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COMMUNICATION

A study on the community structure of damselflies (Insecta: Odonata: Zygoptera) in Paschim Medinipur, West Bengal, India

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Abstract: For gauging suitability of zygopteran odonates as bioindicators of ecosystems, an attempt was made to record the seasonal diversity of damselflies from seven different types of habitats in Paschim Medinipur District, West Bengal covering 14 land use sites. The study revealed existence of 19 species of damselflies belonging to 10 genera under two families. While the riparian zone had maximum number of species (15), paddy field had the lowest number (six). *Ceriagrion coromandelianum* and *Agriocnemis pygmaea* were the most common species. *C. coromandelianum* was eudominant in grassland and wetland-forest interface, whereas *A. pygmaea* was eudominant in fish pond and paddy field. Six species, viz., *Paracercion calamorum*, *P. malayanum*, *Pseudagrion australasiae*, *P. decorum, P. spencei*, *and P. microcephalum* were confined only to the riparian zone. Maximum abundance of damselflies was found in the riparian zone and minimum in the paddy field. Damselflies exhibited a distinct peak in March–April and a lesser peak in September–October. Most of the land use patterns exhibited similar zygopteran faunal composition. Species diversity index was moderate (1.4–2.5) and evenness index was on the higher side (0.76–0.94). Dominance Index ranged from 26.2 to 64.6. Riparian zone appeared to be the least stressed and most equitable habitat with highest diversity and evenness index and lowest dominance index. Paddy field seemed to be the harshest habitat for damselflies with least diversity and highest dominance index. The present study suggests that community analysis of damselflies can be quite useful in the assessment of the quality of any ecosystem.

Keywords: Bioindicator, damselfly, dominance index, evenness index, land use type, species diversity index, Zygoptera.

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Author contributions: PKJ conducted field work with regular data collection, identification and documentation along with interpretation of results and preparation of initial manuscript. PHM has designed and supervised the study with contribution in editing and reviewing the draft article and maintaining communications. TB has provided inputs in data analysis and interpretation, revision and write-up of final manuscript.

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INTRODUCTION

Sensitivity of damselflies to structural habitat features and their amphibious habit makes them well suited as bioindicators of environmental changes (Subramanian et al. 2008; Dolný et al. 2011). In general, odonates have been popular for monitoring health of wetlands all over the world (Chovanec & Waringer 2001). The species assemblages of damselflies are influenced by the aquatic and terrestrial vegetation which act as one of the main cues for their habitat choice. Although considerable work has been done on the ecology and diversity of odonates in many parts of India, some of the latest ones are those of Baba et al. (2019), D'Souza & Pai (2019), Payra et al. (2020), Bedjanič et al. (2020), and Pavithran et al. (2020).

In West Bengal, Odonata fauna has been explored in recent years by Payra & Tiple (2019) & Pahari et al. (2019) from Purba Medinipur and Nayak (2020) from Asansol–Durgapur industrial area. Despite efforts of Jana et al. (2009), large parts of Paschim Medinipur have remained unexplored with respect to odonate distribution and ecology. In the aforementioned context, the present study was undertaken across different habitat structures and land use patterns comprising aquatic and semi–aquatic water bodies of Paschim Medinipur District.

METHODS

Study area

The present study was carried out in five blocks of Paschim Medinipur District of West Bengal, India namely Pingla, Debra, Kharagpur I, Kharagpur II and Midnapore, predominantly encompassing freshwater lentic wetlands (Figure 1). On the basis of the habitat heterogeneity, seven land use types, viz., fish pond (FP), eutrophic pond (EP), unmanaged wetland (UW), grassland (GL), paddy field (PF), wetland-forest interface (WFI), and riparian zone (RZ) were selected (Image 1a–g). The fish pond was a semi-natural water body used only for commercial fish culture and with little littoral and floating macrophytes. The man-made eutrophic pond, having high nutrient content, was severely infested with *Pistia* sp. (90 %), with smaller proportions of *Alternanthera philoxeroides* (8 %) and other hydrophytes (2 %). Unmanaged wetland was a natural water body with profuse macrophytes of varieties. The macrophytes were inventoried with reference to Mallick & Chakraborty (2014). Grassland included open fallow lands having stretches of herbaceous plants dominated by grasses. Paddy fields were lands under paddy cultivation. Wetland-forest interface were the confluence of homestead vegetation and water bodies. Riparian zone comprised of riverbank along Kangsabati River.

