The zooplankton is much more diverse. Although the numerical dominance tends to favour Crustacea, the diversity indexes for the four months are higher than those for other waters, and it is clear that the community structure of the zooplankton of the permanent beels reflects a relatively stable environment.

4.3.5 The Flushed Beels

These waters are flushed (but not scoured) annually by floodwater from the rivers, augmented by run-off from the adjacent land. Species diversity is high, with Cyanophyceae approaching the significance which they attain in the unflushed beels. In general, however, there is no clear dominance between groups, with different families taking then loosing dominance from month to month in different beels. Only Halti Beel, which is virtually pumped dry by agricultural abstraction by the end of March, shows a clear dominance by Chlorophyceae during February.

The zooplankton in these beels is dominated by Crustacea, even as late as May. Populations are still high when flood waters reach them in early June, a point of vital importance to floodplain fisheries.

4.3.6 Ponds

The ponds in the highland zone are in a different category from the floodland beels, as they receive only run-off from rainwater, and are never flushed. The phytoplankton of the old permanent ponds shows some variability in dominance, whilst the zooplankton is an even mix of Rotiferal and Crustacea (BP proportional abundance index = 3.07).

The temporary pond phytoplankton in March was very species-poor and dominated by Euglenophyceae. The phytoplankton of these ponds therefore appears to be similar to that of those beels which are pumped dry at this time of the year, such as Halti Beel. The zooplankton is heavily dominated by Rotiferal, in contrast to Halti Beel, in which Crustacea dominate at this time.

4.4 Zooplankton and Phytoplankton of the North West Region

The complexity of the plankton dynamics is considerable. Checklists of the phytoplankton and zooplankton species are provided (Tables 4.26, 4.27)

86 species of zooplankton were identified during this survey. They comprised 38 species of the Crustacea (16 Copepoda, 22 Cladocera), and 48 species of the minor phylum Rotiferal. Identifications were made using the keys of Ward and Whipple (1952) and Bhouyain (1992). The Checklists of zooplankton indicate their average relative abundance during the period February-May 1992 and the main habitats from which they were recorded, on a scale of * (rare) to **** (abundant).

137 species of phytoplankton were identified during this survey. They comprised of 64 species of Chlorophyceae, 38 Cyanophyceae, 26 species of Bacillariophyceae and nine other species.

A number of these aquatic micro-flora and micro-fauna are commonly used as indicator species for assessing particular problems related to pollution and other environmental processes. The limitations of time and resources prevented this approach to the analysis. It is hoped that the first database of this kind can now be used for continued monitoring, research and analysis for precisely these purposes. Further details on the proposed future monitoring programme are dealt with in Volume 3.

Table 4.1 Ground and Surface Water Quality at Survey Stations in the North West Region.

LOCATION	OXYGEN			GENERAL			NUTRIENTS		OTHERS		
	DO	BOD	COD	pH	TS	TDS	NO4	NH4	Cl	SO4	Fe
	mg/l	mg/l	mg/l		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l
Andasurla Beel (Bakapur)	8.4	4.2	20	7.5	100	65	0	0.2	11	0	1
Atral/Barnal confl.	6.9	2.8	26	7.7	105	70	0	0.1	8	0.4	1.1
Atral/Barnal confl. HTW	2.2	12.1	42	6.8	230	178	0	1.3	22	8.5	1.6
Atral/Nandokuja confl.	6.2	3.1	65	8	406	350	0	0.6	18	0.4	0.9
Atral/Nandokuja STW	2.6	7.5	22	6.7	257	212	0	1	20	14.1	0.9
Bamandanga Beel	8	3	30	8	117	54	0	0.3	6	0	0.9
Bamandangha Beel STW	2	22	40	6.7	290	165	0	1.6	14	0	8
Bangali River (Sariakandi)	8.3	1.5	28	8.2	126	88	0	0.2	7	0	0.9
Burail River	8	3.9	38	8	215	162	0	0.3	9	0.1	1
Ghargot River (Gaibandha)	7.5	6.6	40	8	174	102	0	0.3	6	0	1.1
Haiti Beel (Chalan Beel C)	8	6.6	26	7.7	207	152	0	0.2	17	12	1
Haiti Beel STW	2.4	9	55	7.2	375	315	2	0.4	13	35.2	1
Harudangha Beel	8	2.5	12	7.4	46	25	0	0.6	4	0	1.1
Harudangha Beel STW	0.8	12	18	6.5	133	53	0	1.2	6.8	0	2.9
Jamuna River (Kurigram)	8.7	2.6	25	8.2	212	182	0	0.1	6	11.3	0.7
Teesta/Jamuna confl HTW	2	40	38	6.5	160	101	0	0.2	4	0	1.2
Teesta/Jamuna confl. DTW	0.3	2.5	32	6.7	184	92	0	1.3	6	1.1	5.8
Jamuna River (Manos Reg.)	8.6	3	21	8.1	132	46	0	0.3	7	0	1.6
Jamuna R. below Burail confl.	8.5	5.8	30	8	158	108	0	0.4	4	18.2	1.2
Kumirdaha Beel	7.8	5.8	32	8	177	65	0	0.4	4	0	1.2
Kumirdaha Beel STW	1.9	8.5	50	7	290	198	0	2	38	41.5	2.1
Atrai/Nandokuja confl.	1.8	40	52	8.2	394	332	0	1.2	15	0	1.9
Atrai/Nandokuja confl.	5.4	4	60	8	384	330	0	0.7	19	0.1	1.1
Padma River	8.2	4	40	8.1	232	190	0	0.2	14	22.5	1
Sib River (Chaubaria)	6.9	2.7	24	7.7	152	94	0	0.3	14	0.5	1.9
Teesta River	8.4	1.8	12	7.7	149	51	0	0.2	8	0	1.8
Utraeel Beel (S Central)	7.6	5	22	7.5	145	94	0	0.3	10	0	0.9

DO = Dissolved Oxygen
GOD = Biological Oxygen Demand
COD = Chemical Oxygen Demand

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Table 4.2 Reported Human and Fish Pathologies Close to Water Sampling Stations.

LOCATION	COLIFORMS no/100ml	HUMAN DISEASES REPORTED		FISH DISEASES	
				From	To
Andasuria Beel (Bakapur)	120	Diarrhoea	Dysentery	Aug	Oct
Atrai/Barnai confl.	116	Cholera	Dysentery	Sept	Dec
Atrai/Barnai confl. HTW	34	Cholera	Dysentery	NA	NA
Atrai/Nandokuja confl.	190	Diarrhoea	Dysentery	Oct	Dec
Atrai/Nandokuja STW	96	Diarrhoea	Dysentery	NA	NA
Bamandanga Beel	120	Dysentery	ND	Aug	Sept
Bamandangha Beel STW	80	Diarrhoea	Dysentery	NA	NA
Bangali River (Sariakandi)	170	Diarrhoea	ND	NDA	NDA
Burail River	40	Diarrhoea	ND	NDA	NDA
Ghargot River (Gaibandha)	TNTC	Diarrhoea	Dysentery	NDA	NDA
Halti Beel (Chalan Beel C)	60	Diarrhoea	Dysentery	Oct	Nov
Halti Beel STW	100	Diarrhoea	Dysentery	NA	NA
Harudangha Beel	50	Diarrhoea	Cholera	Sept	Feb
Harudangha Beel STW	120	Diarrhoea	Dysentery		
Jamuna River (Kurigram)	300	Dysentery	ND	Nov	Dec
Teesta/Jamuna confl HTW	100	Dysentery	ND	NA	NA
Teesta/Jamuna confl. DTW	0	Dysentery	Diarrhoea	NA	NA
Jamuna River (Manos Reg.)	250	Diarrhoea	Dysentery	Sept	Oct
Jamuna R. below Burail confl.	70	Diarrhoea	Dysentery	NDA	NDA
Kumirdaha Beel	130	Diarrhoea	ND	Sept	Oct
Kumirdaha Beel STW	40	Diarrhoea	Dysentery	NA	NA
Atrai/Nandokuja confl.	80	Diarrhoea	Cholera	Feb	Mar
Atrai/Nandokuja confl.	TNTC	Diarrhoea	ND	Feb	Mar
Padma River	100	Dysentery	Diarrhoea	Oct	Nov
Sib River (Chaubaria)	110	Diarrhoea	Cholera	Sept	Oct
Teesta River	160	Diarrhoea	ND	Oct	Nov
Utraeel Beel (S Central)	140	Diarrhoea	Dysentery	Oct	Nov

TNTC = Too Numerous to count

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Table 4.3 Reported use of Fertilisers and Biocides Close to Water Sampling Stations.

LOCATION	FERTILISERS	BIOCIDES
Andasuria Beel (Bakapur)	Urea; TSP; MP	Dicremon; Malathion; Sumithio
Atrai/Barnai confl.	Urea: TSP; Zinc sulphate	Diazinon; Malathion; Sumithion
Atrai/Barnai confl. HTW	No data	No data
Atrai/Nandokuja confl.	Urea; TSP; MP	Sumithion; Furadan; Heptachlo
Atrai/Nandokuja STW	No data	No data
Bamandanga Beel	Urea: TSP; Zinc sulphate	Thiodin; Thionol; Danada
Bamandangha Beel STW	No data	No data
Bangali River (Sariakandi)	Urea; TSP; Zinc sulphate	Sumithion; Dieldrin; Furadan
Burail River	Urea: TSP; MP	Diazinon; Malathion; Nogos
Ghargot River (Gaibandha)	No data	No data
Halti Beel (Chalan Beel C)	Urea: TSP; Zinc sulphate	Basudin; Furadan; Nogos
Halti Beel STW	No Data	No data
Harudangha Beel	Urea; TSP; Gypsum*	Dimecron; Malathion; Basudin
Harudangha Beel STW	No data	No data
Jamuna River (Kurigram)	Urea; TSP; MP	Thiol; Malathion; Thiodin
Teesta/Jamuna confl HTW	No data	No data
Teesta/Jamuna confl. DTW	Na data	No data
Jamuna River (Manos Reg.)	Ure; MP; Gypsum*	Dieldrin; Basudin; Nogos
Jamuna R. below Burail confl.	Urea; TSP; Gypsum*	Nogos; Aldrin; Malathion
Kumirdaha Beel	Urea; TSP; Gypsum*	Furadan; Nogos; Basudin
Kumirdaha Beel STW	No Data	No data
Atrai/Nandokuja confl.	Urea; TSP; Zinc sulphate	Sumithion; Furadan; Basudin
Atrai/Nandokuja confl.	Urea; TSP; Zinc sulphate	Heptachlor; Basudin; Nogos
Padma River	No Data	No data
Sib River (Chaubaria)	Urea; TSP; Zinc sulphate	Sumithion; Faradan; Thiodin
Teesta River	Urea; TSP; Zinc sulphate	Furadan; Malathion; Thiodin
Utraeel Beel (S Central)	Urea; TSP; Gypsum*	Furadan; Thiodin; Sumithion

TSP Triple Superphosphate
MP 'Muriate of Potash' - i.e. Potassium Chloride
Gypsum* Commonly Reported, but may be Confused with Lime.
Zinc Sulphate - Widely used to Counter Soil Zinc Deficiency,

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Table 4.4 River Bank Macrophytes

Major Group	Genus	Species	Freq.	Utility		
Herbs	Amaranthus	spinosus	3	Veterinary	Fodder	Vegetable
	Centella	asiatica	3	Dysentery	Emetic	Vegetable
	Polygonum	orientalis	3			
	Centipeda	orbicularis	2			
	Eclipta	alba	2			
	Leucus	aspera	2			

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Table 4.5 River Channel Macro-fauna

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Bandicota	indica	3	Grain
	Herpestes	auropunctatus	3	Snakes, small animals
	Platanista	gangetica	3	Fish
	Lutra	lutra	2	Fish
Birds	Amaurornis	phoenicurus	3	Small animals, insects
	Anastomus	oscitans	3	Small animals
	Ardeola	alba	3	Fish, frogs
	Bubuleus	ibis	3	Fish, frogs
	Charadrius	dubius	3	Insects, worms
	Columba	livia	3	Grain etc
	Egretta	intermedia	3	Fish, frogs
	Gallinego	henura	3	Omnivore
	Halcyon	smyrnensis	3	Fish
	Nettapus	coromandelianus	3	Omnivore
	Passer	domesticus	3	Grain etc
	Phalacrocorax	niger	3	Fish
	Ploceus	philippinus	3	Grain
	Sterna	aurantia	3	Fish
	Streptopelia	chnensis	3	Grain
	Tringa	hypoleucos	3	Insects
	Alchdo	atthis	2	Fish
	Ciconia	episcopus	2	Fish, small animals
	Haliaster	indus	2	Fish
	Orthotomus	sutorius	2	Insects
	Tadorna	ferruginea	2	Omnivore
	Turdoides	striatus	2	Insect larvae, etc
	Vanellus	indicus	2	Insects, worms
	Ceryle	rudis	1	Fish
Reptiles	Varanus	bengalensis	4	Small animals
	Enhydris	enhydris	3	Fish, frogs
	Trionyx	sp	3	Onmivore
	Xenochrophis	piscator	3	Fish, frogs
	Bungarus	caeruleus	2	Small animals
	Chitra	indica	2	Omnivore
	Cyclemys	dentata	2	Plants
	Naja	naja	2	Small animals
	Pelochelys	bibroni	2	Omnivore
	Ptyas	mucosus	2	Small animals
	Typhtops	porrectus	2	Worms
	Vipera	russelli	2	Small animals
	Varanus	sp	1	Small animals
Amphibia	Rana	sp	3	Insects

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Table 4.6 Charland macrophytes and their reported usage.

HABITAT	MAJOR GROUP	GENUS	SPECIES	FREQ	USAGE		
Wet banks	Herbs	Gnaphalium	affinae	5	Pioneer(Compositae		
		Ranunculus	sp	5	Pioneer		
		Centipeda	orbicularis	4			
		Eragrostis	gangetica	4	Fodder		
		Fimbristylis	sp	4			
		Polygonum	plebegium	4	Antihaemorrhagic		
		Caesulia	axillaris	3			
		Centella	asiatica	3	Dysentery	Emetic	Vegetable
		Cynodon	dactylon	3	Antiseptic	Fodder	Religious (H
		Elensine	indica	3	Fodder		
		Polygonum	orientalis	3			
		Scoparia	dulcis	3			
		Cotula	hemispherica	2			
		Digitaria	violascens	2			
		Eclipta	alba	2			
		Grangea	moderaspatana	2			
		Rumex	maritimus	1			
Wet plain	Herbs	Oryza	sp	5	Cereal crop	Fodder	Thatching
		Ranunculus	scleratus	5	Soil stabiliser		
		Fimbristylis	sp	3	Grazing		
		Gnaphalium	affine	3			
		Gnaphalium	indicum	3			
		Ludwidgia	hyssopifolia	3			
		Ranunculus	sp	3	Pioneer		
		Centella	asiatica	2	Dysentery	Emetic	Vegetable
		Cotula	hemispherica	2			
		Cynodon	dactylon	2	Antiseptic	Fodder	Religious (H
		Digitaria	sp	2	Fodder		
		Gnaphalium	spontaneum	2	Fodder		
		Herpestis	chamaedroides	2			
		Polycarpon	loeflingia	2			
		Polygonum	plebegium	2			
		Spilanthes	acmella	2			
		Oxalis	corniculata	2			
		Rumex	maritimus	1			
Dry plain	Herbs	Rununculus	scleratus	5	Pioneer plant		
		Amania	sp	3	Fodder		
		Centipida	orbicularis	3	Fodder		
		Eragrotis	tenella	3			
		Lindocnia	sp	3			
		Saccharum	spontaneum	3	Fodder	Crafts	Thatching
		Chenopoduim	ambrosioides	2	Grazing		
		Grangea	maderaspatana	2			
		Lippia	geminata	2			
		Lippia	nodiflora	2			
		Ludwigia	hyssopifolia	2			
		Polycarpon	sp	2			
		Solanum	nigrum	2			
		Sphaeranthus	sp	2			
		Cyperus	sp	1			
		Solanum	verbascifolium	1			
Cultivated land	Herbs	Lens	esculenta	5	Vegetable crop		Fodder
		Brassica	sp	4	Oil crop		Fuel
		Momordica	charantea	3	Vegetable crop		
		Amaranthus	spinosus	2	Veterinary	Fuel	Vegetable
		Cynodon	dactylon	2	Antiseptic	Fodder	Religious (H
		Gomphrena	globosa	2			
		Ipomoae	aquatica	2	Vegetable		
		Leonurus	sibericus	1	Fuel		

Table 4.7 Charland Area Macro-fa

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammal	Lutra	Lutra	2	Fish
Birds	Motacilla	alba	4	Insect feeder
	Anastomus	oscitans	3	Fish, molluscs, frogs
	Ardeola	alba	3	Fish, frogs
	Egretta	intermedia	3	Fish, frogs
	Leptoptilos	dubius	3	Snakes, frogs
	Motacilla	sp.	3	Small invertebrates
	Nettapus	coromandelianus	3	Small invertebrates
	Alcedo	atthis	2	Fish
	Gallinago	henura	2	Insect larvae
	Halcyon	smyrnensis	2	Fish
	Haliaster	indus	2	Scavenger
	Ichthyophaga	ichthyaetus	2	Fish
	Sterna	aurantia	2	Fish

