013	27.69±4.72	28.69±2.38	29.27±2.11	28.70±2.09	28.99±2.86
	2014	25.78±2.82	26.19±4.83	27.18±1.50	26.90±2.75	28.19±2.36

Table 2: List of Identified Zooplankton

Group	Species
Cladocera	*Bosmina* sp.
	Bosmina cf. *tripurae* (Jurine 1820)
	Bosmina longirostris (O. F. Muller, 1776)
	Bosminopsis sp.
Cladocera	*Chydorus* sp.
	Dadaya macrops (Daday, 1898)
	Kurzia longirostris (Daday, 1898)
	Kurzia sp.
	Oxyurella sp.
	Alona sp.
	Disperalona caudata Smirnov, 1996
	Alona affinis (Leydig, 1860) s. lat.
	Alona guttata Sars, 1862
	Celsinotum macronyx (Daday, 1898)
	Ephimrous barroisi Richard 1894
	Anthalona sp.
	Chydorus sphaericus (O. F. Muller, 1776)
	Chydorus ventricosus Daday, 1898
	Chydorus cf. *ovalis* Kurz, 1874
	Pleuroxus denticulatus Birge, 1879
Cladocera	*Diaphanosoma dubium* (Manuilova, 1964)
	Latonopsis australis Sars, 1885 s.lat.
Cladocera	*Daphnia lumholtzi* Sars, 1885
	Ceriodaphnia cornuta Sars, 1885
	Ceriodaphnia sp.
	Simocephalus sp.
	Simocephalus mixtus Sars, 1903
Cladocera	*Moina* sp.
	Moina micrura Kurz, 1874
	Moinodaphnia sp.

Group	Species
Cladocera	*Macrothrix* sp.
	Macrothrix spinosa King, 1853
	Macrothrix triserialis (Brady, 1886
Copepoda	*Cyclops* sp.
	Mesocyclop sp.
	Mesocyclop edax Forbes, 1891
Copepoda	*Diaptomus* sp.
	Limnocalanus sp.
	Limnocalanus macrurus Sars G.O., 1863
	Bryocamptus sp.
	Helodiaptomus sp.
	Neodiaptomus sp.
	Nauplii of *Cyclops*
	Nauplii of *Diaptomus*
Rotifera	*Asplanchna* sp.
	Asplanchna brightwellii Gosse, 1850
Rotifera	*Keratella* sp.
	Keratella valga (Ehrenberg, 1834)
	Brachionus sp.
	Brachionus forficula Wierzejski, 1891
	Plationus patulus patulus (O. F. Muller 1786)
	Platyias quadricornisquadricornis (Ehrenberg, 1832)
	Testudinella patina (Hermann, 1783)
	Testudinella striata (Murray, 1913)
	Dicranophorus forcipatus (O. F. Muller, 1786).
Rotifera	*Lecane* sp.
	Lacane ungulata (Gosse, 1887)
	Lacane leontina (Turner, 1892)
	Lacane bulla bulla (Gosse, 1851)
	Monostyla sp.
	Eosphera sp.

Group	Species
Ostracoda	*Cypris* sp.
Protozooplankton	*Arcella* sp.
	Difflugia sp.
	Centropyxis sp.
	Ophryoglena sp.
	Epistylis sp.

Table: 3. Diversity, richness and evenness indices among Zooplankton groups during the rice growing season of 2013-14

Indices	**Cladocera**	**Copepoda**	**Rotifera**	**Ostracoda**	**Protozooplankton**
Diversity index	2.45	1.44	1.30	0	1.27
Evenness index	0.55	0.54	0.81	1.00	0.71
Richness index	5.64	1.65	1.33	0.26	1.10

Table: 4. Village wise diversity, richness and evenness indices of Cladocera during the rice growing season of 2013-14

Indices	**Pine grobe**	**Tajang**	**Nenchalya**	**Dutta**	**Mudang tage**
Diversity index	2.670	1.846	1.974	1.984	1.892
Evenness index	0.515	0.226	0.257	0.279	0.237
Richness index	5.111	4.499	4.602	4.201	4.668

Table: 5. Village wise diversity, richness and evenness indices of Copepoda during the rice growing season of 2013-14

Indices	**Pine grobe**	**Tajang**	**Nenchalya**	**Dutta**	**Mudang tage**
Diversity index	1.397	1.090	1.226	1.289	1.272
Evenness index	0.404	0.297	0.340	0.363	0.357
Richness index	1.930	1.890	1.840	1.873	1.840

Table: 6. Village wise diversity, richness and evenness indices of Protozooplankton during the rice growing season of 2013-14

Indices	**Pine grobe**	**Tajang**	**Nenchalya**	**Dutta**	**Mudang tage**
Diversity index	1.589	1.590	1.570	1.533	1.589
Evenness index	0.979	0.968	0.961	0.926	0.980
Richness index	0.785	0.787	0.791	0.814	0.787

Table: 7. Village wise diversity, richness and evenness indices of Rotifera during the rice growing season of 2013-14

Indices	Pine grobe	Tajang	Nenchalya	Dutta	Mudang tage
Diversity index	2.298	2.398	2.435	2.294	2.099
Evenness index	0.622	0.647	0.671	0.583	0.509
Richness index	3.760	3.892	3.862	3.792	3.607

Table: 8. Village wise diversity, richness and evenness indices of Ostracoda during the rice growing season of 2013-14

Indices	Pine grobe	Tajang	Nenchalya	Dutta	Mudang tage
Diversity index	0.000	0.000	0.000	0.000	0.000
Evenness index	1.000	1.000	1.000	1.000	1.000
Richness index	0.000	0.000	0.000	0.000	0.000

Table: 9. Yields records of rice and fish in rice fields of Ziro

Village	Rice yield ($kgha^{-1}season^{-1}$)	Fish yield ($kgha^{-1}season^{-1}$)
Pine grobe	2000.0-4000.0	350.0-500.0
Tajang	2000.0-3000.0	270.0-480.0
Nenchalya	2000.0-3000.0	260.0-430.0
Dutta	3000.0-4000.0	420.0-500.0
Mudang Tage	3000.0-4000.0	390.0-500.0

Table: 10. Yields records of rice and fish in the rice fields of Ziro,

Village	Rice yield ($kgha^{-1}season^{-1}$)	Fish yield ($kgha^{-1}season^{-1}$)
Pine grobe	2050.0-4000.0	380.0-500.0
Tajang	2000.0-3000.0	320.0-450.0
Nenchalya	2000.0-4000.0	240.0-480.0
Dutta	3050.0-4000.0	410.0-500.0
Mudang Tage	2500.0-4000.0	390.0-500.0

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