Sampling

Field sampling of adult zygopterans was done from March 2018 to February 2019. The sampling and quantitative measurements of adult damselfly species were carried out at each study site between 0800 h and 1400 h using line transect method. Transect routes, distances walked, and durations were kept constant across study sites throughout the survey. All sites were surveyed once per month preferably under reasonable weather conditions, barring a few instances. The prominent features of the study sites were also noted on the spot. Adult damselfly species were identified and photographed in the field; doubtful specimens were captured using an aerial insect net. Later they were identified by examining the morphological characteristics through a hand lens and were released after recording. For identification purpose, few damselflies were sacrificed by gently pressing their thorax and kept dry in paper envelope or in 70 % ethanol and were brought to the laboratory. The observed and collected species were identified to the lowest possible rank using taxonomic literature and field identification keys provided by Subramanian (2009), Mitra & Babu (2010), and by photographic guides from 'Odonata of India' website (Anonymous 2020). Updated species names were taken following the Subramanian & Babu (2017).

Data analysis

Important community parameters like abundance, relative abundance, Shannon–Wiener diversity index (H´) (Shannon & Wiener 1963), evenness index of Pielou (EI) (Pielou 1975), McNaughton & Wolf's dominance index (DI) (McNaughton & Wolf 1970), and Sørensen's similarity index (Sørensen 1948) were calculated using MS Excel.

RESULTS

During the course of study, 19 zygopteran species belonging to 10 genera under two families were recorded from the study sites. The family Coenagrionidae contained 17 species and family Platycnemididae contained two species.

Species richness exhibited spatial and temporal changes (Table 1). RZ had maximum numbers of species

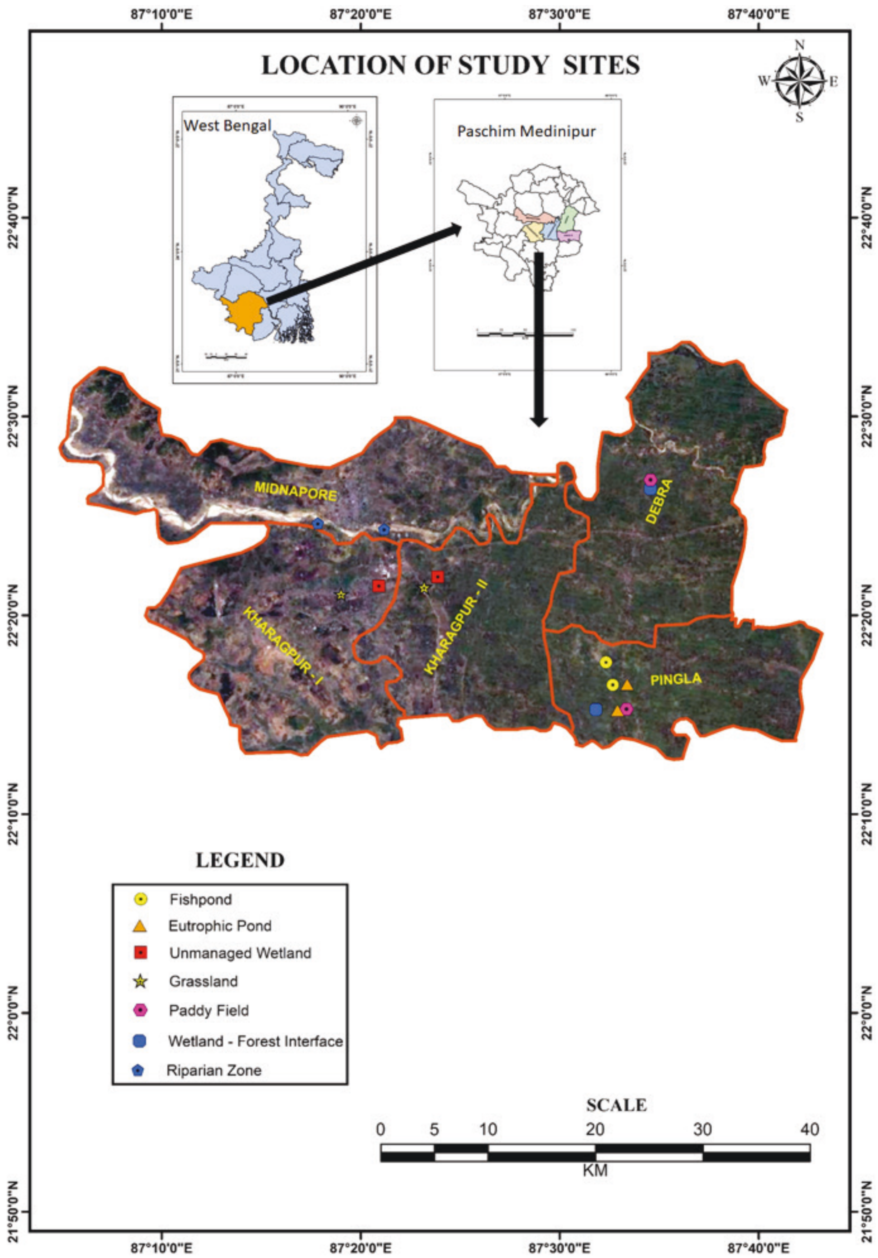

Figure 1. Map of Paschim Medinipur District within the state of West Bengal, showing locations and land use types of all study sites.