Table 4.8 Agricultural Land Macrophytes

HABITAT	TYPE	GENUS	SPECIES	FREQ	UTILITY		
Ricefield	Herb	Oryza	sp	5	Cereal crop	Thatching	Fodder
Ricefield margins	Shrubs	Haliotropium	indicum	2	Veterinary	Eye diseases	Compost
		Lantana	camara	2	Fuel		
	Herbs	Centella	asiatica	4	Dysentery	Emetic	Vegetable
		Cynodon	dactylon	4	Antiseptic	Cultural	Grazing
		Gnaphalium	affine	4	Compost		
		Gnaphalium	alba	4	Compost		
		Echinochloa	colonum	3	Fodder		
		Echinochloa	crussgalli	3	Fodder		
		Ipomoea	aquatica	3	Vegetable	Fodder	
		Ludwigia	adsecndens	3			
		Polygonum	hydropiper	3	Antihaemorrhagic		
		Polygonum	plibegium	3			
		Amaranthus	spinosus	2	Veterinary	Vegetable	Fuel
		Argemone	mexicana	2	Antiseptic?		
		Fimbristylis	sp	2			
		Hygrophila	auriçulata	2	Veterinary use	Fodder	
		Leonurus	sibericus	2			
Wheatfield	Herbs	Triticum	aestivum	5	Grain crop	Thatching	Fodder
		Amaranthus	spinosus	2	Compost		
		Gomphrena	globosa	2	Compost		
Wheatfield margins	Shrub	Heliotropium	indicum	2	Veterinary	Eye medicine	Compost
	Herbs	Gnaphalium	affine	3			
		Gnaphalium	alba	3			
		Phylla	nudiflora	3	Grazing		
		Centella	asiatica	2	Dysentery	Emetic	Vegetable
		Ranunculus	sceleratus	2			
		Rumex	maritimus	2			
		Vernonia	patula	2			
		Echinochloa	colonum	4	Fodder		
		Setaria	barbata	4	Fodder		
		Amaranthus	spinosus	3	Veterinary	Vegetable	Fodder
		Argemone	mexicana	3	Veterinary	Fodder	
		Cynodon	dactylon	3	Antiseptic	Religious (M/H)	Fodder
		Gomphrena	globosa	3	Grazing		
		Polycarpon	prostratum	3	Vegetable		
		Polygonum	hydropiper	3	Antihaemorrhagic	Fuel	
		Ipomoea	aquatica	2	Vegetable	Fodder	

Table 4.9 Agricultural Land Macro-fauna.

HABITAT	MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Ricefield	Birds	Dicrurus	adsimilis	3	Insects
		Bubuleus	ibis	3	Fish, frogs
		Sturnus	contra	2	Insects
		Acridotheres	tristis	2	Insects
	Reptile	Varanus	bengalensis	2	Small animals
Ricefield margins	Mammals	Bandicota	indica	3	Omnivore
		Herpestes	auropunctatus	3	Snakes, rodents
		Vulpes	bengalensis	3	Scavenger
	Reptiles	Bungarus	caeruleus	3	Small animals
		Naja	naja	3	Small animals
		Ptyas	mucosus	3	Small animals
		Varanus	bengalensis	3	Small animals
		Xenochrophis	piscator	3	Fish, frogs
		Varanus	sp	2	Small animals
Wheatfield	Birds	Dicrurus	adsimilis	3	Insects
		Sturnus	contra	2	Insects
		Upupa	epops	2	Insects on ground
	Mammals	Bandicota	bengalensis	4	Grain etc
		Bandicota	indica	4	Grain, insects
Wheatfield margins	Birds	Dicrurus	adsimilis	2	Insects
		Upupa	epops	2	Insects
	Mammal	Herpestes	auropunctatus	3	Snakes, rodents
	Reptile	Varanus	bengalensis	3	Small animals

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Table 4.10 Beel Aquatic Macrophytes

GENUS	SPECIES	FREQ	UTILITY		
Ceratophyllum	dumersum	5			
Cryptocoryne	retrospiralis	4			
Hydrilla	verticillata	4	Fodder	Compost	
Hygroryza	aristata	4	Fodder	Compost	
Ipomoea	aquatica	4	Vegetable	Fodder	
Trapa	natans	4	Food (seeds)		
Hydrocharis	dubia	3	Fishing habitat	Water cooling	Compost
Polygonum	sp	3			
Sagittaria	sagittifolia	3			
Schoenoplectus	articulatus	3	Fodder	Compost	
Schoenoplectus	grossus	3	Fodder	Compost	

Note: Aquatic Macrophytes only occur in a Minority of Beels.

Table 4.11 Beel Macro-fauna.

TYPE	GENUS	SPECIES	FREQ	FOOD
Mammal	Lutra	Lutra	2	Fish
Birds	Amaurornis	phoeniculrus	4	Small animals, insects
	Dendrocygna	javanica	4	Omnivore
	Alcedo	atthis	3	Fish
	Ardeola	alba	3	Fish, frogs
	Ardeola	grayii	3	Fish, frogs
	Bubuleus	ibis	3	Fish, frogs
	Egretta	intermedia	3	Fish, frogs
	Gallinego	henura	3	Insects, fish, frogs
	Haliaster	indus	3	Fish, frogs
	Nettapus	coromandelianus	3	Omnivore
	Phalacrocorax	niger	3	Fish
	Accipiter	badius	2	Scavenger
	Milvus	migrans	2	Scavenger
	Sterna	aurantia	2	Fish
	Tadorna	ferrugiea	2	Omnivore
	Ciconia	episcopus	1	Small animals
	Leptoptilos	dubius	1	Invertebrates, fish
Reptiles	Atretium	schistosum	3	Fish
	Cyclemys	dentata	3	Plants
	Enhydris	enhydris	3	Fish, frogs
	Xeonochrophis	piscator	3	Fish, frogs
Amphibia	Rana	sp	4	Insects

Table 4.12 Non-flood Protected Homestead Macrophytes and their Reported Usage.

MAJOR GROUP	GENUS	SPECIES	FREQ	USAGE		
Tree	Azadirachta	Indica	1	General Timber	Skin Diseases	
Shrubs	Ricinus	communis	3	Rheumatism	Bank stabiliser	Fuel
	Alocasia	indica	2	Vegetable		
	Heliotropium	indicum	2	Medicinal		
Herbs	Musa	sp.	4	Fruit crop	Vegetable	Religious
	Centella	asiatica	3	Dysentery	Emetic	Vegetable
	Polygonum	hydropiper	3	Antihaemorrhagic		
	Amaranthus	spinosus	2	Veterinary	Vegetable	Fodder
	Amaranthus	viridis	2	Vegetable	Fodder	Fuel
	Gynandropsis	gynandra	2	Fuel		

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Table 4.13 Non-flood Protected Homestead Area Macro-fauna.

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Callosciurus	pygerythrus	3	Seeds, fruit, etc
	Mus	musculus	3	Grain, etc
	Herpestes	auropunctatus	2	Snakes, rodents
	Mus	booduga	2	Grain etc
Birds	Acridotheris	fuscus	4	Insects
	Acridotheris	tristis	3	Insects
	Columba	livia	3	Grain
	Corvus	splendens	3	Scavenger
	Passer	domesticus	3	Grain etc
	Sturnus	contra	3	Insects
	Dicrurus	adsimilis	2	Insects
Reptiles	Calotes	versicolor	3	Insects
	Ptyas	mucosus	3	Small animals
	Xenochrophis	piscator	3	Frogs, fish etc
	Naja	naja	1	Small animals
	Varanus	flaviscens	1	Small animals
	Vipera	russelli	1	Small animals
Amphibia	Bufo	melanostictus	3	Insects

Table 4.14 Flood Protected Homestead Area Macrophytes.

MAJOR GROUP	GENUS	SPECIES	FREQ	USAGE		
Trees	Acacia	nilotica	2	Construction	Cartwheels	Anvils
	Moringa	oleifera	2	Vegetable crop	Fodder	Fuel
Shrubs	Ipomoea	fistulosa	4	Fuel	Narcotic	
	Carica	papaya	3	Indigestion	Fruit crop	Meat tenderiser
	Datura	fastuosa	2	Medicinal	Fuel	
	Ricinus	communis	2	Rheumatism	Fuel	Bank stabiliser
Herbs	Musa	sapientum	4	Fruit crop	Vegetable	Religious (M/H)
	Centella	asiatica	3	Dysentery	Emetic	Vegetable
	Polygonum	hydropiper	3	Antihaemorrhagic		
	Argemone	mexicana	2	Medicinal		

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Table 4.15 Homestead Macro-fauna in Flood Protected Area beside the Jamuna River.

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Callosciurus	pygerythrus	4	Fruit, seeds
	Herpestes	auropunctatus	3	Snakes, small animals
Birds	Acridotheres	tristis	3	Insects
	Centropus	sinensis	3	Fruit
	Corvus	splendens	3	Scavenger
	Passer	domesticus	3	Grain etc
	Sturnus	contra	3	Insects
	Orthotomus	sutoria	2	Insects
Reptiles	Mabuya	carinata	4	Insects
	Callotes	versicolor	3	Insects
	Ptyas	mucosus	3	Small animals
	Xenochrophis	piscator	3	Frogs, fish
	Varanus	bengalensis	2	Small animals
Amphibia	Bufo	melanosticta	3	Insects
	Rana	sp	3	Insects

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Table 4.16 Embankment Macrophytes and their Reported Usage.

MAJOR GROUP	GENUS	SPECIES	FREQ	USAGE		
Trees	Acacia	nilotica	4	Construction	Cartwheels	Anvils
	Dalbergia	sissoo	3	General timber		Fuel
Shrubs	Calotropis	gigantea	3	Rheumatism	Fuel	Religious (H)
	Cassia	occidentalis	3	Excema	Fuel	
	Lantana	camara	3	Fuel		
	Ricinus	communis	3	Rheumatism	Fuel	Bank stabiliser
	Heliotropium	indicum	2	Veterinary		
Herbs	Cassia	occidentalis	4	Excema	Fuel	
	Chrysopogon	aciculatus	4	Headaches		Bank stabiliser
	Echinochloa	colonum	4	Fodder		Bank stabiliser
	Cassia	sp	3	Fuel		
	Clerodenrum	viscosum	3	Veterinary	Fuel	
	Cynodon	dactylon	3	Antiseptic	Fodder	Religious (H)
	Musa	sp.	3	Fruit crop	Vegetable	Religious
	Amaranthus	spinosus	2	Veterinary	Vegetable	Fuel
	Aponogeton	natans	2	Fuel		
	Leonurus	sp	2	Fuel		
	Polycarpon	prostratum	2	Vegetable		
	Solanum	nigrum	2	Fuel		
	Cuscuta	reflexa	1	Antihelminthic		
	Musa	paradisiaca				

Table 4.17 Embankment Macro-fauna.

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Bandicota	bengalensis	3	Grain etc
	Bandicota	indica	3	Grain etc
	Callosciurus	pygerythrus	3	Fruit, seeds
	Herpestes	auropunctatus	2	Snakes, small animals
	Pteropus	giganteus	2	Fruit
	Vulpis	bengalensis	2	Scavenger
Birds	Acridotheris	tristis	4	Insects
	Acridotheris	fuscus	3	Insects
	Alcedo	atthis	3	Fish
	Bubuleus	ibis	3	Fish, frogs
	Copsychus	saularis	3	Insects
	Corvus	splendens	3	Scavenger
	Lonchura	malabarica	3	Grain
	Passer	domesticus	3	Grain etc
	Ploceus	philippinus	3	Grain
	Psittacula	krameri	3	Fruit, grain
	Streptopelia	decaocta	3	Grain
	Sturnus	contra	3	Insects
	Upupa	epops	3	Insect larvae
	Acridotheres	ginginianus	2	Insects
	Athene	brama	2	Small animals
	Bubo	zeylonensis	2	Small animals
	Centropus	sinensis	2	Insects, fruit
	Clamator	jacobrinus	2	Insects
	Corvus	macrorhynchos	2	Scavenger
	Dicrurus	adsimilis	2	Insects
	Dinopium	benghalense	2	Insect larvae, worms
	Eudynamys	scolopacea	2	Fruit
	Gyps	bengalensis	2	scavenger
	Halcyon	smyrnensis	2	Fish
	Milvus	migrans	2	Scavenger
	Nectarinia	zeylonica	2	Nectar
	Oriolus	xanthornus	2	Fruit, larvae, nectar
	Orthotomus	sutorius	2	Nectar, insect grubs
	Pycnonotus	cafer	2	Insects, fruit
	Streptopelia	chinensis	2	Grain
	Accipiter	badius	1	Fish, small animals
Reptiles	Calotes	versicolor	3	Insects
	Enhydris	enhydris	3	Small animals
	Ptyas	mucosus	3	Small animals
	Varanus	bengalensis	3	Small animals
Reptile	Varanus	sp	2	Small animals
Reptile	Vipera	russelli	2	Small animals
Amphibia	Bufo	melanostictus	2	Insects

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Table 4.18 Highland Homestead Macro-fauna

MAJOR GROUP	GENUS	SPECIES	FREQ	FOOD
Mammals	Mus	booduga	4	Grain etc
	Mus	musculus	4	Grain etc
	Callosciurus	pygerythrus	3	Fruit, seeds, grain
	Pteropus	giganteus	3	Fruit
	Vulpes	bengalensis	3	Scavenger
	Bandicota	bengalensis	2	Grain
	Herpestes	auropunctatus	2	Snakes, small animals
	Lutra	lutra	1	Fish
Birds	Acridotheres	tristis	4	Insects
	Columba	livea	4	Grain
	Passer	domesticus	4	Grain etc
	Ardeola	alba	3	Fish, frogs
	Athene	brama	3	Small animals
	Bubuleus	ibis	3	Fish, frogs
	Copsychus	malabaricus	3	Insects
	Copsychus	saularis	3	Insects
	Corvus	splendens	3	Scavenger
	Cypsiurus	parvus	3	Insects
	Dicrurus	*adsimilis*	3	Insects
	Egretta	intermedia	3	Fish, frogs
	Halcyon	*smyrnensis*	3	Fish
	Lonchura	malabarica	3	Grain
	Ploceus	*philippinus*	3	Grain
	Streptopelia	decaocta	3	Grain
	Sturnus	*contra*	3	*Insects*
	Bubo	sp	2	Small animals
	Bubo	*zeylonensis*	2	*Small animals*
	Centropus	sinensis	2	Fruit
	Corvus	macrorhynchOs	2	Scavenger
	Dendrocitta	vagabunda	2	Insects, eggs
	Dinopium	benghalense	2	Insects
	Eudynamys	scolopacea	2	Omnivore
	Haliaster	indus	2	Scavenger
	Icthyophaga	icthyaetus	2	Fish
	Milvus	migrans	2	Scavenger
	Oriolus	xanthornus	2	Insects etc
	Orthotomus	sutoria	2	Insects
	Psittacula	krameri	2	Fruit, grain etc
	Pycnonotus	cafer	2	Insects,fruit
	Accipiter	badius	1	Birds, small mammals
	Gyps	bengalensis	1	Scavenger
	Megalaima	haemacephala	1	Insects
	Nectarinia	zeylonica	1	Nectar
Reptiles	Hemidactylus	brooki	4	Insects in houses
	Calotes	versicolor	3	Insects
	Enhydris	enhydris	3	Small animals, frogs
	Mabuya	carinata	3	Insects
	Ptyas	mucosus	3	Small animals
	Xenochrophis	piscator	3	Fish, frogs
	Varanus	*bengalensis*	2	*Small animals*
	Varanus	sp	2	Small animals
	Vipera	*russelli*	2	*Small animals*
	Bungarus	caeruleus	1	Small animals, gekkos
	Naja	*naja*	1	*Small animals*
Amphibia	Bufo	melanosticta	4	Insects etc
	Rana	*tigrina*	2	*Insects*

Table 4.19 Homestead Area Macrophytes and their Reported Usage.