(15). This was followed by UW (13), FP (12), GL (10), EP (8), WFI (7) and PF (6).

Maximum number of individuals was recorded at RZ and minimum at PF. Like species richness, number of individuals also varied spatially and temporally (Table 1; Figure 2). Damselfly exhibited a more or less bimodal pattern of population fluctuation with two peaks, first one in the pre-monsoon period (March–April) and the second one in the post-monsoon period (September–October) which was not quite distinct in the WFI (Figure 2). From paddy fields no damselfly species were recorded in the month of June. WFI has highest abundance only in pre-monsoon period and there was little increase in number of individuals in post-monsoon period as compared to other land use types.

Dominance status of each species in a particular habitat was ascertained on the basis of its relative abundance according to scale of Engelmann (1973). Table 1 reveals that *Agriocnemis pygmaea* was eudominant species in FP and PF and dominant in remaining five habitats. Likewise, *Ceriagrion coromandelianum* was eudominant in GL and WFI and dominant species in the remaining habitats. No species was eudominant in EP, UW, and RZ. Other dominant species were *Ceriagrion cerinorubellum* & *Copera marginipes* in EP and WFI, *Agriocnemis lacteola* & *Ischnura rubilio* in PF, *Ischnura*

Table 1. Species richness (S), number (N), relative abundance (RA in %), and dominance status (DS) of zygopteran species in different land use types.
[RA <1= subrecedent (SR); 1–3.1= recedent (R); 3.2–10= subdominant (SD); 10.1–31.6= dominant (D); >31.7= eudominant (ED)] (Engelmann 1973).

	Landuse Types →	FP			EP			UW			GL			PF			WFI			RZ		
	Scientific Names ↓	N	RA	DS	N	RA	DS	N	RA	DS	N	RA	DS	N	RA	DS	N	RA	DS	N	RA	DS
Family Coenagrionidae																						
1	*Agriocnemis kalinga* Nair & Subramanian, 2015	1	0.2	SR	-	-	-	32	5.4	SD	4	1.2	R			-	-	-	-	62	6.1	SD
2	*Agriocnemis lacteola* Selys, 1877	-	-	-	-	-	-	28	4.7	SD	33	9.8	SD	23	11.8	D	-	-	-	-	-	-
3	*Agriocnemis pygmaea* (Rambur, 1842)	200	34.0	ED	98	21.4	D	159	26.9	D	98	29.2	D	75	38.5	ED	43	15.9	D	123	12.1	D
4	*Amphiallagma parvum* (Selys, 1876)	25	4.2	SD	-	-	-	39	6.6	SD	-	-	-	-	-	-	-	-	-	99	9.7	SD
5	*Ceriagrion cerinorubellum* (Brauer, 1865)	16	2.7	R	77	16.8	D	48	8.1	SD	24	7.1	SD	4	2.1	R	32	11.8	D	34	3.3	SD
6	*Ceriagrion coromandelianum* (Fabricius, 1798)	68	11.5	D	102	22.3	D	67	11.3	D	115	34.2	ED	38	19.5	D	105	38.7	ED	124	12.2	D
7	*Ischnura rubilio* Selys, 1876	39	6.6	SD	6	1.3	R	13	2.2	R	15	4.5	SD	51	26.2	D	-	-	-	38	3.7	SD
8	*Ischnura senegalensis* (Rambur, 1842)	77	13.1	D	-	-	-	42	7.1	SD	13	3.9	SD	4	2.1	R	-	-	-	123	12.1	D
9	*Mortonagrion aborense* (Laidlaw, 1914)	22	3.7	SD	26	5.7	SD	30	5.1	SD	-	-	-	-	-	-	33	12.2	D	-	-	-
10	*Onychargia atrocyana* (Selys, 1865)	4	0.7	SR	45	9.8	SD	36	6.1	SD	8	2.4	R	-	-	-	12	4.4	SD	-	-	-
11	*Paracercion calamorum* (Ris, 1916)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	2.6	R
12	*Paracercion malayanum* (Selys, 1876)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	43	4.2	SD
13	*Pseudagrion australasiae* Selys, 1876	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26	2.6	R
14	*Pseudagrion decorum* (Rambur, 1842)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	142	14.0	D
15	*Pseudagrion microcephalum* (Rambur, 1842)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	51	5.0	SD
16	*Pseudagrion rubriceps* Selys, 1876	46	7.8	SD	-	-	-	16	2.7	R	-	-	-	-	-	-	-	-	-	64	6.3	SD
17	*Pseudagrion spencei* Fraser, 1922			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	27	2.7	R
Family Platycnemididae																						
18	*Copera marginipes* (Rambur, 1842)	39	6.6	SD	72	15.7	D	52	8.8	SD	13	3.9	SD	-	-	-	41	15.1	D	-	-	-
19	*Pseudocopera ciliata* (Selys, 1863)	52	8.8	SD	32	7.0	SD	29	4.9	SD	13	3.9	SD	-	-	-	5	1.8	R	35	3.4	SD
	Total number of Species (S)		**12**			**8**			**13**			**10**			**6**			**7**			**15**	
	Total number of Individuals (N)		**589**			**458**			**591**			**336**			**195**			**271**			**1017**	

Table 2. Sørensen's index of similarity between land use types.

	EP	UW	GL	PF	WFI	RZ
FP	0.80	0.96	0.82	0.56	0.74	0.67
EP		0.76	0.78	0.57	0.93	0.43
UW			0.78	0.63	0.70	0.57
GL				0.75	0.71	0.56
PF					0.46	0.48
WFI						0.36

[0.5–0.6= slightly similar; 0.6–0.7= moderately similar; >0.7= strongly similar; 0.5–0.4= slightly dissimilar; 0.4–0.3= moderately dissimilar; <0.3= strongly dissimilar.]

Table 3. Shannon-Wiener diversity index, evenness index, and dominance index of different land use types.

Land use types	S-W Diversity index (H')	Evenness index (EI)	Dominance index (DI)
FP	2.1	0.83	47.0
EP	1.9	0.91	43.7
UW	2.3	0.91	38.2
GL	1.7	0.76	63.4
PF	1.4	0.81	64.6
WFI	1.7	0.86	54.6
RZ	2.5	0.94	26.2

senegalensis & *Pseudagrion decorum* in RZ, and *Mortonagrion aborense* in WFI. Rest of the species were either subdominant or recedent. Three species, viz., *Paracercion calamorum, Pseudagrion australasiae*, and *Pseudagrion spencei* were recedent in the riparian zone. In FP, two species (*Agriocnemis kalinga* and *Onychargia atrocyana*) were subrecedent.

Interestingly, no representative of family Platycnemididae was found in PF during the entire period of investigation. Turning to the analysis of species composition based on Sorensen's index (Table 2), it is seen that WFI was moderately dissimilar in zygopteran faunal composition with RZ and slightly dissimilar with PF. Likewise, RZ was slightly dissimilar with PF and EP. All other habitats were similar in species composition. Maximum similarity was seen between FP and UW.

Analysis of diversity and evenness indices (Table 3) revealed that species diversity indices were relatively low ranging from 1.4 in the PF to 2.5 in the RZ. Evenness index, on the contrary, was on the higher side ranging between 0.76 in the GL to 0.94 in the RZ. Simultaneously, dominance Index ranged from 26.2 (RZ) to 64.6 (PF).

DISCUSSION

Spatial heterogeneity is often regarded as a key factor that shapes diversity (Tews et al. 2004). Structurally complex habitats provide more niches and diverse ways of exploiting the environmental resources thereby increasing species diversity (Bazzaz 1975). In the present study, 19 species of Zygoptera were recorded which is comparable to the findings of Pahari et al. (2019) who found 20 species from Purba Medinipur District. Lower species richness recorded by them in all probability is because of urbanization. Most of the study sites in the present investigation exhibited similar species composition which might be attributed to the spatial proximity of sites but differences in land use types made some habitats dissimilar in species composition.

Increased richness and abundance of damselflies during pre-monsoon period, as observed in the present study, is in accordance with the findings of Corbet (2004) and Hassall & Thompson (2008), who observed higher richness and abundance during pre-monsoon period which they assigned to increased temperature and precipitation. Documentation of zygopteran diversity is important for the assessment of the health of agroecosystem. The odonate diversity in the present study was reported to be lower in agricultural landscapes than in other ecosystems, which corroborates with the findings of Kulkarni & Subramanian (2013) and it has been suggested that the lower diversity was due to the water quality, insecticide usage and vegetation structure in the paddy fields which significantly affects the zygopteran community (Baba et al. 2019; Giuliano & Bogliani 2019).