MAJOR GROUP	GENUS	SPECIES	FREQ	UTILITY		
Trees	Citrus	grandis	4	Fruit crop	Fuel	
	Ficus	heterophylla	4	Fruit	Fuel	
	Mangifera	indica	4	Fruit crop	Fodder	General timber
	Phoenix	sylvestris	4	Fruit crop	Crafts (domestic)	Construction
	Albizia	procera	3	General timber	Construction	Boatbuilding
	Areca	catechu	3	Cash fruit crop	Fish traps	Construction
	Artocarpus	heterophyllus	3	Fruit crop	General timber	Cultural
	Azadirachta	indica	3	General timber	Antiseptic	Fuel
	Bombax	ceiba	3	Construction	Fibre	Fuel
	Borassus	flabellifer	3	Construction	Fruit crop	Crafts (domestic)
	Cocos	nucifera	3	Fruit/drink	Construction	Crafts/fibre
	Zizyphus	mauritiana	3	Fruit crop	Fodder	Fuel
	Acacia	nilotica	2	Construction	Cartwheels	Anvil
	Anthocephalus	chinensis	2	General timber	Fuel	Decorations
	Apanamixis	polystachya	2	General timber	Fuel	Construction
	Cassia	fistula	2	General timber	Fuel	
	Dalbergia	sissoo	2	General timber	Fuel	
	Ficus	comosa	2	General timber	Fuel	Medicinal
	Moringa	*oleifera*	2	*Fruit/veg crop*	*Gastric medicine*	*Fodder*
	Polyalthia	longifolia	2	General timber	Ornamental	
	Spondias	pinnata	2	Fruit	Fuel	
	Syzygium	sp	2	Fruit crop	General timber	Fuel
	Tamarindus	*indica*	2	*Fruit crop*	*Fuel*	
	Aegle	marmelos	1	Fruit crop (palm)	G-I tract medicine	General timber
	Annona	reticulata	1	Fruit crop	General timber	Fuel
	Averrhoa	carambola	1	Fruit	Jaundice	Fuel
	Butea	*superba*	1	*Fuel*	*Decorative*	
	Cerbera	odollam	1	timber	fuel	
	Diospyros	peregrina	1	Construction	Boatbuilding	Commercial crafts
	Ficus	benghlensis	1	General timber	Wet season fodder	Fuel
Shrubs	Calotropis	gigantea	3	Rheumatism	Fuel	Religious (H)
	Heliotropium	indicum	3	Veterinary	Eye medicine	
	Hibiscus	rosasinensis	3	Ornamental	Religious	Fuel
	Abroma	augusta	2	Gynaecological	Dysentery	Fuel
	Carica	papaya	2	Fruit crop	Gastic medicine	Meat tenderiser
	Datura	fastuosa	2	Medicinal	Fuel	
	Ficus	hispida	2	Fruit	Fuel	
	Ipomoea	fistulosa	2	Fuel	Narcotic	
	Ricinus	comunis	2	Rheumatism	Bank stabiliser	Fuel
	Acalypha	welkesiana	1	cultural		
Herbs	Bambusa	sp	5	Construction	Crafts (domestic)	Crafts (commercial)
	Calotropis	gigantea	5	rheumatism	Fuel	
	Clerodendrum	viscosum	4	Rheumatism	Veterinary	Fuel
	Aloe	barbadensis	4	Vegetable		
	Amaranthus	viridis	4	Vegetable	Fodder	
	Ananas	sativus	3	Fruit crop		
	Centella	asiatica	4	Dysentery	Emetic	Vegetable
	Chrysopogon	aciculatus	4	Fodder	Antihaemorrhagic	
	Cleome	viscosa	4	Emergency fuel		
	Enhydra	*fluctuans*	2	*Fuel*		
	Musa	sapientum	4	Fruit/veg crop	Craft (domestic)	Religious (H)
	Amaranthus	spinosus	3	Veterinary	Vegetable	Fodder
	Aponogeton	natans	3	Fuel		
	Argemone	mexicana	3	*Medicinal*		
	Cassia	occidentalis	3	Excema	Fodder	Fuel
	Clerodendrum	viscosum	3	Veterinary	Fuel	
	Colocasia	esculenta	3	Skin diseases	Vegetable crop	
	Cynodon	dactylon	3	Antiseptic	Fodder	Religious (H)
	Ipomoea	aquatica	3	Vegetable	Fodder	
	Alocasia	indica	2	Rheumatism	Vegetable	Emergency food
	Leonurus	sibericus	2	Fuel		
	Polycarpon	prostratum	2	Vegetable		
	Polygonum	hydropiper	2	Antihaemorrhagic	Fuel	
	Portulaca	oleracea	2	Anti-vomiting	Vegetable	
	Rumex	maritimus	2			
	Solanum	nigrum	2			
	Buettneria	pilosa	1	Bone fractures		
	Malva	verticillata	1	Medicinal		

H = Hindus

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Table 4.20 Pond Bank Macrophytes

MAJOR GROUP	GENUS	SPECIES	FREQ	UTILITY		
Trees	Acacia	nilotica	4	Construction	Cartwheels	Anvil
	Borassus	flavelifer	3	Fruit crop	Dysentery	Construction
	Phoenix	sylvestris	3	Fruit crop	Crafts	Construction
	Azadirechta	indica	1	General timber		Skin diseases
Shrub	Ipomoea	fistulosa	3	Fuel		
	Heliotropium	indicum	2	Veterinary	Eye medicine	
Herbs	Caesulia	axillaris	2			
	Centella	asiatica	2	Dysentery	Emetic	Vegetable
	Fimbristylis	sp	2	Grazing		
	Polygonum	hydropiper	2	Antihaemorrhagic		Fuel
	Solanum	nigrum	2			
	Vernonia	patula	2			

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Table 4.21 Pond Macro-fauna.

MAJOR GROUP	GENUS	SPECIES	FRE	FOOD
Mammals	Bandicota	bengalensis	3	Grain
	Callosciurus	pygerythrus	3	Fruit, seeds
	Herpestes	auropunctatus	2	Snakes, small animals
Birds	Alcado	atthis	3	Fish
	Ardeola	alba	3	Frogs, insects
	Bubuleus	ibis	3	Fish, frogs
	Dicrurus	adsimilis	3	Insects
	Halcyon	smyrnensis	3	Fish
	Streptopelia	decaocta	3	Grain
	Sturnus	contra	3	Insects
	Acridotheris	tristis	2	Insects
	Amaurornis	phoenicurus	2	Insects, etc
	Athene	brama	2	Small animals
	Egretta	intermedia	2	Fish, frogs
	Gallinago	henura	2	Insects, etc
	Merops	orientalis	2	Insects
	Oriolus	xanthornus	2	Insect larvae, etc
Reptiles	Calotes	versicolor	3	Insects
	Enhydris	enhydris	3	Fish, small animals
	Varanus	sp.	2	Small animals
	Xenochrophis	piscator	2	Small animals
Amphibia	Rana	tigrina	2	Insects

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Table 4.22 Refuge Woodland Macrophytes.

MAJOR GROUP	GENUS	SPECIES	FREQ	USAGE		
Herbs	Bambusa	sp	4	Construction crop		Fuel
	Centella	asiatica	3	Dysentery	Emetic	Vegetable
	Chrysopogon	aciculatus	3	Headaches	Grazing	
	Colocasia	esculenta	3	Skin diseases		Vegetable
	Leucas	aspera	3			
	Phylla	nudiflora	3	Grazing		
	Smilax	zeylanica	3	Medicinal		
	Ageratum	conyzoides	2	Grazing		
	Gnaphalium	alba	2			
	Leonurus	sibericus	2			
	Rumex	dentatus	2			
	Saccharum	spontaneum	2	Fodder	Thatching	Crafts
	Solanum	nigrum	2			
	Vernonia	patula	2			
	Ammannia	baccifera	1			
	Clerodendrum	viscosum	1	Rheumatism	Veterinary	Fuel
Trees	Phoenix	sylvestris	3	Fruit crop	Construction	Crafts
	Polyalthia	longifolia	3	General timber	Fuel	Ornamental
	Bombax	ceiba	2	Construction	Fibre	Fuel
	Syzygium	sp	2	Construction	Fruit crop	Fuel
	Mangifera	indica	1	Fruit crop	Fodder	Crafts
	Zizyphus	mauritiana	1	Fruit	Fodder	Fuel

Table 4.23 Bamboo Cluster Macrophytes and Macro-fauna.

MACRO	GENUS	SPECIES	FREQ		USAGE	
Herb	Bambusa	sp	5	Construction	Fuel	Craft
MACRO-	GENUS	SPECIES	FREQ		FOOD	
Birds	Egretta	intermedia	4	Fish, frogs		
	Alcedo	atthis	2	Fish		
	Sturnus	contra	2	Insects		
Reptile	Varanus	sp	2	Rodents, birds		

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Table 4.24 (A) Species List and Resource Utilisation of Terrestrial Macrophytes in the North West Region, 1992

TYPE	SCIENTIFIC NAME		ENGLISH NAME	BENGALI NAME	UTILITY			
	Genus	Species						
Trees	Acacia	nilotica	Bulbul Tree	Babla/Badul	Construction	Cartwheels	Anvils	
	Aegle	marmelos	Bengal Quince	Bel/Bela	Fruit crop (palm)	G-I tract medicine	General timber	
	Albizia	lucida		Sil Koroi	General timber	Fuel	Boat building	
	Albizia	procera	White Siris	Sada Koroi	General timber	Fuel	Boat building	
	Annona	reticulata	Bullock's Heart	Nona	Fruit crop	Fuel	General timber	
	Anthocephalus	chinensis	Kadam	Kadam	General timber	Fuel	Decorations	
	Apanamixis	polystachya		Pitraj/Raina	General timber	Fuel	Construction	
	Areca	catechu	Betel Nut Palm	Supari/Gua	General timber	Fish traps	Fruit crop	
	Artocarpus	heterophyllus	Jack Fruit Tree	Kathal	Fruit crop	General timber	Commercial craft	Ornamental w
	Averrhoa	carambola		Kamranga	Fruit	Jaundice	Fuel	
	Azadirechta	indica	Margosa	Neem	General timber	Skin disease	Fuel	
	Bombax	ceiba	Red Silk Cotton	Simul	Construction	Fibre	Fuel	
	Borassus	flabellifer	Palmyra Palm	Tal	Construction	Fruit crop	Crafts (domestic)	Dysentery
	Butea	superba	Flame of the Farest	Lal Palash	Fuel	Decorative	NA	
	Cassia	fistula	Indian Laburnum	Bandarlathi/Sonalu	General timber	Fuel	NA	
	Cerbera	odollam		Dakur	timber	Fuel	NA	
	Citrus	grandis		Jambura	Fruit crop	Fuel	NA	
	Cocos	nucifera	Coconut	Narikel/Dab	Fruit/drink crop	Fibre	Construction	Ornamental
	Dalbergia	sisso	Sissoo	Sisso/Sisu	General timber	Fuel	NA	
	Diospyros	peregrina	Nigerian Ebony	Gab	Construction	Boatbuilding	Commercial crafts	Cultural
	Ficus	benghalensis	Banyan Tree	Bot	General timber	Wet season fodder	Fuel	
	Ficus	comosa		Pakur	General timber	Fuel	Medicinal	
	Ficus	heterophylla		Bhuidumur	Fruit	Fuel	NA	
	Mangifera	indica	Mango Tree	Aam	Fruit crop	Fodder	General timber	Wood crafts
	Moringa	oleifera		Sajna	Vegetable crop	Fruit crop	Fuel	Fodder
	Phoenix	sylvestris	Wild Date Palm	Khejur	Fruit crop	Crafts	Construction	
	Polyalthia	longifolia	Mast Tree	Debdaru	General timber	Ornamental	Fuel	
	Spondias	pinnata	Hog-Palm	Amra	Fruit	Fuel	NA	
	Syzygium	sp	Indian Black Berry	Jam	Fruit crop	General timber	Fuel	
	Tamarindus	indica	Tamarind	Tetul	Fruit crop	Fuel	Fodder	
	Zizyphus	mauritiana	Jujube Tree/Indian Plam	Borai/Kul Gach	Fruit crop	Fodder	Fuel	
Shrubs	Abroma	augusta		Ulatkambal	Gynaecological	Dysentery	Fuel	
	Acalypha	welkesiana		Patabahar	cultural	NA	NA	
	Calotropis	gigantea		Akanda Pata	Rheumatism	Religious (H)	Fuel	
	Carica	papaya	Papaya	Pepe	Fruit crop	Gastic medicine	Meat tenderiser	
	Datura	fastuosa		Dhutra	Medicinal	Fuel	NA	
	Ficus	hispida		Dumur/Kak-Dumur	Fruit	Fuel	NA	
	Heliotropium	indicum		Hatishur	Veterinary	Eye diseases	Compost	
	Hibiscus	rosasinensis	China Rose	Jaba	Ornamental	Religious	Fuel	
	Ipomoea	fistulosa		Dhol Kalmi	Fuel	Narcotic	NA	
	Justicia	adhatoda		Basak Pata	Cough	Fuel	NA	
	Lantana	Camara		Guegandha	Fuel	NA	NA	
	Ricinus	communis		Reri	Rheumatism	Bank stabliser	Fuel	

Table 4.24 (B) Species List and Resource Utilisation of Terrestrial Macrophytes in the North West Region, 1992

TYPE	SCIENTIFIC NAME		ENGLISH NAME	BENGALI NAME	UTILITY			
	Genus	species						
Herbs	Ageratum	conyzoides		Phukuri	Grazing	NA	NA	
	Ammannia	baccifera			NA	NA	NA	
	Leucas	aspera		Dulfi/Danda Kalas	NA	NA	NA	
	Phylla	nudiflora		Karoghash	Grazing	NA	NA	
	Clerodendrum	viscosum		Bhant	Rheumatism	Veterinary	Fuel	
	Enhydra	flactuans			Fuel	NA	NA	
	Smilax	zeylanica		Kumarilata	Medicinal	NA	NA	
	Vernonia	petula		Shiallata/Kuksim	NA	NA		
	Alocasia	indica		Maan Kachu	Emergency food	Vegetable	Rheumatism	
	Aloe	barbadensis		Ghee Kachu	Vegetable	NA	NA	
	Amania	sp			Fodder	NA	NA	
	Amaranthus	spinosus		Kanta Note	Veterinary	Vegetable	Fodder	Fuel
	Amaranthus	viridis		Note Shak	Vegetable	Fodder	Fuel	
	Ananas	sativus	Pine Apple	Anaras	Fruit crop	Fuel	NA	
	Aponogeton	natans		Ghetu	Fuel	NA	NA	
	Argemone	mexicana		Shial Kanta	Veterinary antise	Fooder	NA	
	Bambusa	sp	Bamboo	Bans	Construction crop	Fule	Crafts	
	Brassica	sp	Mustard	Sarisha	Vegetable oil crop	Fuel	NA	
	Buettneria	pilosa		Harjorah	Bone fractures	NA	NA	
	Caesulia	axillaris			NA	NA	NA	
	Cassia	occidentalis		Jhanjhani	Eczema	Fodder	Fuel	
	Centella	asiatica		Thankuni	Dysentery	Emetic	Vegetable	
	Centipida	orbicularis		Hachuti	Fodder	NA	NA	
	Chenopoduim	ambrosioides		Chandan Bete	Grazing	NA	NA	
	Chrysopogon	aciculatus		Chorekanta	Headaches	Bank stabliser	Antihaemorragh	Fooder
	Cleome	viscosa		Yollow Hurhuria	Emergency fuel	NA	NA	
	Colocasia	esculenta		Kachu	Skin diseases	Vegetable crop	NA	
	Cotula	hemispherica			NA	NA	NA	
	Cuscuta	reflexa		Swarnalata	Antihelminthic	NA	NA	
	Cynodon	dactylon		Durbaghas	Antiseptic	Religious (M/H)	Grazing	
	Cyperus	sp			NA	NA	NA	
	Digitaria	violascens			NA	NA	NA	
	Echinochloa	colonum	Grass	Syamaghas	Fooder	Bank stabliser	NA	
	Echinochloa	crussgalli	Grass	Borosaiyama Ghas	Fodder	Bank stabilser	NA	
	Eclipta	alba		Keshraj/Keshuti	NA	NA	NA	
	Eleusine	indica		Malankuri	Fodder	NA	NA	
	Eragrostis	sp			Fodder	NA	NA	
	Fimbristylis	sp			Grazing	NA	NA	
	Gnaphalium	affinae			Charland pioneer	Compost	NA	
	Gnaphalium	alba			Compost	NA	NA	
	Gnaphalium	indicum			NA	NA	NA	
	Gnaphalium	spontaneum			Fodder	NA	NA	
	Gomphrena	globosa		Botamphul	Grazing	Compost	NA	
	Grangea	maderaspatana		Nemuti	NA	NA	NA	
	Gynandropsis	gynandra		White Hurhuria	Fuel	NA	NA	
	Herpestis	chamaedroides			NA	NA	NA	
	Hygrophila	auriculata		Keshardam	Veterinary use	Fodder	NA	