Ceriagrion coromandelianum and *Agriocnemis pygmaea* were the most common species encountered during the present study being eudominant and dominant species, respectively, wherever these were distributed. Relatively low species diversity index is suggestive of a relatively harsh, stressed and disturbed habitat. According to Wilhm & Dorris (1968) general diversity index ranging 1–3, suggests a moderate disturbance or stress operating in the habitat. Of the seven land use types, the riparian zone appears to be relatively less stressed whereas paddy field appears to be the most stressed. These human-altered ecosystems can be essential in serving as alternative habitats for biodiversity, especially water reliant species such as odonates. Species diversity and evenness indices in the present study are comparable with those of a study by Pahari et al. (2019) in Purba Medinipur District. Higher evenness indices (>0.8) in majority of the habitat types

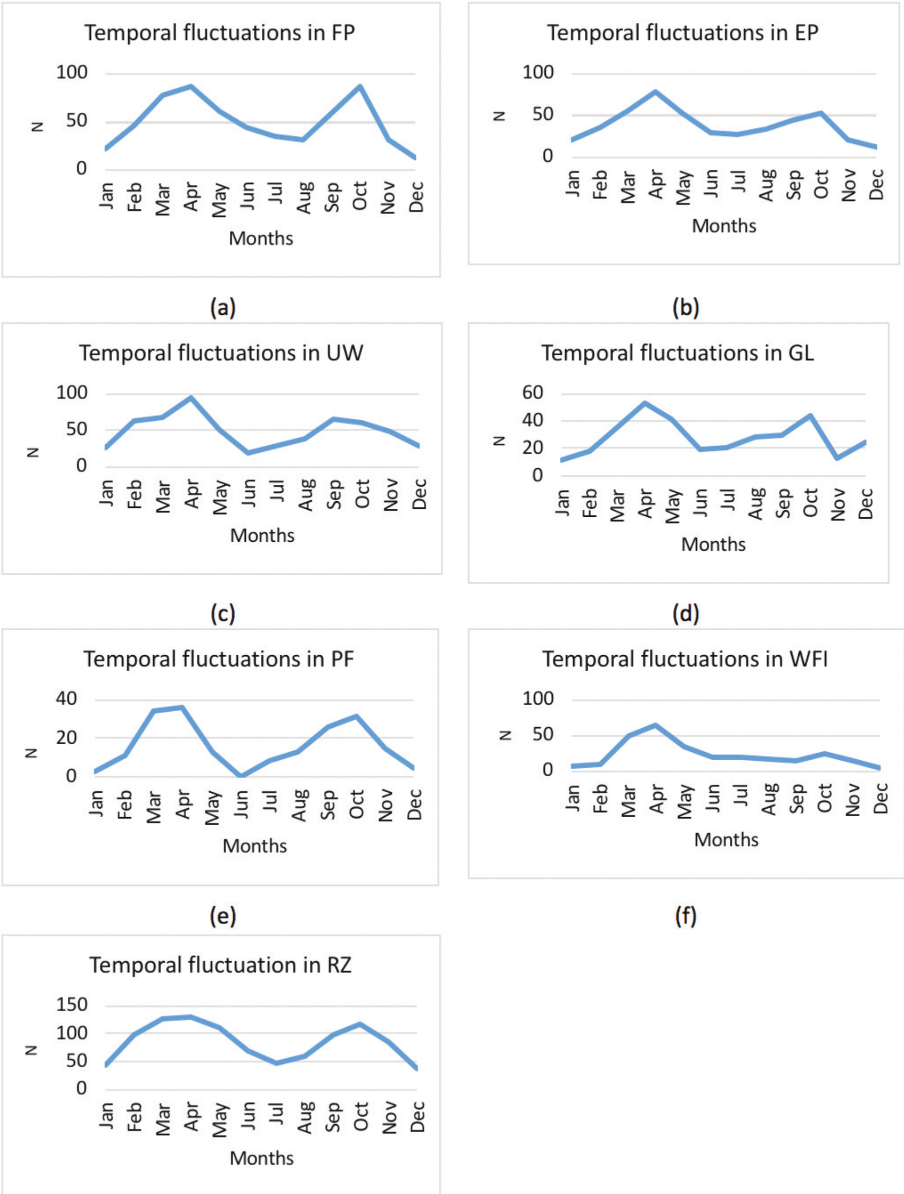

Figure 2. Temporal fluctuation in Number of Individuals (N) of damselflies during 2018–2019 across land use types. [FP= fish pond, EP= eutrophic pond, UW= unmanaged wetland, GL= grassland, PF= paddy field, WFI= wetland-forest interface, RZ= riparian zone].

indicate a structural heterogeneity of the habitats. Grassland with the least evenness index appears to be the most homogeneous habitat.

Findings pertaining to the dominance index also substantiate the relation between species diversity and habitat structure and quality. McNaughton & Wolf (1970) asserted that the dominance index can be correlated with the harshness of the environment, which increases with the increase in harshness and decreases with the equitability of the habitat. Karr (1971) and Ghosh & Bhattacharya (2018) though found that dominance index for avifauna declined with vegetational development. Pahari et al. (2019) opined that dominance index of odonates is an indicator of the quality of environment. Harsh environment favours dominance of one or two species making them eudominant or dominant by eliminating some other species. In the present study, dominance index was high in paddy field and grassland which are structurally simple with little vegetational diversity subjected to greater anthropogenic interferences, experience more fluctuation of climatic and edaphic factors and as such are less equitable and harsh as compared to other habitats. On the contrary, riparian zone and unmanaged

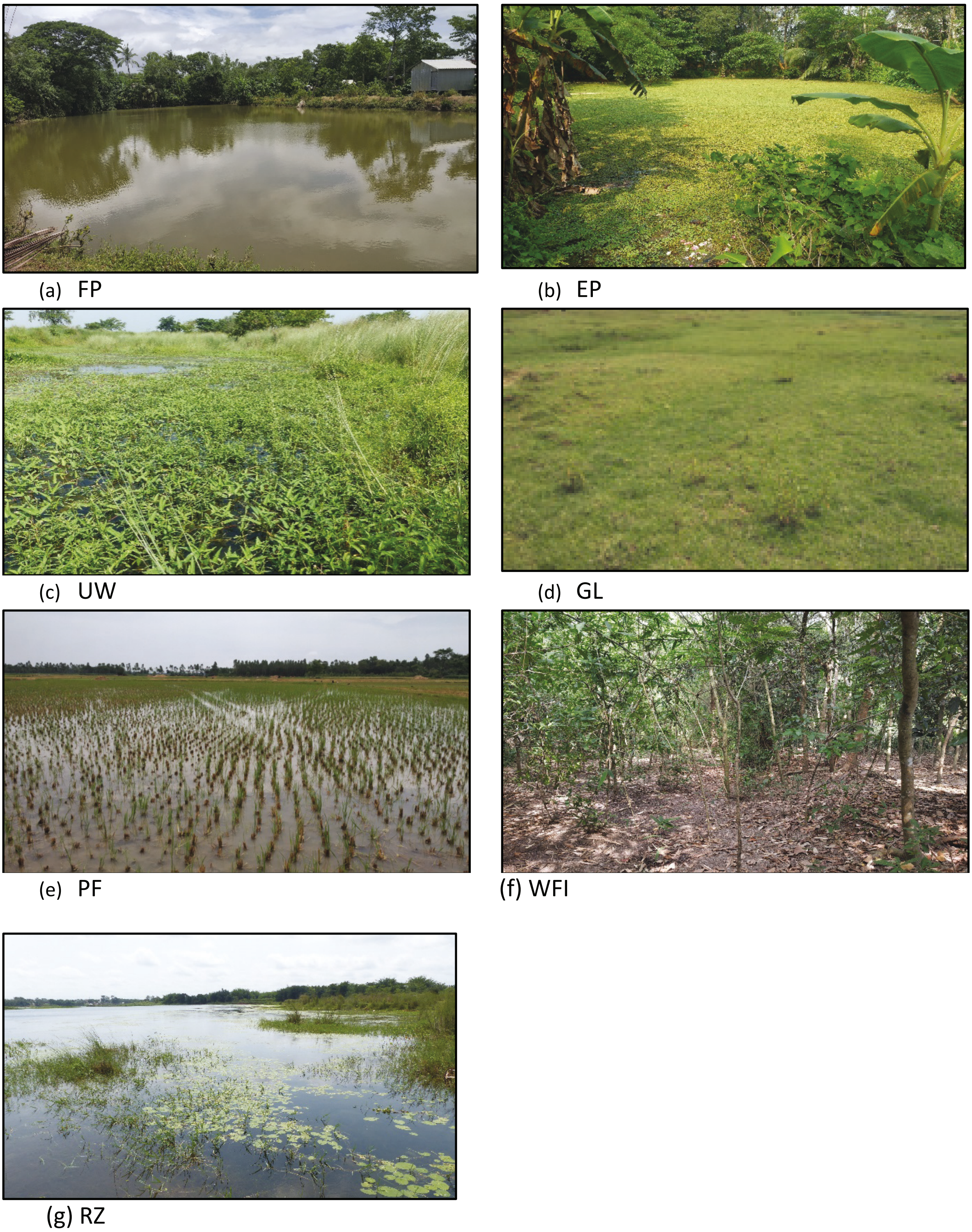

Image 1. Study sites in selected blocks: a—fish pond in Pingla | b—eutrophic pond in Pingla | c—unmanaged wetland in Kharagpur II | d—grassland in Kharagpur I | e—paddy field in Debra | f—wetland–forest interface in Pingla | g—riparian zone in Midnapore. © Pathik Kumar Jana. EP—eutrophic pond | FP—fish pond | GL—grassland | PF—paddy field | RZ—riparian zone | UW—unmanaged wetland | WFI—wetland–forest interface.

wetland had low dominance index and hence may offer better and equitable habitat resulting into relatively high zygopteran species diversity as compared to other land use types. It may thus be concluded that the damselflies have potentiality to be used as good indicators of the condition and health of land use types and habitat quality.