TYPE	SCIENTIFIC NAME		ENGLISH NAME	BENGALI NAME	UTILITY		
	Genus	species					
Herbs	Lens	esculenta		Musuri	Vegetable crop	Fuel	NA
	Leonurus	sibericus		Bhambi Phul	Fuel	NA	NA
	Lindocnia	sp			NA	NA	NA
	Lippia	geminata			NA	NA	NA
	Lippia	nodiflora			NA	NA	NA
	Ludwigia	adscendens		Keshardam	NA	NA	NA
	Ludwigia	hyssopifolia			NA	NA	NA
	Malva	verticillata		Napashak	medicinal	NA	NA
	Momordica	charantea		Karola	Vegetable crop	NA	NA
	Musa	sapientum	Banana	Kala	Fruit crop	Vegetable	Religious (H)
	Musa	paradisiaca	Plantain	Kach Kala	Fruit crop	Vegetable	Religious (H)
	Oryza	sp	Rice	Dhan	Grain crop	Thatching	Fodder
	Oxalis	corniculata		Amrul	NA	NA	NA
	Polycarpon	loeflingia			NA	NA	NA
	Polycarpon	prostratum		Gimashak	Vegetable	NA	NA
	Polycarpon	sp			NA	NA	NA
	Polygonum	hydropiper		Bishkatali	Antihaemorrhagic	Fuel	NA
	Polygonum	orientalis		Bishkatali	NA	NA	NA
	Polygonum	plebegium		Abjaban	Antihaemorrhagic	NA	NA
	Polygonum	sp		Bishkatali	Fuel	NA	NA
	Portulaca	oleracea		Nuina	Anti-vomiting	Vegetable	NA
	Ranunculus	scleratus		Palik	Charland pioneer	NA	NA
	Rumex	maritimus			NA	NA	NA
	Saccharum	spontaneum		Kash	Fodder	Crafts	Thatching
	Scoparia	dulcis		Bondhane/Furfuni	NA	NA	NA
	Setaria	barbata		Banspata Ghash	Fodder	NA	NA
	Solanum	nigrum		Futi Begun	Fuel	NA	NA
	Solanum	verbascifolium		Urusa	NA	NA	NA
	Sphaeranthus	sp			NA	NA	NA
	Spilanthes	acmella		Marhatitiga	NA	NA	NA
	Triticum	aestivum		Gom	Grain crop	Thatching	Fodder
	Vernonia	patula		Shiallata	NA	NA	NA
Aquatics	Ceratophyllum	dumersum		Kantajhaji	NA	NA	NA
	Cryptocoryne	retrospiralis			NA	NA	NA
	Hydrilla	verticillata		Jhangi	Compost	NA	NA
	Hydrocharis	dubia			Fishing habitat	Water cooling	Compost
	Hygroryza	aristata		Janglidhan	Fodder	Compost	(Emergency Food)
	Ipomoea	aquatica		Kalmi Shak	Vegetable	Fodder	NA
	Sagittaria	sagittifolia		Chhotokut	Fodder	Compost	NA
	Schoenoplectus	articulatus		Patpati/Chicka	NA	Compost	NA
	Schoenoplectus	grossus			Fodder	Compost	NA
	Trapa	Natans	Water Chest Nut	Panipha/Singara	Food (seeds)		

Table 4.25 Vertebrate Species (Macro-fauna, Excluding Fish) Recorded During the Ecological Survey of the North West Region, 1992

TYPE	SCIENTIFIC NAM		ENGLISH NAME	BENGALI NAMES	FOODS
	Genus	Species			
Mammals	Bandicota	bengalensis	Rat	Indur	Omnivore
	Bandicota	indica	Bandicoot Rat	Boro Metho Indur	Omnivore
	Callosciurus	pygerythrus	Irrawaddy Squippel	Kathbirally	Fruit, seeds
	Herpestes	auropunctatus	Small Mongoose	Beje	Snakes, small animals
	Lutra	lutra	Otter	Udbiral	Fish
	Mus	booduga	Little Field Mouse	Choto Metho Indur	Grain etc.
	Mus	musculus	House Mouse	Nengti Indur	Grain etc.
	Platanista	gangetica	Gangetic Dolphin	Sehsu	Fish
	Pteropus	giganteus	Flying Fox	Boro Badur	Fruit
	Vulpes	bengalensis	Fox	Shial	Scavenger
Birds	Accipiter	badius	Shikra	Turki Baj	Fish, small animals
	Acridotheres	ginginianus	Bank Myna	Gang Salik	Insects
	Acridotheres	tristis	Common Myna	Bhat Salik	Insects
	Acridotheres	fuscus	Jungle Myna	Jhuti Salik	Insects
	Alcedo	atthis	Common King Fisher	Choto Machranga	Fish
	Amaurornis	phoenicurus	White Breasted Water Hen	Dahuk	Small animals, insects
	Anastomus	oscitans	Openbill Stork	Shamuk Khor	Small animals
	Ardeola	alba	Great Egret	Boro Bok	Fish, frogs
	Ardeola	grayii	Pond Heron	Kani Bok	Fish, frogs
	Athene	brama	Spotted Owlet	Kuture Pacha	Small animals
	Bubo	zeylonensis	Brown Fish Owl	Mecho Pacha	Small animals
	Bubuleus	ibis	Cattle Egret	Go Bok	Fish, frogs
	Centropus	sinensis	Crow Pheasant	Kana Kukka	Fruit
	Ceryle	rudis	Pied King Fisher	Pakra Machranga	Fish
	Charadrius	dubius	Little Ringed Plover	Choto Giria	Insects, worms
	Ciconia	episcopus	White Necked Stork	Manikjore	Fish, small animals
	Clamator	jacotbinus	Pied Crested Cuckoo	Shahi Bulbul	Insects
	Columba	livia	Blue Rock Pigeon	Jalali Kabutor	Grain
	Copsychus	malabaricus	Shama	Shama	Insects
	Copsychus	saularis	Magpie-robin	Doyel	Insects
	Corvus	Macrorhynchos	Jungle Crow	Dar Kak	Scavenger
	Corvus	splendens	House Crow	Pati Kak	Scavenger
	Cypsiurus	parvus	Palm Swift	Nak Kati	Insects
	Dendrocitta	vagabunda	Tree Pie	Harichacha	Insects, eggs
	Dendrocygna	javanica	Lesser Whistling Teal	Choto Sharali	Omnivore
	Dicrurus	adsimilis	Black Drongo	Finga	Insects
	Dinopium	benghalense	Wood Peacker	Kat-Thokra	Insect larvae, worms
	Egretta	interemedia	Intermediate-Egrete	Sada Bok	Fish, frogs
	Eudynamys	scolopacea	Koel	Kokil	Omnivore
	Gallinago	henura	Pintail Snipe	Kadakhocha	Insects, fish, frogs
	Gyps	bengalensis	Vulture	Sowkoon	Scavenger
	Halcyon	smyrnensis	White Breasted King Fisher	Sadabuk Machranga	Fish
	Haliaster	indus	Brahminy Kite	Shonkho Cheel	Fish, frogs
	Ichthyophaga	ichthyaetus	Grey Headed Fishing Eagle	Kura	Fish

TYPE	SCIENTIFIC NAM		ENGLISH NAME	BENGALI NAMES	FOODS
	Genus	Species			
Birds	Leptoptilos	dubius	Greater Adjutant	Hargila	Invertebrates, fish
	Lonchura	malabarica	White Throated Munia	Sada Gala Munia	Grain
	Megalaima	haemacephala	Coppersmith Barbet	Boshonto Baure	Insects
	Merops	orientalis	Bee Eater	Sui Chora	Insects
	Milvus	migrans	Black Kite	Bhuban Cheal	Scavenger
	Motacilla	alba	White Wagtail	Sada Khanjan	Insects, worms
	Motacilla	sp.	Wagtail	Khanjan	Insects, worms
	Nettapus	coromandelianus	Cotton Teal	Balihans	Small invertebrates
	Nectarinia	zeylonica	Purplerumped Sun Bird	Madhuchura	Nectar
	Oriolus	xanthornus	Blackheaded Oriole	Kutum Pakhi/Holde Pakhi	Insect larvae, etc.
	Orthotomus	sutorius	Tailor Bird	Tuntuni	Insects, insect grubs, worms
	Passer	domesticus	House Sparrow	Choroi	Grain etc.
	Phalacrocorax	niger	Little Cormorant	Pancowri	Fish
	Ploceus	philippinus	Buya	Babui	Grain
	Psittacula	krameri	Parakeet	Teya	Fruit, grain
	Pycnonotus	cafer	Red Vented Bulbul	Bulbul	Fruit, insects
	Sterna	aurantia	Indian River Tern	Gang Cheel	Fish
	Streptopelia	decaocta	Ring Dove	Dhobal Ghughu	Grain eater
	Streptopelia	chinensis	Spotted Dove	Tila Ghughu	Grain
	Sturnus	contra	Pied Myna	Go Salik	Insects
	Tadorna	ferruginea	Shelduck	Chokha Chokhe	Omnivore
	Tringa	hypoleucos	Common Sandpiper	Chapakhi	Insects
	Turdoides	striatus	Common Babbler	Satbhai	Insect larvae, etc.
	Upupa	epops	Hoopoe	Hudhud	Insects on ground
	Vanellus	indicus	Redwattled Lapwing	Hot Titi	Insects, worms
Reptiles	Atretium	schistosum	Olive Keelblack Water Snak	Mete Sap	Fish
	Bungarus	caeruleus	Common Krait	Kalkaute	Small animals
	Calotes	versicolor	Common Garden Ligard	Roktochosa	Insects
	Chitra	indica	Soft Shell Turtle	Chim/Chitra Kachim	Omnivore
	Cyclemys	dentata	Fresh Water Tortoise	Common Kachim	Plants
	Enhydris	enhydris	Common Water Snake	Huria	Fish, small animals
	Hemidactylus	brooki	House Wall Lizard	Tiktike	Insects
	Mabuya	carinata	Skink	Angila	Insects
	Naja	naja	Cobra	Gokhra Sap	Small animals
	Pelochelys	bibroni	Bibronis Softshell Turtle	Chata Kachim	Omnivore
	Ptyas	mucosus	Rat Snake	Daraj Sap	Small animals
	Trionyx	sp	Lurge Turtle		Omnivore
	Typhlops	porrectus	Slender Worm Snake	Dumukho Sap	Worms
	Varanus	bengalensis	Monitor Lizard	Kalo Gui	Small animals
	Varanus	flaviscens	Yellow Land Monitor	Sonagui	Small animals
	Varanus	sp	Monitor	Gui	Small animals
	Vipera	russelli	Russell's Viper	Chandra Bora	Small animals
	Xenochrophis	piscator	Checkered Keelback Water	Dhora Sap	Small animals, fish
Amphibia	Bufo	melanostictus	Toad	Kuno Bang	Insects
	Rana	tigrina	Bull Frog	Sona Bang	Insects

TABLE 4.26 A Checklist of the Phytoplankton of the North West Retion of Bangladesh

CHLOROPHYCEAE 64	CYANOPHYCEAE 38	EUGLENOPHYCEAE
Arthrodesmus curvatus	Merismopedia tenuissima	Nitzschia sp.
Coelastrum microporum	Merismopedia glauca	Pinnularia gibba
Coelastrum biporum	Merismopedia minima	Pinnularia tabellaria
Crucigenia sp.	Merismopedia sp.	Pleurosigma balticum
Diacanthos belenophorus	Lyngbya sp.	Rhopalodia gibba
Eudorina elegans	Calothrix stagnalis	Rhopalodia sp.
Staurastrum sexangulare	Calothrix sp.	Cocconeis sp.
Staurastrum acanthocephalum	*Chroococcus turgidus*	
Staurastrum perundulatum	Chroococcus sp.	EUGLENOPHYCEAE 6
Staurastrum longibrachiatum	Microcystis flos-aquae	
Xanthidium burkillii	Microcystis aeruginosa	Euglena acus
Pediastrum biradiatum	Anabaena fertilisima	Euglena aquons
Pediastrum simplex	Anabaena variabilis	Euglena sp.
Pediastrum duplex	Anabaena constricta	Phacus curvicauda
Pediastrum tetras	Anabaena gelatinicola	Trachelomonas klebsii
Pleodorina indica	*Anabaena spiroides*	*Trachelomonas sp.*
Pleodorina sphaerica	Anabaena fertilisima	
Westella botryoides	Anabaena cercinalis	CHRYSOPHYCEAE 1
Characium obtusum	Anabaena tanganykae	Dinobryon sp.
Closteriopsis longissima	Anabaena tanganykans	
Closteriopsis sp.	Anabaena cercinalis	XANTHOPHYCEAE 1
Mougeotia sp.	Aphanocapsa biformis	Ophiocytium sp.
Ankistrodesmus falcatus	Aphanocapsa koordersi	Total 137 species
Actinastrum hantzschii	*Aphanocapsa crasa*	
Tetraedon sp.	Aphanocapsa banarasensis	
Trochiscia reticulate	Chlorogloca microcystoides	
Trochiscia sp.	Rivularia sp.	
Gonium sp.	Anabaenopsis arnoldii	
Spirogyra sp.	*Oscillatoria princep*	
Selenastrum gracile	Oscillatoria chlorina	
Scenedesmus quadricauola	Oscillatoria sp.	
Schroederia setigera	Phormidium lucidum	
Microspore tumidula	Phormidium sp.	
Microspore floccose	Coelasphaerium dubium	
Microspore sp.	Coelasphaerium sp.	
Microspore quadrate	Myxocercina spectabilis	
Microspore crassior	*Myxocercina barmensis*	
Ulothrix pelagic	Spirulina sp.	
Ulothrix sp.		
Oedogonium sp.	DINOPHYCEAE 1	
Nephrocytium sp.		
Gloeotaenium loithsburganianum	Ceratium furca	
Golenkinia sp.		

Gloeotila spiroides	BACILLARIOPHYCEAE 26	
Gloeotila pelagic		
Hydrodictyon reticulatum	Fragilaria cupucina	
Kirchneriella lunaris	Fragilaria tabellaria	
Kirchneriella sp.	Fragilaria sp.	
Cylindrocapsa sp.	*Gyrosigma acuminatum*	
Oocystis parva	Gyrosigma scalproides	
Coelastrum sp.	Melosira granulata	
Cosmarim subtumidum (Desmid)	Synedra ulna	
Cosmarium sp.	Surirella robusta (Diatom)	
Gonatozygon kinahanii	Surirella sp.	
Closterium angustatum	Cymbella turgida	
Closterium kuetzingii	Cymbella stuxbergii	
Closterium dianae (Desmid)	Cymbella tumida	
Closterium moniliferum	Cymbella robusta	
Volvox carteri	Gomphonema augur	
Gloeotila spiroides	Gomphonema gracile	
Westella sp.	Navicula exigua	
Stigcoclonium sp.	*Navicula maniscula*	
Ererella borhanviensis	Melosira spp.	
Zygnema sp.	Nitzschia hantzschiana	

Table 4.27 (A) Checklist of the Zooplankton Species of the North West Region

COPEPODA	Beel	River	Permanent Ponds	Temporary Ponds
Heliodiaptomus contorts	****	*	***	**
Heliodiaptomus latifi	****	*		
Neodiaptomus strigilipes	*	*		
Diaptomus gracilis	***	*	*	
Diaptomus dorsalis				
Diaptomus peregrinator	*			
Diaptomus sp.	*	*	*	
Mesocyclops leuckarti	****	*	**	
Mesocyclops hyalinus	****		***	
Mesocyclops dybowski		*	*	
Mesocyclops inversus		**		
Mesocyclops distinctus	****		**	
Mesocyclops sp.	*	*		
Cyclops nanus	**	*	***	***
Cyclops varicans rubellus	****			
Cyclops varnalis	*			
CLADOCERA				
Daphnia longiramis	**	*		
Daphnia lumholtzi	****	*		
Daphnia similis	*	*		
Daphnia magna	**			
Daphnia galeate	*			
Bosmina longirostaris	****	*	*	
Bosmina coregoni	***	*		
Ceriodaphnia rigaudi	***	*	*	*
Ceriodaphnia laticaudata	**			
Chydorus globous	****	*		
Chydorus gibbous	*			
Diaphanosoma brachyurum	*			
Diaphanosoma leuchtenb-				
-ergianum	****	*	*	*
Moina brachiate	*	***		
Moina micrura	**		*	
Moina macrocopa	**			
Moina affinis	*			
Moina dubia	*			
Bosminopsis deitersi	*			
Scapholeberis kingi	*	**		
Scapholeberis mucronate	*			
Simocephalus serrulatus	***			

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Table 4.27 (B) Checklist of the Zooplankton Species of the North West Region

ROTIFERAL	Beel	River	Permanent Ponds	Temporary Ponds
Keratella tropica	****	*	*	**
Keratella cochlearis	**	*		
Polyarthra vulgaris	**	*	**	*
Filinia opolinesis	*	*		
Filinia longiseta	*	**		
Trichocerca longiseta	*			
Trichocerca cylindrica	*	*	*	
Trichocerca similis	*	*		
Trichocerca cochlearis	*	*		
Brachionus forficula		**		
Brachionus caliciflorus			*	
Brachionus falcatus			**	
Brachionus budapestinensis		*	**	
Brachionus dimidiatus		*		
Brachionus diversicornis		*	*	
Brachionus quadricornis	**			
Brachionus angularis			***	
Brachionus caudatus	*	***		
Brachionus urceolaris	*	*		
Brachionus quadridentatus		*	*	
Brachionus zhniseri		**		
Brachionus havanensis		*		
Brachionus forciculata		**		
Brachionus plicutilis		*		
Brachionus variabilis		*		
Synchaeta sp.		*	****	
Hexarthra mira	*	*		
Hexarthra intermedia	*			
Cephalodella megalocephaly	*			
Columella obtuse	*			
Lepadella ovalis	*			
Lepadella patella	*			
Testudinella patina	*	**		
Notholca sp.	*			
Lecane ohioensis	*			
Lecane luna	*	*		
Asplanchna priodonta	**	*	*	
Notommata pachura	*	*		
Horaella brehmi	***	**		
Monostyla quadridentata	*			
Monostyla sp.		*		
Epiphanies sp.		*		
Rotarian neptunian		*	*	
Pompholyx sulcate		*	*	
Anuraeopsis fissa		*		
Anuraeopsis coelata	*			
Linda sp.		*		
Pseudoharingia sp.	*			

CHAPTER 5

ANALYSIS

This Chapter provides a more specific analysis of the results of the Survey, and introduces a number of concepts which are expanded upon in the next Chapter.