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Communications

Persistence of *Trachypithecus geei* (Mammalia: Primates: Cercopithecidae) in a rubber plantation in Assam, India
– Joydeep Shil, Jihosuo Biswas, Sudipta Nag & Honnavalli N. Kumara, Pp. 18679–18686

Population assessment of the endangered Western Hoolock Gibbon *Hoolock hoolock* Harlan, 1834 at Sheikh Jamal Inani National Park, Bangladesh, and conservation significance of this site for threatened wildlife species
– M. Tarik Kabir, M. Farid Ahsan, Susan M. Cheyne, Shahrul Anuar Mohd Sah, Susan Lappan, Thad Q. Bartlett & Nadine Ruppert, Pp. 18687–18694

Assessment of changes over a decade in the patterns of livestock depredation by the Himalayan Brown Bear in Ladakh, India
– Aishwarya Maheshwari, A. Arun Kumar & Sambandam Sathyakumar, Pp. 18695–18702

Habitat selection of Himalayan Musk Deer *Moschus leucogaster* (Mammalia: Artiodactyla: Moschidae) with respect to biophysical attributes in Annapurna Conservation Area of Nepal
– Bijaya Neupane, Nar Bahadur Chhetri & Bijaya Dhami, Pp. 18703–18712

Sero-diagnosis of tuberculosis in elephants in Maharashtra, India
– Utkarsh Rajhans, Gayatri Wankhede, Balaji Ambore , Sandeep Chaudhari, Navnath Nighot, Vitthal Dhaygude & Chhaya Sonekar, Pp. 18713–18718

Avian species richness in traditional rice ecosystems: a case study from upper Myanmar
– Steven G. Platt, Myo Min Win, Naing Lin, Swann Htet Naing Aung, Ashish John & Thomas R. Rainwater, Pp. 18719–18737

Conservation status, feeding guilds, and diversity of birds in Daroji Sloth Bear Sanctuary, Karnataka, India
– M.N. Harisha, K.S. Abdul Samad & B.B. Hosetti, Pp. 18738–18751

Birds of Surat-Dangs: a consolidated checklist of 75 years (1944–2020) with special emphasis on noteworthy bird records and bird hotspots from northern Western Ghats of Gujarat, India
– Nikunj Jambu & Kaushal G. Patel, Pp. 18752–18780

Identification of a unique barb from the dorsal body contour feathers of the Indian Pitta *Pitta brachyura* (Aves: Passeriformes: Pittidae)
– Prateek Dey, Swapna Devi Ray, Sanjeev Kumar Sharma , Padmanabhan Pramod & Ram Pratap Singh, Pp. 18781–18791

Underestimated diversity of *Cnemaspis* Strauch, 1887 (Sauria: Gekkonidae) on karst landscapes in Sarawak, East Malaysia, Borneo
– Izneil Nashriq & Indraneil Das, Pp. 18792–18799

***Aborichthys barapensis*, a new species of river loach (Cypriniformes: Nemacheilidae) from Arunachal Pradesh, the eastern Himalaya, India**
– P. Nanda & L. Tamang, Pp. 18800–18808

A study on the community structure of damselflies (Insecta: Odonata: Zygoptera) in Paschim Medinipur, West Bengal, India
– Pathik Kumar Jana, Priyanka Halder Mallick & Tanmay Bhattacharya, Pp. 18809–18816

New distribution and range extension records of geometrid moths (Lepidoptera: Geometridae) from two western Himalayan protected areas
– Pritha Dey & Axel Hausmann, Pp. 18817–18826

Butterfly diversity of Putalibazar Municipality, Syangja District, Gandaki Province, Nepal
– Kismat Neupane & Mahamad Sayab Miya, Pp. 18827–18845

New records and distribution extension of *Nassarius persicus* (Martens, 1874) and *N. tadjallii* Moolenbeek, 2007 (Mollusca: Gastropoda: Nassariidae) to India
– Sayali Nerurkar & Deepak Apte, Pp. 18846–18852

Flowering plants of Agumbe region, central Western Ghats, Karnataka, India
– G.S. Adithya Rao & Y.L. Krishnamurthy, Pp. 18853–18867

Population assessment and habitat distribution modelling of the threatened medicinal plant *Picrorhiza kurroa* Royle ex Benth. in the Kumaun Himalaya, India
– Naveen Chandra, Gajendra Singh, Shashank Lingwal, M.P.S. Bisht & Lalit Mohan Tewari, Pp. 18868–18877

Occurrence of gilled fungi in Puducherry, India
– Vadivelu Kumaresan, Chakravarthy Sariha, Thokur Sreepathy Murali & Gunasekaran Senthilarasu, Pp. 18878–18887

Short Communications

First photographic evidence and distribution of the Indian Pangolin *Manis crassicaudata* (Mammalia: Pholidota: Manidae) in Sariska Tiger Reserve, Rajasthan, India
– Hemant Singh, Gobind Sagar Bhardwaj, N. Gokulakannan, Saket Agasti & K. Aditya, Pp. 18888–18893

Population and conservation threats to the Greater Flamingos *Phoenicopterus roseus* (Aves: Phoenicopteriformes: Phoenicopteridae) at Basai Wetland and Najafgarh Jheel Bird Sanctuary, Haryana, India
– Amit Kumar & Sarita Rana, Pp. 18894–18898

First report on the occurrence of Sargassum Weed Fish *Histrio histrio* (Lophiliformes: Antennariidae) in Nigeria deep water, Gulf of Guinea
– Abdul-Rahman Dirisu, Hanson S. Uyi & Meshack Uyi, Pp. 18899–18902

A new distribution record of stomatopods *Odontodactylus japonicus* (De Haan, 1844) and *Lysiosquilla tredecimdentata* (Holthuis, 1941) from the Puducherry coastal waters, east coast of India
– S. Nithya Mary, V. Ravitchandirane & B. Gunalan, Pp. 18903–18907

New records of *Agriocnemis keralensis* Peters, 1981 and *Gynacantha khasiaca* MacLachlan, 1896 (Insecta: Odonata) from Maharashtra, India
– Yogesh Koli, Akshay Dalvi & Dattaprasad Sawant, Pp. 18908–18919

A new distribution record of the Horn Coral *Caryophyllia grandis* Gardiner & Waugh, 1938 (Anthozoa: Scleractinia) from the Karnataka Coast, India
– J.S. Yogesh Kumar & C. Raghunathan, Pp. 18920–18924

Re-collection, extended distribution, and amplified description of *Vaccinium paucicrenatum* Sleumer (Ericaceae) from the Arunachal Himalaya in India
– Subhasis Panda, Pp. 18925–18932

Notes

Photographic record of the Rusty-spotted Cat *Prionailurus rubiginosus* (I. Geoffroy Saint-Hilaire, 1831) (Mammalia: Carnivora: Felidae) in southern Western Ghats, India
– Devika Sanghamitra & P.O. Nameer, Pp. 18933–18935

Natural history notes on the highly threatened Pinto's Chachalaca *Ortalis remota* (Aves: Cracidae)
– Carlos Otávio Araujo Gussoni & Marco Aurélio Galvão da Silva, Pp. 18936–18938

Black-bellied Coral Snake *Sinomicrurus nigriventer* (Wall, 1908) (Elapidae): an extended distribution in the western Himalaya, India
– Sipu Kumar, Jignasu Dolia, Vartika Chaudhary, Amit Kumar & Abhijit Das, Pp. 18939–18942

First record of the Afghan Poplar Hawkmoth *Laothoe witti* Eitschberger et al., 1998 (Sphingidae: Smerinthinae) from India: a notable range extension for the genus
– Muzafar Riyaz, Pratheesh Mathew, Taslima Shiekh, S. Ignacimuthu & K. Sivasankaran, Pp. 18943–18946

The tribe Cnodalonini (Coleoptera: Tenebrionidae: Stenochiinae) from Maharashtra with two new records
– V.D. Hegde & D. Vasanthakumar, Pp. 18947–18948

Do predatory adult odonates estimate their adult prey odonates' body size and dispersal ability to proceed with a successful attack?
– Tharaka Sudesh Priyadarshana, Pp. 18949–18952

Rediscovery of *Ophiorrhiza incarnata* C.E.C. Fisch. (Rubiaceae) from the Western Ghats of India after a lapse of 83 years
– Perumal Murugan, Vellingiri Ravichandran & Chidambaram Murugan, Pp. 18953–18955

Response

Comments on the "A checklist of mammals with historical records from Darjeeling-Sikkim Himalaya landscape, India"
– P.O. Nameer, Pp. 18956–18958

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