5.1 Water Quality Standards Compliance

The quality of the water at the field sites is recorded in Tables 5.1 - 5.3, whilst current water quality standards are shown for various uses in Table 5.4. The latter draws on data from both the North West Region and from the Jamalpur Priority Project area (FAP 3.1) across the Jamuna. Within the Study Area, most water sources meet the requirements for most uses. However, ground water has consistently lower dissolved oxygen levels that an are stipulated for all uses. This is irrelevant, in fact, and the purpose of setting a standard which is consistently breached by the only reasonably reliable source of drinking water is obscure. Similarly, BOD and ammonia levels in ground water are commonly higher than the stipulated limits for domestic use, yet groundwater is unquestionably the preferred and safest source. Surface water ammonia levels are also significantly above the standards set for fishing waters (presumably established to prevent toxicity problems to fish), yet there is no indication that the fish suffer as a consequence.

Of the other variables, the failure of all water sources to meet the minimum hardness level (hardness is the only standard in which a minimum acceptable level is set) is hardly surprising, since the Jamuna is a soft water, with a calcium carbonate hardness of less than half this standard (FAP 3.1 data). The reason for establishing a standard which can only be met by adopting a chemical fix to increase the ambient level - a technology which is hardly accessible to the rural poor - is obscure.

5.2 Iodine Deficiency

Of far more significance is the extraordinarily low level of iodine available from all ground and surface water sources. The severe iodine deficiency which exists in a large area of the Region is undoubtedly related to this factor. However, since the actual concentrations appear to be more or less constant regardless of source, yet iodine deficiency is noticeably more common in some areas than others, it is possible that some biological source is able to concentrate the element, and may be used unwittingly in human diets in some areas but not others. In view of the serious medical and economic effects of iodine deficiency and the continued inability to provide iodised salt on a regular and reliable basis, this possibility is one which should be investigated and is further discussed in the Public Health and Nutrition Study (Volume 14).

5.3 Fertiliser Enrichment of Groundwater

It has often been claimed that the increasing use of nitrogen-based fertilisers for agriculture presents a threat to groundwater supplies. The most widely used artificial nitrogen-based fertiliser is urea, which releases ammonium ions to the soil. Oxidative processes in the soil convert this to nitrate, which is directly available to plant roots. The reason for this concern is that high nitrate concentrations in drinking water are known to cause the dangerous blood condition methaemoglobinaemia in infants. The upper acceptable limit for nitrate nitrogen in groundwater has therefore been set at 10mg/l.

In all water sources tested in this study (except for one surface water contaminated with factory wastes) nitrate was undetectable. Nitrogen in the form of ammonium was generally acceptable, with maximum levels of only 1.3mg/l, notably in groundwater. However, this is accompanied by low dissolved oxygen levels in groundwater and slightly raised chemical and biochemical oxygen demand. This indicates that the small quantity of ammonium which reaches the groundwater aquifers, presumably from urea fertiliser use and possibly from livestock and human urine, is not oxidised to nitrate in the low-oxygen groundwater in the aquifers. Since urea clearly has a positive visible effect on crop growth, it is suggested that much of that which is applied is rapidly oxidised in the aerobic horizons of the upper surface of the soil and taken up by the crops.

That small fraction which does leach downward rapidly enters groundwater aquifers close to the surface, and remains as unoxidised ammonia. We therefore conclude that there is no evidence from this study that nitrate contamination of groundwater represents any material threat to human health in the North West Region.

Conversely, the comparatively low nitrate levels in groundwater suggest that plant growth may be limited by nitrogen availability, and crops certainly do respond to the addition of nitrogen. However, that this is not a sufficient explanation is supported by the fact that natural vegetation is capable of rapid and vigorous growth without having to rely on the addition of chemical fertilisers, once the monsoon season arrives. This suggests that there is another source of nitrogen available to plants which is independent of human intervention. Since the river and flood waters themselves have only modest nitrate levels, this nitrogen is almost certainly obtained by nitrogen fixation from the air by the Cyanophyceae during the flood season, and by other soil biochemical processes during the dry season. This topic is discussed in more detail in Chapter 6.

5.4. The Major Habitats of the Floodplain

5.4.1 The Ecological Importance of the Highland Areas

The division of the terrestrial habitats into highland, floodland and lowland has a sound ecological basis. Each zone has distinct characteristics, and these are reflected by quite separate species assemblages. Viewed from the air, these divisions are immediately clear, with the distribution highland areas forming a discontinuous pattern of trees and homesteads, interlaced with the river channels. The diversity of terrestrial communities, as shown by the plant species abundance plot (Tables 5.5 and 5.6 and Figs 5.1 and 5.2) clearly reveals the tremendous gap between the complexity of the highland communities compared with those in the floodland and, particularly graphically, the barren agricultural fields of the floodlands.

In this ecosystem, the ecological role of the highlands is paramount, despite their often small proportion of the total area. The diversity of terrestrial plants in the highlands far exceeds that of any other habitat, and there are of course many more terrestrial vertebrate species associated with this rich flora. Man also is intimately associated with this habitat.

It is not simply that flood free land is the ideal place for permanent shelter, although this is of course of great importance. But the ecological significance of the highlands to man is centred on this very diversity. The Study clearly shows that a very large majority of the plants growing in this habitat have uses - and often multiple uses - which make rank highland as the second most important source of resources after the agricultural fields themselves.

The floodplain fish are increasingly becoming recognised as a common resource - in legal and economic terms, a common good - which is available to everyone regardless of landholding or social status. But what is not widely recognised is the undoubted fact that the highland floral resources now represent an even more significant common good than do the floodplain fish stocks. Despite rural property rights, the collection of wild plant products is a vital survival strategy. Plants provide construction materials for shelter, raw materials for a range of domestic and commercial crafts, fuel for cooking, fodder for livestock, fruit and vegetables, and medicines for a remarkable range of common ailments. The value of such resources in real terms is far higher that of the few grammes of fish available rarely to all but the most affluent.

It is therefore relevant to point out that FCD interventions have very little capacity to affect this most diverse and valuable habitat negatively, except where they directly destroy highland by constructing banks or access roads to them. Indeed, they may well provide a positive impact, by reducing water tables during the flood season, and therefore stimulating beneficial biochemical processes and symbiotic biological associations in the soil. But in general terms, the purpose of FCD is to limit flooding on the floodland - so by definition, it is can have only minor impacts on people's access to highland resources.

5.4.2 The Ecological Significance of Embankments

Terrestrial plant and animal species abundances are high on embankments. Although nominally part of the floodplain, these represent new highland areas which can be used as refuges during the floods by a wide range of vertebrates as well as man. Whilst the soils of the embankments may be saturated for short periods at times of the peak floods, they soon drain and provide a suitable habitat for shrubs and trees which are unable to colonise the floodlands.

Embankments therefore provide linear habitats which act as migration corridors for many terrestrial species. By linking highland areas, they permit genetic interchange between populations which would otherwise become isolated and subject to local decline. Moreover, because these highland habitats are the centres of diversity on the floodplain, embankments represent a very important element in the maintenance of wildlife colonisation and dispersal throughout the year, in exactly the same way as rivers act as corridors for the migration and dispersal of aquatic species.

A second function of embankments, especially those used for compartmentalisation, is the provision of refuges for species which are important in pest control. The high proportion of insect-eating birds in the fauna of the embankments indicates their role in natural pest management. Similarly, the high frequency of insect-eating reptiles such as the common geckoes reveals the value of these habitats for the control of flies and mosquitoes in and around dwellings situated on the embankments.

5.4.3 Ecology of Disease in the Drier Environments

The possibility of discovering disease vectors during this Study has been slight, due to the focus of attention on terrestrial vertebrates and macrophytes rather than on insects and similar invertebrates. However, in some pathologies the collection of such data has already been demonstrated to have been of direct value.

Visceral leishmaniasis (Kala azar) has become progressively more common in the Chalan Beel B area over the last twenty years, since the construction of the polders. Detailed data on long-term trends in the incidence of this disease are unavailable, and it is therefore not possible to state with certainty whether the present high incidence in the Chalan Beel/Singra area has been specifically caused by poldering the area, or is in fact a phase in a cyclic morbidity pattern of the disease.

The disease is caused by a blood parasite which is spread by female Phlebotamine sandflies. It is generally believed that in Bangladesh it humans without the presence of an animal reservoir. In other countries natural reservoirs of wild animals are known to exist; these are usually carnivorous mammals, although it is commonly found in desert rodents in Africa. During this study, it was not possible to establish whether field trials aimed at confirming the absence of a non-human reservoir have been carried out in the Study area in recent years. Consequently, the relevance of potential animal reservoir species in the epidemiology of the disease in this specific area is unclear, although it may be reasonable to suppose that, if there is a linkage present, this is not at present demonstrable.

However, the potential for wild reservoirs to become established in the future cannot be entirely ruled out, and it would appear sensible to confirm that the absence of a natural reservoir before introducing any large-scale treatment and eradication programme in the Chalan Beel area. Reference to the site and habitat species lists shows that mice, bandicoots and the mongoose (Herpestes auropunctatus) are more common in homestead and embankment areas, but less so on floodland which is unprotected from floods. These therefore represent potential reservoirs of Leishmaniasis which may alter susceptibility to the disease in flood-protected areas.

Similarly, the use of the plant database also shows that at least two of the species of plants known to attract the vector occur more frequently in homestead areas than in floodland areas. Of these both Musa and Amaranths spinous are commonly cultivated, whilst the latter is also used as fodder and for veterinary purposes. Their increased availability as a nectar source for the vectors may thus increase the habitats colonised by them.

Clearly, such deductions need careful field research before any conclusions can be drawn, but they do illustrate the value of recording field data in this form to stimulate hypotheses about ecological linkages which may be completely obscure without access to the field information. For this reason, a complete set of ecological field records is provided as an Annex to this Report.

5.4.4 The Significance of the Beels in the Terrestrial Context

The remarkably low species abundances of vertebrates and macrophytes in and around the beels when compared with the true terrestrial habitats indicates that, whatever their ecological importance may be, it is unlikely to be significant in terms of the hierarchy of terrestrial habitats. This lowly position may provoke some surprise, since wetlands are generally considered to be particularly diverse habitats. However, in the specialised conditions of the Jamuna floodplain, where waterfowl play a very restricted role and where all available land has been converted to agriculture, the beels are now but a shadow of their former selves, and most of their natural community has long since departed.

The present significance of the beels as a **terrestrial macro-habitat** has been subsumed in very many cases by the demands of agriculture. Beels represent a very convenient location for low cost rice cultivation, since the soils are inevitably very wet and there is a immediately available surface water supply close to the fields. So many beels are rapidly becoming encroached on by rice-based agriculture, and their natural flora and fauna have all but vanished.

So great is this disturbance that the value of the beels as conservation areas in the traditional sense has almost disappeared. Water birds are now scarce or absent, fish have been seriously over exploited, and those animals such as the otter which depend on them are also under pressure. This is particularly unfortunate since an alternative source of irrigation water as abundantly available from tubewells, and the continued encroachment of the beels is by no means essential, especially in view of the fact that Bangladesh now has a rice surplus.

However, the value of the beels in the management of both the floodland and the river fish stocks is a separate aspect to the consideration of their role in the macro-ecology of the floodlands, and this aspect is discussed in more detail in Chapter 5.

5.4.4 The Riverine Habitats

The river banks themselves show remarkably poor plant species abundances. This is likely to be due to the erosive capacity of the rivers during the flood periods, but the open access to such land as a common good may also be a factor, since this provides grazing and browsing by cattle and goats which soon reduce the floral diversity of habitats. The animal diversity is also extremely low. This is attributed to poor cover and exposure to disturbance.

In marked contrast, the charlands animal and plant diversities are high, being very close to those of the embankments. The plant species association includes a number of pioneer species which are extremely distasteful to animals (for example Ranunculus scleratus), and which play a central role in the early stabilisation of the river chars. The number of plants which actually have a major functional role in human communities (ie. are not used solely for medicinal purposes) is proportionally rather low, indicating that charland has a low resource value to man.

Birds make up the majority of the charland vertebrate species. During the Study, the actual frequency of even species usually regarded as common was low. This may reflect the poor productivity of the charlands.

5.4.5 The Padma Riverine Habitats

The Padma River site is dramatically different to the Jamuna sites examined. Whilst the charlands are broadly similar in their low species diversity, the river bank habitat provides a home for much larger numbers of plant and animal species, despite its proximity to the city of Rajshahi. The most significant difference between the Padma and Jamuna Rivers is in their plankton communities. Whilst that of the Jamuna is characteristic of fast-flowing, extremely silty rivers, that of the Padma more closely resembles the plankton of waters such as Andasuria and Bamandangha Beels.

This difference can be attributed to the very great reduction in flow rates in the Padma below the Farakka Barrage, allowing silt to settle and light to penetrate more deeply into the river water. The resultant heavy phytoplankton populations promote strong zooplankton population growth, and this is reflected by the high productivity and the presence of larger numbers of riverine birds which feed on fish, frogs and other aquatic species.

5.5 The Dynamics of the Plankton Populations

5.5.1 The Cyclic Fluctuations in Species Abundance

Tables 5.7 to 5.14 show how plankton dominance in the main aquatic habitats fluctuates rapidly from month to month. The plot of the analysis of species abundance of the aquatic habitats (Fig. 5.3.) is based on data collected in March. It shows the major rivers (apart from the Padma) in a group characterised by comparatively small numbers of species and of total numbers of individuals. The Teesta River stands out for its very low scores in both variables, as it falls in diversity earlier than the Jamuna.

Examination of the field data shows that there is considerable monthly fluctuation in species abundance in both the phytoplankton and the zooplankton. This will be reflected in the positions of individual sites on this type of plot - the spacial distribution of these values will change markedly throughout the year, in a very well defined fashion. In the principal rivers, the positions of the Jamuna sites will fall back towards the position of the Teesta by April, and the values for both rivers will reach the origin by May. This is indicative of the loss of the plankton, and reflects the increase in silt transportation at the start of the flood season. The effect of the Farakka Barrage on the Padma will be to maintain the species abundance value at a high level until the Barrage is opened, when the value will fall to zero almost instantaneously.

The temporary river indexes will also fall in a similarly abrupt fashion as soon as they begin to be affected by either floodwater or heavy surface runoff, whilst those of the flushed beels will fall slightly later. However, the index of those beels which are less strongly flushed or which only receive rainwater or surface run-off, may well not fall so markedly, since silt transportability will fall as the current velocity reduces, and phytoplankton growth will be maintained.

In the beels, the values will move vertically in this type of plot, reflecting the very marked short-term blooms of individual phytoplankton species populations, and the corresponding slightly delayed blooms of the zooplankton in response to them. Species richness, however, will be comparatively stable during the dry season.

However, with the onset of the floods, this situation will change rapidly. In the flushing beels, the species abundance values will move towards the origin at rates which will depend on the current velocity and origin of the water which flushes them. Where there is a sudden onrush of river water because of a breach in an embankment, the species abundance value will fall rapidly towards zero, and the plankton will disappear almost instantly. However in gently flushed beels, the effect will be less marked, as the slower-flowing water will deposit its silt load and become more transparent.

5.5.2 Plankton Cycles and the Timing of Fish Reproduction

Successive monthly species abundance values for the plankton of different types of site can therefore be expected to exhibit quite characteristic cyclic patterns of variation during the annual inundation cycle. These undoubtedly have considerable implications for the ecology of the floodplain, and especially for the fish stocks, which need to be more fully investigated before further major interventions are adopted which have the power to affect the ecology of the aquatic habitats.

For example, the timing of changes in composition of the zooplankton is crucial for the newly-hatched fish fry. All fish species, regardless of their food requirements as adults, feed on very small members of the zooplankton immediately after they commence feeding. The yolksac which provides their food after hatching consists of a high-protein food which is essential for rapid growth. This high energy content protein requirement continues for some days, or even weeks, after the yolksac is absorbed, so fry at this stage always feed first on Rotiferal, then on the larger Crustacea (Copepoda and Cladocera).

Floodplain fish therefore require access to relatively sheltered waters in which the current velocity is low enough for light penetration into the water and phytoplankton growth is possible. This allows the development of the Rotiferal populations, and subsequently of the Crustaceans which feed on them. The timing of the arrival of the fry is therefore crucial, and it is noticeable that Rotiferal tend to be more frequent in the beel zooplankton in May, about the time that the rivers start to rise sharply (see Table 5.15.)

The resident beel fish species are reported to spawn earlier, and many of them lay rather larger eggs than those of the major carps. The fry are therefore able to take advantage of the earlier Crustacean populations of the beels and temporary river pools. But inevitably, they then represent a considerable hazard to the fry of the later-spawning river migrants, which are a very convenient size for them to use as their food.

Table 5.1 Summary of Water Quality Data for Wells in the North West Region (Feb.-March, 1992)

Site cod	Location	Type	DO mg/l	BOD mg/l	COD mg/l	pH	NH4 mg/l	Cl mg/l	SO4 mg/l	Fe mg/l	Coliforms no./100ml
G6	Chandipur (TRE)	DTW	0.3	2.5	32	6.7	1.3	6	1.1	5.8	120
R10	Natore (Ananda Nagar)	STW	2.6	7.5	22	6.7	1	20	14.1	0.9	160
R19	Gaibandha (Jumar Bari)	STW	1.9	8.5	50	7	2	38	41.5	2.1	120
R17	Halti Beel (Piprul)	STW	2.4	9	55	7.2	0.4	13	35.2	1	110
G2	Harudanga Beel	STW	0.8	12	?	6.5	1.2	6.8	0	2.9	50
R6	Natore (Singra)	HTW	2.2	12.1	42	6.8	1.3	22	8.5	1.6	300
G5	Bamandanga Beel	STW	2	22	40	6.7	1.6	14	0	8	100
G7	Chandipur (TRE)	HTW	2	40	38	6.5	0.2	4	0	1.2	100
	Range :	Min	0.3	2.5	22	6.5	0.2	4	0	0.9	50
		Max	2.6	40	55	7.2	1.6	38	41.5	5.8	300

HTW = hand tubewell; STW = shallow tubewell (machine operated); DTW = deep tubewell.

Table 5.2 Summary of Water Quality Data for Beels and Temporary Rivers in the North West Region (Feb-March, 1992)

Site cod	Location	Water source type	DO mg/l	BOD mg/l	COD mg/l	pH	NH4 mg/l	Cl mg/l	SO4 mg/l	Fe mg/l	Coliforms no./100ml
G1	*Harudanga Beel*	*Permanent beel*	8	2.5	12	7.4	0.6	4	0	1.1	116
R4	Utraeel Beel (S Central)	Flushed beel	7.6	8	22	7.5	0.3	10	0	0.9	250
R16	Halti Beel (S Central)	Flushed beel	8	6.6	26	7.7	0.2	17	12	1	170
G4	Bamandanga Beel	Flushed beel	8	3	30	8	0.3	6	0	0.9	40
R18	Gaibandha (Kumir Daha)	Flushed beel	7.8	5.8	32	8	0.4	4	0	1.2	140
R7	Natore (Singra)	Nandokuka R (T)	6.9	2.7	24	7.7	0.3	14	0.5	1.9	80
R5	Natore (Solakura)	Gur R. (Temp)	6.9	2.8	26	7.7	0.1	8	0.4	1.1	80
R2	Naogoan (Choubaria)	Sib R. (Temp)	6.9	2.7	24	7.7	0.3	14	0.5	1.9	0
R9	Natore (Chaskor Bazar)	Atrai R (Temp)	6.2	3.1	65	8	0.6	18	0.4	0.9	70
R8	Natore (Chaskor Kheaghat)	Nandokuja R (T)	5.4	4	60	8	0.7	19	0.1	1.1	34
G8	Gobindapur	Ghagot R. (T)	7.5	6.6	40	8	0.3	6	0	ND	40
	Range :	Min	5.4	2.5	12	7.4	0.1	4	0	0.9	0
		Max	8.4	6.6	65	8	0.7	19	12	1.9	250

Flushed beels (shaded)

Table 5.3 Summary of Water Quality Data for Permanent Rivers

Site cod	Location	Water source type	DO mg/l	BOD mg/l	COD mg/l	pH	NH4 mg/l	Cl mg/l	SO4 mg/l	Fe mg/l	Coliforms no./100ml
R12	Sariakandi Ferry Ghat	Bangali R.	8.3	11.5	28	8.2	0.2	7	0	0.9	60
R1	Kurigram (Jorgas Ghat)	Jamuna R.	8.7	2.6	25	8.2	0.1	6	11.3	0.7	130
G3	Pirgacha (Painal Ghat)	Teesta R.	8.4	1.8	12	7.7	0.2	8	0	1.8	100
R13	Pabna (Char Pechakola)	Hurasagar R.	8	3.9	38	8	0.3	9	0.1	1	190
R11	Rajshahi (Darga Para)	Padma R.	8.2	4	40	8.1	0.2	14	22.5	1	1000
R15	Gaibandha (Manos Reg.)	Jamuna R.	8.6	3	21	8.1	0.3	7	0	1.6	1000
R14	Pabna (Nakalia Bazar)	Jamuna R.	8.5	5.8	30	8	0.4	4	18.2	1.2	120
	Range :	Min	8	1.8	12	7.7	0.1	4	0	0.7	60
		Max	8.7	12	40	8.2	0.4	14	22.5	1.8	1000

Note Coliforms = 1000 (actual no. 'too numerous to count')

Table 5.4 Summary of Water Quality Data and Standards

WATER SOURCE	OXYGEN			GENERAL		PLANT GROWTH ELEMENTS					OTHER CHEMICAL VARIABLES			
TYPE	DO mg/l	BOD mg/l	COD mg/l	pH	Hardness mg/l	N (as NO3) mg/l	NH3 mg/l	PO4 mg/l	K mg/l	Si mg/l	Cl mg/l	SO4 mg/l	Fe mg/l	I mg/l
Deep tubewell	`0.3 *	`2.5 *	`32 *	`6.8 *	ND	0	`1.3 *	ND	ND	ND	`6 *	`1.1 *	`5.8 *	ND
Shallow/hand tubewell	`0.8-2.4	`7.5-12	`22-55	`6.5-7.2	`(50-160)	`(0.1 *)	`1-2	`(14 *)	`(2.7 *)	`(19.2 *)	`4-38	`0-41	`0.9-2.9	5.6E-05
Permanent standing wate	`8 *	`2.5 *	`12 *	`7.4 *	`(8-54)	`(0-0.2)	`0.6 *	`(0.1-0.2)	`(4.2-14.4)	`(2-8.5)	`6 *	`0 *	`1 *	8.5E-05
Seasonally flushed beels	`7.6-8	`3-6.6	`12-32	`7.5-8	ND	0	`0.2-0.4	ND	ND	ND	`4-17	`0-12	`0.9-1.2	ND
Temporary rivers	`5.4-7.5	`2.7-6.6	`24-65	`7.7-8	`(40-114)	`(0-0.2)	`0.1-0.7	`(0-0.5)	`(2.3-14)	`(2-16.7)	`6-19	`0-0.5	`0.9-1.9	7.7E-05
Permanent (Main) rivers	`8-8.7	`1.8-5.8	`12-40	`7.7-8.2	`(60-80)	`(0.3-0.4)	`0.1-0.2	`(1-1.5)	`(2.8-3.3)	`(7.5-8.2)	`4-14	`0.7-1.8	`0.7-1.6	7.5E-05
STANDARDS														
Drinking water	6	0.2	4	`6.5-8.5	`200-500	10	0.5	6	12	NS	`150-600	400	`0.3-1	NS
Recreation	`4-5	3	4	`6-9.5	NS	NS	2	6	NS	NS	600	NS	NS	NS
Fishing	`4-6	6	NS	`6.5-8.5	`80-120	NS	0.025	10	NS	NS	600	NS	NS	NS
Industrial	5	10	`3-10	`6-9.5	250	NS	NS	NS	NS	NS	NS	1000	0.5	NS
Irrigation	5	10	NS	`6-8.5	NS	NS	3	10	NS	NS	2000	NS	NS	NS
Livestock	`4-6	NS	NS	`5.5-9	NS	250	NS	NS	NS	NS	NS	NS	NS	NS

Notes:
`* Single sample data
`() Suplemental data from Jamalpur Priority Study (FAP3.1), 1992
`NS No standard set
STANDAR Data from `Environmental Quality Standards (EQS) for Bangladesh', Dept. of Environment, Dhaka, July 1991.

Table 5.5 Terrestrial Plant Species Abundances.

Code	Habitat	No of spp	Class Totals
H	Homestead (highland)	72	183
Rf	Refuge woodland clusters	22	50
Cw	Char wet plain	22	60
E	Embankment	21	60
Rm	Ricefield margin	19	58
Cb	Char wet banks	18	55
Wm	Wheatfield margin	17	47
D	Char dry plain	16	38
B	Beel	12	43
Po	Pond banks	12	28
P	Homestead (Protected floodland)	10	27
X	Homestead (Unprotected floodland)	10	24
Cc	Char cultivated	8	21
Rv	River channel	6	15
W	Wheatfield	3	9
Bb	Bamboo clusters	1	5
`...R	Ricefield	1	5

Table 5.6 Terrestrial Animal Species Abundance

Code	Habitat	No of Sp.	Individual
H	Homestead (highland)	59	147
E	Embankment	43	108
Rv	River channel	42	107
Po	Pond banks	22	55
X	Homestead (Unprotected floodland)	18	46
P	Homestead (Protected floodland)	15	45
Rm	Ricefield margin	9	26
W	Wheatfield	6	19
`...R	Ricefield	5	12
Bb	Bamboo clusters	4	10
Wm	Wheatfield margin	4	10
B	Beel	4	10

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Table 5.7 Phytoplankton Dominance in North West Region Waters in Feb. 1992

GROUP	SITE	No of sp	Index	Dominant sp	Type
Permanent river	BUR	8	1.33	Microspora	Chlor
Phytoplankton	JA2	3	2	Spirogyra	Chlor
	JA3	19	2.64	Microspora	Chlor
	JA4	13	2.36	Microspora	Chlor
	PAD	15	1.15	Microspora	Chlor
	TEE	8	11.2	Spirogyra	Chlor
Averages		11	3.4		Chlor
Temporary river	AT1	19	2.98	Synedra	Bacil
Phytoplankton	AT2	2	2	Synedra/Microspora	Chl/Bas
	SIB	10	1.84	Ceratium	Dino
Averages		15.5	3.41		Mixed
Permanent	BBB	NS			
Beels	HAR	13	2.22	Microcystis	Cyan
Averages		6.5	2.22		
Flushed	AND	13	1.91	Ceratium	Dino
Beels	BAM	9	1.1	Ceratium	Dino
	HAL	15	1.97	Microspora	Chlor
	KUM	4	1.72	Ceratium	Dino
	MAD	11	3.96	Kirchneriella	Chlor
Averages		10.4	2.13		Mixed

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Table 5.8 Phytoplankton Dominance in North West Region Waters in March, 1992

GROUP	SITE	No of sp	Index	Dominant sp	Type
Permanent river	BUR	9	1.46	Microspora	Chlor
Phytoplankton	JA2	3	1.73	Spirogyra	Chlor
	JA3	9	2.05	Microspora	Chlor
	JA4	7	2.13	Gloeotila	Chlor
	PAD	6	1.13	Microspora	Chlor
	TEE	3	1.33	Synedra	Bac
Averages		6.167	1.64		Chlor
Temporary river	AT1	4	1.45	Ceratium	Dino
Phytoplankton	AT2	5	1.46	Surirella	Bacil
	SIB	2	1.19	Ceratium	Dino
Averages		5.5	2.05		Dino
Permanent beel	BBB	2	1.11	Ceratium	Dino
Phytoplankton	HAR	10	2.2	Anabaena	Cyan
Averages		6	1.65		Cyan
Flushed beel	AND	14	1.02	Ceratium	Dino
Phytoplankton	BAM	10	1.59	Microcystis	Cyan
	HAL	4	2.83	Euglena	Eugl
	KUM	1	1	Ceratium	Dino
	MAD	3	2	Microcystis	Cyan
Averages		6.4	1.688		Mixed
Temporary pond	POND1	4	2.14	Euglena	Eugl
Phytoplankton	POND4	4	2.12	Euglena	Eugl
Averages		4	2.13		Eugl
Permanent pond	POND2	1	1	Trachelomonas	Eugl
Phytoplankton	POND3	3	1.67	Pediastrum	Chlor
	POND5	5	2.13	Microcystis	Cyan
	POND6	4	1.95	Ceratium	Dino
	POND7	8	2.65	Pediastrum	Chlor
Averages		4.2	1.88		Chlor

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Table 5.9 Phytoplankton Dominance in North West Region Waters in April, 1992

Group	Site	No of sp	Index	Dominant sp	Type
Permanent river	BUR	0	0	None	
Phytoplankton	JA2	0	0	None	
	JA3	7	3.4	Gomphonema/Synedra	Chlor
	JA4	1	1	Synedra	Bac
	PAD	14	2	Dinobryon	Chryso
	TEE	4	1.93	Synedra	Bac
Averages		4.333	1.3883		Bacil
Temporary river	AT1	3	1.9	Surirella	Bacil
Phytoplankton	AT2	6	1.76	Microcystis	Cyan
	SIB	0	0	None	
Averages		4.5	1.83		Cyan
Permanent beel	BBB	5	1.28	Ceratium	Dino
Phytoplankton	HAR	15	1.4	Microcystis	Cyan
Averages		10	1.34		Cyan
Flushed beel	AND	10	3.69	Ulothrix	Chlor
Phytoplankton	BAM	12	1.76	Ceratium	Dino
	HAL	0	0	Dry	
	KUM	4	1.54	Microspora	Chlor
	MAD	7	1.26	Microspora	Chlor
Averages		6.6	1.65		Chlor

Table 5.10 Phytoplankton Dominance in North West Region Waters in May, 1992

GROUP	SITE	No of sp	Index	Dominant sp	Type
Permanent river	BUR	0	0	None (silty)	
Phytoplankton	JA2	7	2.91	Microspora/Nitzschia	Chlor/Bac
	JA3	4	1.9	Synedra	Chlor
	JA4	0	0	None (silty)	.
	PAD	11	1.4	Microspora	Chlor
	TEE	1	1	Pediastrum	Chlor
Averages		3.83	1.202		Chlor
Temporary river	AT1	2	1.56	Microspora	Chlor
Phytoplankton	AT2	4	1.14	Microspora	Chlor
	SIB	3	1.61	Microcystis	Cyan
Averages		4.5	2.155		Chlor
Permanent beel	BBB	8	1.07	Microspora	Chlor
Phytoplankton	HAR	4	1.2	Microcystis	Cyan
Averages		6	1.14		Chlor
Flushed beel	AND	12	2.71	Anabaena	Cyan
Phytoplankton	BAM	12	1.63	Microspora	Chlor
	HAL			Dry	
	KUM	5	1.17	Microcystis	Cyan
	MAD	8	1.05	Microspora	Chlor
Averages		7.4	1.312		Chlor

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Table 5.11 Zooplankton Dominance in North West Region Waters in February, 1992

Group	Site	No. of Sp.	Index	Dominant Sp.	Type
Permanent river	BUR	13	3.45	Keratella	Rot
Phytoplankton	JA2	5	2.16	Cyclops	Cop
	JA3	0	0	None	
	JA4	8	5.19	Many	Rot
	PAD	11	3.39	Brachionus	Rot
	TEE	3	1.5	Ceriodaphnia	Clad
Averages		6.667	2.615		Rotif
Temporary river	AT1	5	2.66	Horella	Rot
Phytoplankton	AT2	14	2.57	Heliodiaptomus	Cop
	SIB	10	2.48	Heliodiaptomus	Cop
Averages		9.667	2.57		Cop
Permanent beel	BBB	ND	ND	Not sampled	
Phytoplankton	HAR	16	4.52	Bosmina	Clad
Averages		16	4.52		Clad
Flushed beel	AND	6	2.08	Heliodaptomus	Cop
Phytoplankton	BAM	13	2.61	Keratella	Rot
	HAL	8	1.96	Notholca	Rot
	KUM	14	2.39	Ceriodaphnia	Clad
	MAD	6	3.43	Ceriodaphnia	Clad
Averages		9.4	2.494		Crust/Rot

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Table 5.12 Zooplankton Dominance in North West Region Waters in March, 1992

Group	Site	No. of Sp.	Index	Dominant Sp.	Type
Permanent river	BUR	9	1.46	Bosmina	Clad
Phytoplankton	JA2	7	2.86	Polyarthra	Rot
	JA3	10	6.5	Many	Cop/Clad/Rot
	JA4	4	4	Many	Cop/Clad/Rot
	PAD	16	1.6	Brachionus	Rot
	TEE	1	1	Bosmina	Clad
Averages		7.833	2.903		Crust/Rot
Temporary river	AT1	10	2.52	Mesocyclops	Cop
Phytoplankton	AT2	15	2.04	Heliodiaptomus	Cop
	SIB	8	2.87	Diaphanosoma	Clad
Averages		11	2.477		Cop
Permanent beel	BBB	6	2.22	Neodiaptomus	Cop
Phytoplankton	HAR	5	3.59	Keratella	Rot
Averages		5.5	2.91		Cop/Rot
Flushed beel	AND	11	1.6	Diaptomus	Cop
Phytoplankton	BAM	13	3.88	Heliodiaptomus	Cop
	HAL	7	2.06	Mesocyclops	Cop
	KUM	9	4.08	Ceriodaphnia	Clad
	MAD	6	2.1	Ceriodaphnia	Clad
Averages		9.2	2.744		Cop
Temporary pond	POND1	8	1.61	Brachionus	Rot
Phytoplankton	POND4	12	1.21	Brachionus	Rot
Averages		6	1.41		Rot
Permanent pond	POND2	18	2.43	Hexarthra	Rot
Phytoplankton	POND3	16	5.57	Filinia	Rot
	POND5	12	2.31	Simocephalus	Clad
	POND6	8	3.04	Simocephalus	Clad
	POND7	13	1.99	Brachionus	Rot
Averages		13.4	3.068		Rot

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Table 5.13 Zooplankton Dominance in North West Region Waters in April, 1992

Group	Site	No. of Sp.	Index	Dominant Sp.	Type
Permanent river	BUR	11	1.77	Keratella	Rot
Phytoplankton	JA2	2	2	Bosmina/Mesocyclops	Clad/Cop
	JA3	0	0	None	
	JA4	0	0	None	
	PAD	6	2.66	Brachionus/Keratella	Rot
	TEE	0	0		
Averages		3.167	1.07		Rotif
Temporary river	AT1	5	1.48	Diaptomus	Cop
Phytoplankton	AT2	6	1.24	Mesocyclops	Cop
	SIB	6	2.57	Diaphanosoma	Clad
Averages		5.667	1.76		
Permanent beel	BBB	4	1.88	Trichocerca	Trich
Phytoplankton	HAR	5	2.85	Bosmina	Clad
Averages		4.5	2.36		Clad/Rot
Flushed beel	AND	7	1.49	Cyclops	Cop
Phytoplankton	BAM	13	1.76	Heliodiaptomus	Cop
	HAL	0	0		
	KUM	7	2.86	Heliodiaptomus	Cop
	MAD	4	1.43	Polyarthra	Rot
Averages		6.2	1.508		Cop

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Table 5.14 Zooplankton Dominance in North West Region Waters in May, 1992

Group	Site	No. of Sp.	Index	Dominant Sp.	Type
Permanent river	BUR	0	0	No Jamuna/Teesta	None
Phytoplankton	JA2	0	0	Species due to	
	JA3	0	0	Heavy silt loads	
	JA4	0	0		
	PAD	6	3.39	Keratella	Rotifers
	TEE	0	0		
Averages		1	0.565		
Temporary river	AT1	13	3	Keratella	Rotifers
Phytoplankton	AT2	7	2.38	Polyarthra	Rotifers
	SIB	9	1.55	Polyarthra	Rotifers
Averages		9.6667	2.31		
Permanent beel	BBB	4	2.57	Moina/Ceriodaphnia	Clad
Phytoplankton	HAR	8	4.23	Bosmina/Keratella	Clad/Rot
Averages		6	3.4		
Flushed beel	AND	12	2.75	Keratella	Rot
Phytoplankton	BAM	6	1.63	Heliodiaptomus	Cop
	HAL	0	0	Dry	
	KUM	8	2.91	Ceriodaphnia/Mesocyclops	
	MAD	9	2.18	Neodiaptomus	Cop
Averages		7	1.894		Cop/Rot

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Table 5.15 Berger-Parker Diversity Indices for North West Region Waters Plankton Species, Feb-May 1992.

Water type	Group	Feb. no	Index	Dominant Group	Mar. no	Index	Dominant Group	Apr. no	Index	Dominant Group	May no	Index	Dominant Group
Permanent river	Phytoplankton	11	3.45	Chloroph	6.2	1.64	Chloroph	4.3	1.39	Bacillarioph	4.5	1.2	Chloroph
	Zooplankton	6.7	2.62	Rotifers	7.8	2.9	Mixed	3.2	1.07	Rotifers	0	0	Absent
Temporary river	Phytoplankton	15.5	3.41	Mixed	5.5	2.05	Dinoph	4.5	1.85	Cyanoph	4.5	2.16	Chloroph
	Zooplankton	9.7	2.57	Copepods	11	2.48	Copepods	5.7	1.76	Copepods	9.7	2.31	Rotifers
Permanent beel	Phytoplankton	6.5	2.22	Cyanoph	6	1.65	Cyanoph	10	1.34	Cyanoph	6	1.14	Chloroph
	Zooplankton	16	4.52	Cladocera	5.5	2.91	Mixed	4.5	2.36	Crustacea	6	3.4	Cladocera
Flushed beel	Phytoplankton	10.4	2.13	Mixed	6.4	1.69	Mixed	6.6	1.65	Chloroph	7.4	1.31	Chloroph
	Zooplankton	9.4	2.49	Mixed	9.2	2.74	Copepods	6.2	1.51	Copepods	7	1.89	Mixed
Temporary pond	Phytoplankton	ND	ND		4	2.13	Euglenoph	ND	ND		ND	ND	
	Zooplankton	ND	ND		6	1.41	Rotifers	ND	ND		ND	ND	
Permanent pond	Phytoplankton	ND	ND		4.2	1.88	Chloroph	ND	ND		ND	ND	
	Zooplankton	ND	ND		13.4	3.07	Rotifers	ND	ND		ND	ND	

FIGURE 5.1
Plant Species Abundance.

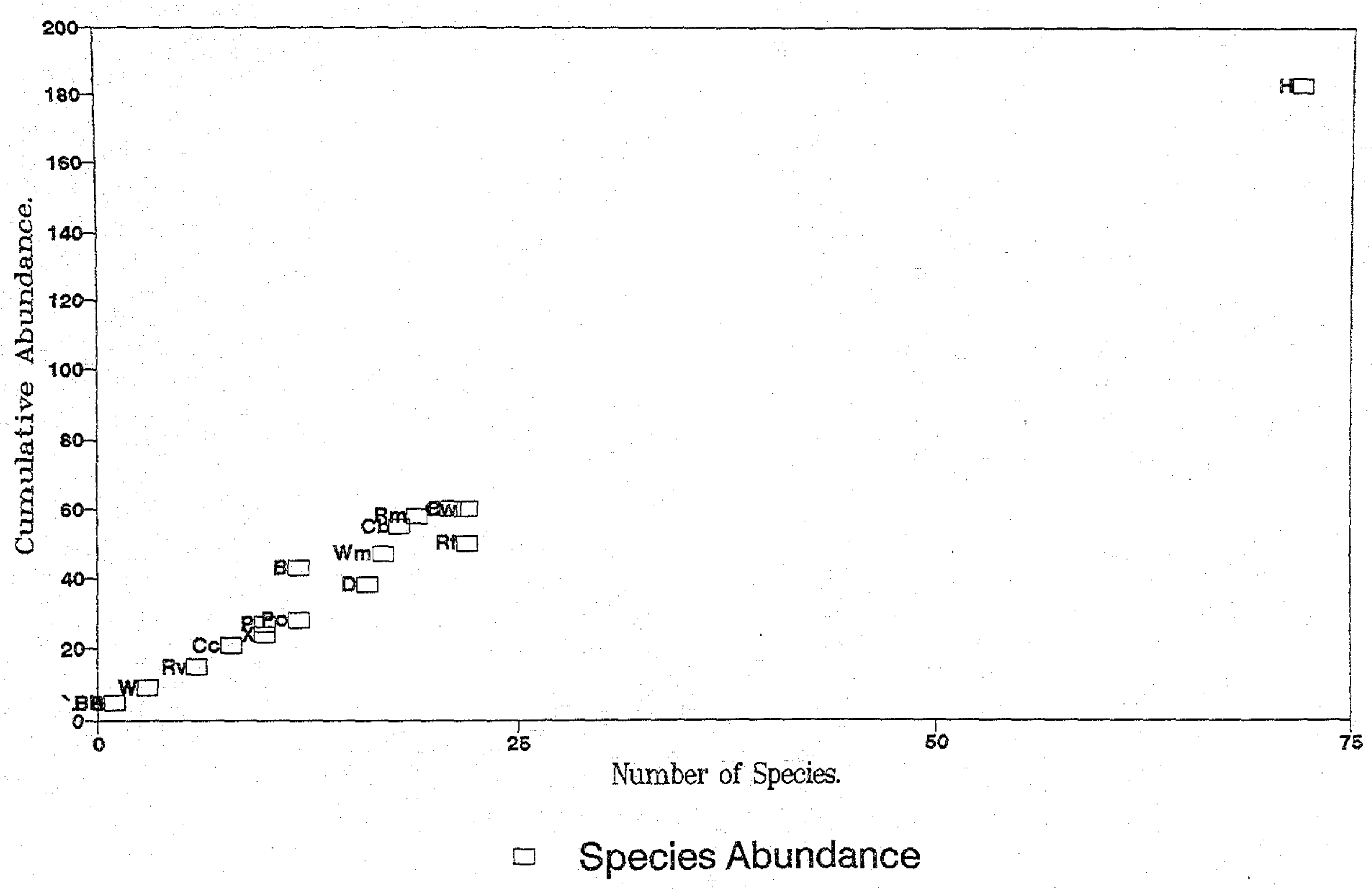


FIGURE 5.2
Animal Species Abundance.

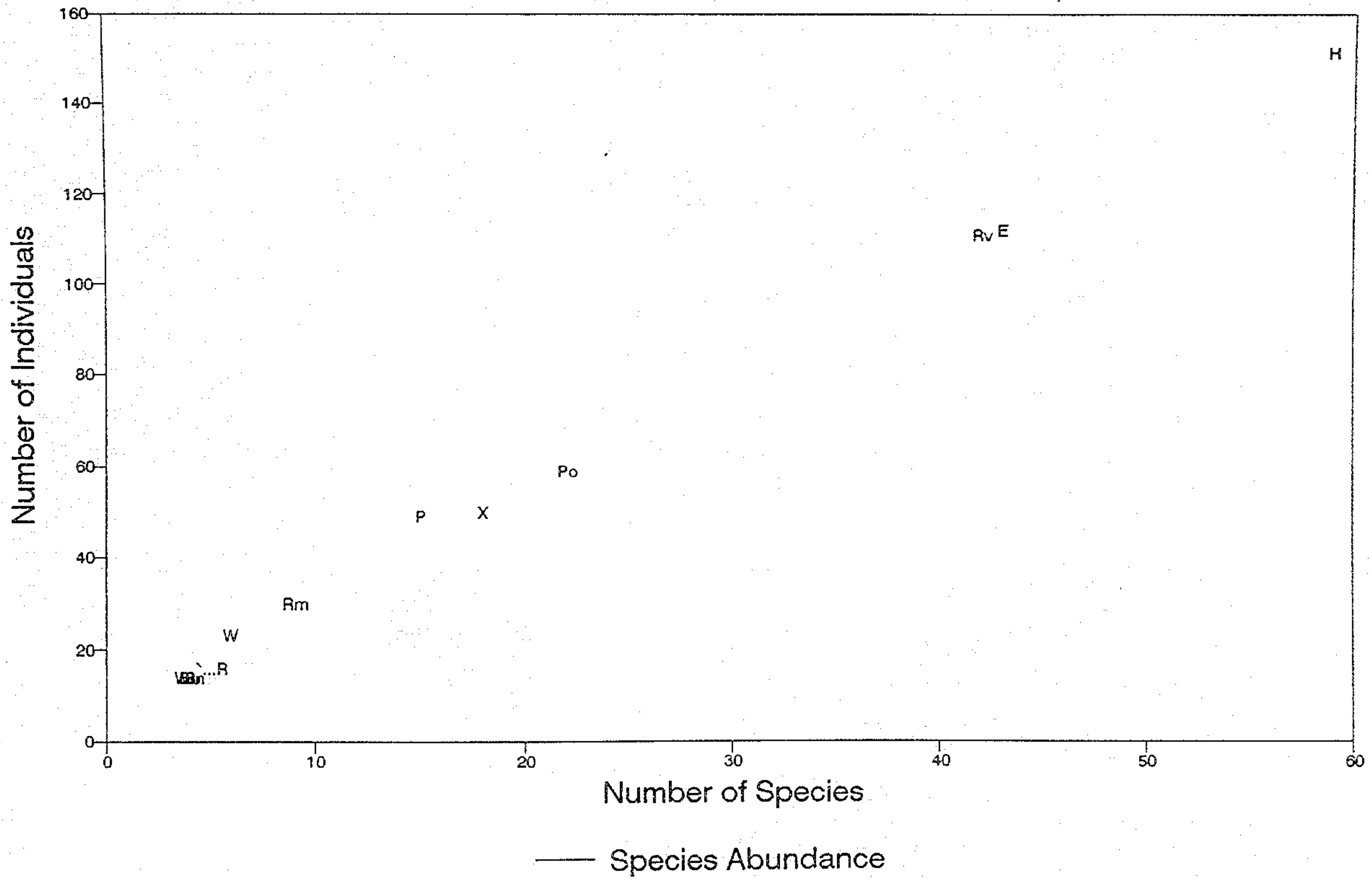
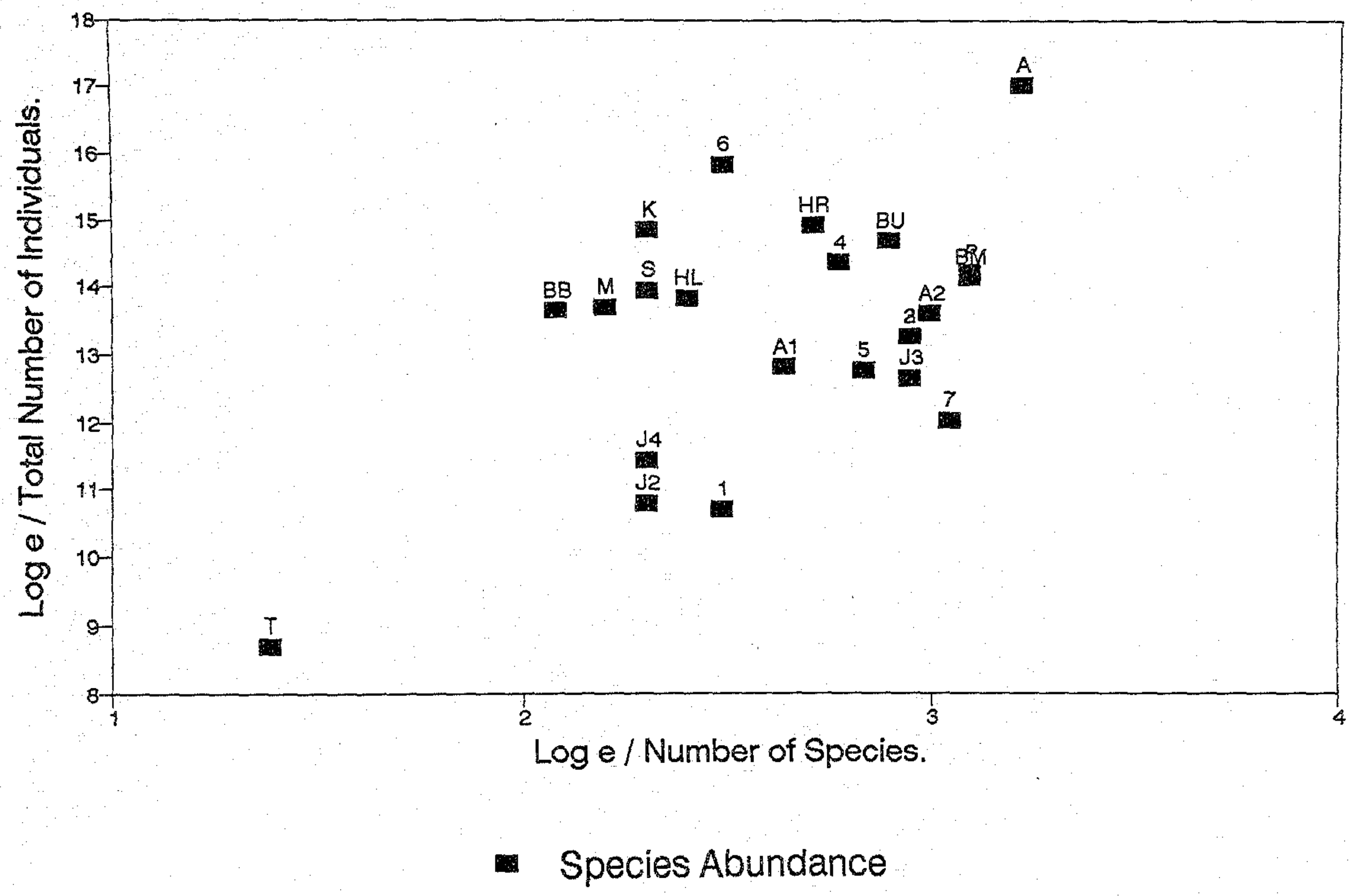


FIGURE 5.3 - AQUATIC SPECIES ABUNDANCE
Plankton in March, 1992



CHAPTER 6

DISCUSSION

This Chapter provides a description of the functional ecology of the floodplain, based on ecological energetics and generalised thermodynamics theory and the interpretation and application of the ecological data collected during the survey.

6.1 Limitations of the Study

Compiling a report on the ecology of the Region presents a considerable dilemma. The range of data collected during this short study illustrates the great complexity of the floodplain. To provide even a sketchy outline of the Region as a functional unit would entail the preparation of a very substantial volume of analysis. The requirements of this Study, however, indicate that the discussion should be focused on the interpretation of the potential impacts of proposals for altering the existing flooding patterns in specific areas.

This report therefore represents a highly selective examination of the functional relationships of the terrestrial and aquatic habitats, and of their interactions with the human population. It is in no sense a comprehensive assessment of the total ecology of the Region, and should not be assessed or interpreted as if it were.

To provide a background for the interpretation of the data the functional ecology of the floodplain id defined. Only with the benefit of an understanding of the inter-relationships between the two major domains - the land and the water - can the role of the human population be defined in a meaningful way. This Chapter therefore briefly describes the basic ecological processes on which the integrity of the floodplain ecosystem depends, and shows how man's activities affect those processes.

6.2 Functional Ecology of the Jamuna Floodplain

6.2.1 Historical Changes

The Jamuna floodplain has been profoundly altered by human activities, especially over the past two centuries. Human population expansion exerts pressures on plant and animal communities through exploitation and disturbance, as well as through the more profound disruptions caused by his adapting the land for cultivation, irrigation and the expansion of settlements. But whilst the floodplain ecology has been profoundly changed by man's activities, the biology of those species which remain is still intimately related to the environmental conditions which formerly existed there.

6.3 An Energetics Approach to the Analysis of the Floodplain Ecosystem

6.3.1 The Need for Energy in Biological Systems

The key concept in ecosystem analysis is energy flow. All organisms need a renewable source of energy in order to replace that which they constantly use in respiration, growth, reproduction and other activities and processes. The primary source of energy is sunlight, and only plants are able to utilise this energy directly. Since there is virtually no importation of energy as biochemicals in the

main rivers, the ecology of the floodplain is totally dependant on energy capture by plants resident there, and the efficient transfer and redistribution of this energy, as biochemicals, through food chains and webs. The major issue to be clarified is the location of this energy capture source, since the whole ecology of the floodplain is dependent upon it.
A detailed analysis of the pathways and magnitude of energy flows within each part of the floodplain is not feasible. However, a general appreciation of the thermodynamic characteristics of the floodplain ecosystem is capable of revealing a great deal about the basic processes which govern the direction and magnitude of environmental impacts.

In their original state, the species of the floodplain ecosystem, both terrestrial and aquatic, formed interlinking parts of a stable, highly organised open system which was far from thermodynamic equilibrium. This system maintained itself in this state by actively accumulating energy from external sources (photosynthesis) and reducing its rate of entropy production to a minimum by efficiently recycling all material which had usable chemical energy levels. This is the most prominent and important of all ecological processes.

6.3.2 The Effect of Human Interventions

Human activities have significantly disturbed this relationship. It is an integral property of such systems that when they are stressed excessively, they reach a crisis (or bifurcation) point, at which they undergo a sudden readjustment to a new steady state. In this new state, the efficiency of energy transfer is greatly depleted, and the rate of entropy production increases substantially. Whatever final state may be adopted by the system, the process is irreversible - the original state of the system cannot be recovered (see, for example, Glansdorff and Prigogine, 1971; Coveney and High field, 1991).

There are complicated non-linear relationships between the living biotic communities and the environmental variables which affect them. In the Jamuna floodplain ecosystem, fish form a vital major energy pathway which links the aquatic and terrestrial habitats. They act as an energy harvesting and transfer mechanism, gathering the residual energy left on the flooded lands at the end of one dry season, and transferring it to the aquatic habitats at the start of the next dry season (Cross, 1992).

If the dynamic balance between energy production on the floodlands during the dry season and its transfer to the aquatic habitats during the floods is destroyed, then the aquatic system will become unstable. Agriculture itself diverts most of the energy capture potential of the floodplain away from the aquatic habitats. The photosynthesis of his own crops stores energy which he then harvests with the maximum efficiency - consequently, this energy is no longer available to the aquatic species.

6.4 Primary Energy Capture in the Terrestrial Habitats

6.4.1 The Cycle of Energy Capture on the Flood lands

As the present Study has shown, energy capture is by no means uniformly distributed across the whole floodplain. Even in its original state, before the invasion of the region by the human species, there was a substantial spacial disparity. On the highlands and floodlands, the terrestrial plant communities are capable of using sunlight to accumulate large biochemical reserves, which form the primary energy source for the whole animal and microbiological communities. During the flood season this process is interrupted on the floodlands (but not the highlands), because terrestrial plants cannot respire under water. Moreover, the water transparency is too low for effective photosynthesis

by the phytoplankton, and only very low populations develop. However, energy capture does not cease entirely in the floodlands during the flood season. About one third of the species of an apparently insignificant class of organisms known as the blue-green algae (the Cyanophyceae), whose systematic position is not entirely clear, are able to fix atmospheric nitrogen dissolved in water in order to produce the protein they need to grow.

Thin skins of blue-green algae develop on the surface of wet or shallowly flooded land during the flood season, and these continue to capture energy when almost all other plants are dormant or suppressed by unfavourable environmental conditions. In some sheltered areas some populations of phytoplankton undoubtedly develop, and augment this energy capture process, but the Cyanophyceae are probably the most significant source of energy capture on the floodlands during almost half of the year.

6.4.2 The Role of Soil Organisms in Terrestrial Habitat Energetics

Whilst the detrimental effects of waterlogging on soil chemistry and physics are widely appreciated, there is a surprising neglect of the biological implications of seasonal flooding. The role of soil organisms in recycling the stored chemical energy in crop and other residues after harvesting is complex and not completely investigated, but it is known that soil energy transfer pathways are dramatically affected by changes in the aeration of the soil when they become waterlogged. Since some of these processes are vital to effective nutrient uptake and the oxidation of crop residues in the soil, these processes are of great economic importance, and are considered below.

6.4.3 Recycling of Biochemical Residues in Floodplain Soils

Just as fish transfer energy captured on land to the aquatic habitats, so soil organisms convert raw materials in the soil to forms in which they can be recycled. The recycling of biochemical residues is an important survival strategy used by the biological community as a whole for reducing entropy, and therefore avoiding the state of final thermodynamic equilibrium represented by death. Only by reducing entropy production can an individual, species or biological community increase its energy content, in apparent contradiction to the second law of thermodynamics - this is the most significant property of biological systems.

On the floodlands, the most obvious source of energy capture is the process of photosynthesis by the terrestrial plants, whether they be the wild plants or their modern replacements, the crops planted by man. But there are three other essential processes, too often overlooked, which must occur if the efficiency of energy utilisation is to be maximised. These are the recycling of residual biochemicals, the fixation of atmospheric nitrogen, and the promotion of soil nutrient absorption by trees.

6.4.4 Oxidation and Glycolysis

Photosynthesis involves the fixation and combination with water of atmospheric carbon dioxide, forming carbohydrates. These contain energy, but are of no value to plants themselves. To utilise the energy in carbohydrates, plants use more complex compounds containing nitrogen, but most terrestrial plants are incapable of obtaining nitrogen from the air. Instead they have to use nitrates in soil as their primary source. Nitrate concentrations in ground water may be too low for maximal growth, so farmers have to apply nitrogen (usually, in Bangladesh, in the form of urea, which oxidises to nitrate in the soil).

When plants and animals die and decay, there are substantial reserves of nitrogen locked up within their biochemicals. The recycling of these chemicals is achieved by soil bacteria and fungi, using different chemical processes, depending largely on whether free oxygen is available. During the annual cycle of inundation and dry season, these two processes alternate, but the energetic implications are substantial, particularly where FCD interventions are likely to result in a significant change in the air/water ratio in the soil.

Aerobic processes related to decay are prevalent in well-drained land, whereas anaerobic processes may be more important in waterlogged land. The former involve respiration, which is an oxidative process fuelled by oxygen from the air. They provide an energy-efficient transfer mechanism by which organic residues may be converted to forms which can be made available to subsequent plant growth in the soil.

In contrast, anaerobic decay and recycling draws on the biochemical process of glycolysis. This produces far less amounts of the essential biochemical energy transmitters (adenosine triphosphate - ATP) than are produced in respiration. The ratio of ATP-production in aerobic and anaerobic processes is 18 to 1, although self regulatory processes may compensate for this to some degree under conditions of fluctuating soil aeration, as fungi switch between respiration and glycolysis.

Consequently, the effect of changing the soil oxygenation regime through the development of seasonal flooding is the substitution of an energy-efficient transfer pathway by an inefficient pathway. The incorporation of biochemical residues into the soil complex in forms which can be utilised by plants becomes far less efficient during the flood season, but this is compensated for by the efficient harvesting of plant and animal remains by the fish during the floods. There is therefore a seasonal rotation of biochemical degradation, which optimises the conversion efficiency of biochemical residues, and avoids at least part of the inefficiencies represented by the glycolytic oxidation pathway.

6.4.5 Nitrogen Fixation in the Soil

Many crops and wild plants obtain part of their nitrogen requirements from a symbiotic relationship with bacteria of the genus Rhizobium, which are able to chemically fix atmospheric nitrogen as a primary source for their nitrogen requirements. Moreover, the energy efficiency of this natural biological process, which relies on catalysis by organic intermediates within the bacterial cells, is much greater than that of the Haber-Bosch process used in the industrial manufacture of ammonia fertilisers.

Rhizobium of various species are able to infect their hosts by establishing functional colonies within nodules which develop on the roots, a process which is fairly species-specific and is controlled by specific chemicals (lectins) similar in function to antigens, which are secreted by the host plants (Bauer, 1977).

Some thousands of species of the sub-families Papillionacae, Mimosoideae and Ceasalpinoideae within the superfamily Leguminous form this association, and some are both ecologically and economically important in the Bangladesh floodplain. The family includes a number of common trees such as the Acacia widely planted on embankments, and a number of small crop weeds such as the vetches and clovers which are locally common on agricultural land. It also comprises valuable crop and fodder plants such as clovers, alfalfa and lucerne, and chickpeas, as well as peas and beans used for direct culinary purposes.

But whilst neither the wild legumes nor those of agricultural importance may be actually killed by seasonal waterlogging, provided that immersion is only short-lived, the root nodules are unable to fix nitrogen when they are immersed in water.

The development of a strong Rhizobium symbiosis in legumes can result in the fixation of 65-335 kg/ha/year of nitrogen (Alexander, 1977). For a review of research on nitrogen fixation by crop symbionts, see Subba Row, (1988). Not only does this greatly increase the productivity of the plant itself, it also has a substantial beneficial effect on crops which may subsequently be grown on that soil. When leguminous crops and fodders are harvested, some of the fixed nitrogen remains in the soil, as a component of the root nodules. After decay of the crop residue, this nitrogen becomes available to subsequent crops, so reducing the amount of nitrogenous fertilisers required.

Moreover, this fixed nitrogen is partially in the form of complex nitrogen-containing organic molecules which are not easily leached by soil water. In contrast, it is common for up to 80% of the nitrogen fertilisers applied to crops such as rice to be lost from the soil by leaching before it can be used by the crops; in some countries this has lead to nitrogen enrichment of groundwater and subsequent problems in the aquatic domain.

6.4.6 The Mycorrhyzal Association of Fungi and Trees

Most trees are capable of forming a commensal relationship with mycorrhyzal fungi. Some are known to be capable of symbiosis with both ectomycorrhyzal and endomycorrhyzal fungi, whilst almost all associate on occasions with the VAM (vesicular arbuscular mycorrhyzae). The ability of many trees to obtain nutrients from the soil is enhanced by this association. VAM have been shown to increase sulphur, phosphorus and zinc uptake in a variety of trees, including citrus (Gray and Gerdemann, 1969; 1973; La Rue et al, 1975). This capability is lost when soil becomes waterlogged.

6.5 Primary Energy Capture in the Aquatic Habitats

6.5.1 The Principal (Permanent) Rivers

Within the river habitats themselves, the availability of energy is highly problematic. The principal rivers contain a high silt load, even during the dry season, which enormously reduces light penetration, and this prevents the development of a significant phytoplankton community in these waters. Only for a short period - perhaps no more than three months each year, between November and February, is there any significant energy capture by the river phytoplankton. Since light intensity is at its lowest at this time, the potential for phytoplankton productivity, even were the silt load to be reduced, is also at its lowest. Whilst is not correct to suggest that there is no primary energy capture in these rivers, the amount acquired from this source is far lower than that captured in an equal area of the floodplain or the beels during the year.

6.5.2 Energy Capture in the Permanent Beels

Unlike other aquatic habitats, the phytoplankton of the permanent beels is dominated by the Cyanophyceae. At least 30% of these 'blue-green algae' species have the remarkable ability to fix atmospheric nitrogen dissolved in the water, and they are one of the most important sources of nitrogen in the floodlands. Many form an almost imperceptible skin across the bottom of the shallow water, releasing oxygen into the water which is required by all aquatic animals.

Unfortunately, a number such as Microcystis and Anabaena occasionally release powerful neurotoxins which can cause sudden fish mortalities, as well as severe reactions in humans. These toxins are quite capable of killing small children who are already weakened by diarrhoea and other chronic illnesses if they drink water contaminated with the toxins.

6.5.3 The Temporary Rivers and Flushed Beels

During the dry season, the minor rivers degenerate into a series of pools of standing water. In these and the still waters of the permanent and temporary depressions known as beels, substantial phytoplankton populations develop. These are then heavily grazed by the zooplankton, which develop slightly out of synchrony with them. This reduces the phytoplankton density, increases water transparency, and reduces the efficiency of light capture. Populations of phytoplankton and zooplankton oscillate violently, and these temporary aquatic communities develop a short-term cyclic periodicity, exhibiting fast-changing dominances by different species during the short dry season.

In the temporary rivers and flushed beels the phytoplankton is more balanced, and is usually dominated by Chlorophyceae. Whilst these are more benign, they are unable to carry out nitrogen fixation. So whilst the temporary river dry-season pools and the flushed beels rely on the importation of nitrogen with floodwater or run-off from the land, the permanent beels are able to capture their own by using fixation of atmospheric nitrogen by the Cyanophyceae.
The temporary river dry-season pools and flushed beels are therefore more likely to experience nitrate limitation of their phytoplankton populations than are the permanent beels. This is likely to be reflected in their total productivity levels, a factor which it has unfortunately not been possible to investigate in this Study.

6.6 The Anomaly of the Jamuna Fish Diversity

Despite its low rate of primary energy capture, the Jamuna River is notable for the very large number of species of fish which live in it, and for the high apparent productivity of the river, which cannot be explained by the energy capture capacity of the river itself. The astonishing diversity of the fish fauna - over 200 species have been described - is also inexplicable when compared with the remarkably small number of types of habitat which the river contains.

It is clear, therefore, that there must be another energy source which the river fish are able to exploit, and that this source must be extremely large if it is able to support such large populations of fish. It must also be very diverse, since the fish are clearly adapted to exploiting a very wide range of food supplies, as is demonstrated by their wide range of food preferences and their varied anatomy and digestive physiology.

This energy source is the floodplain. When the floods rise in June, the terrestrial vegetation which has developed on the floodlands during the dry season is suddenly covered with water, as also are vast numbers of small invertebrates which have made these plants and the soil their homes - insects, spiders, and many more are drowned and start to decay. The biochemical energy available in these dead organisms is exploited directly by the fish which invade the floodlands, and this is the source of the apparent productivity of the river fisheries. It is also the solution of the anomalously high diversity of the fish species, since each is adapted to its own specific source of food supply on these flooded lands.

6.7 The Management of the Jamuna Floodplain Terrestrial Resources

The channelling of energy flow towards human needs, by resource exploitation and habitat conversion, inevitably means that less energy is available to other species. And since the survival of a species is in great part dependent on its ability to gain access to the energy sources in its habitat, those which are least able to maintain their energy sources become weakened, and will die out unless specific methods are used to maintain this access artificially, through the deliberate and active processes of conservation and energy management.

Within the present ecosystem, many of the remaining autochthonous (i.e. indigenous) species appear to be able to exist only if they are tolerated by man, and allocated a share of the energy resources, either because they are useful or because they inhabit areas not seen as presently usable for human activities. The remarkable range of uses to which terrestrial plants are put demonstrates the very close relationship between the rural human population and the flora of the floodplain region. There are very few plants which have no recorded use, and these are generally so persistent or noxious that it is not yet worth the human effort of eradicating them entirely.

6.7.1 Biological Energy Management

(a) Aquatic Nitrogen Fixation

Yet in comparison with some other countries using similar agricultural production systems, there seems to be a rather poor appreciation of how the allocation of energy and space in apparent conflict with the objective to maximise production can actually improve total productivity. The use of the aquatic fern Azolla has been found to increase overall productivity in rice fields dramatically. This tiny floating plant forms a commensal relationship with an alga which is able to fix atmospheric nitrogen - incorporated into rice field soils during transplanting, it provides a substantial and cost-free reserve of slow-release nitrogen as well as improving the quality of the soil.

It can also be used as a source of high protein dried meal, by harvesting it and drying it in the sun. This product can be stored for a considerable time, and used as a component in both human and livestock nutrition. It is quite common in parts of the North West Region (for example, many ponds in the Chalan Beel area are completely covered with Azolla, yet its value is unappreciated.

(b) Dry-land Nitrogen Fixation

It was notable during this survey that leguminous plants able to form the symbiotic relationship with Rhizobium and similar bacteria are infrequent on agricultural land. It appears that the pressure on land resources for human and livestock use is now so heavy that such plants are treated either as weeds, to be removed before they compete with the rice or wheat, or else they are harvested as soon as possible to provide fodder for the livestock.

Yet the absence of leguminous plants as inter-crops in the wheat and vegetable fields results in a loss of the completely free nitrogen which is available through the Rhizobium association. The legumes do not, of course, compete with the crop for soil nitrogen, since they fix rather more than they need through the activities of Rhizobium in the root nodules.