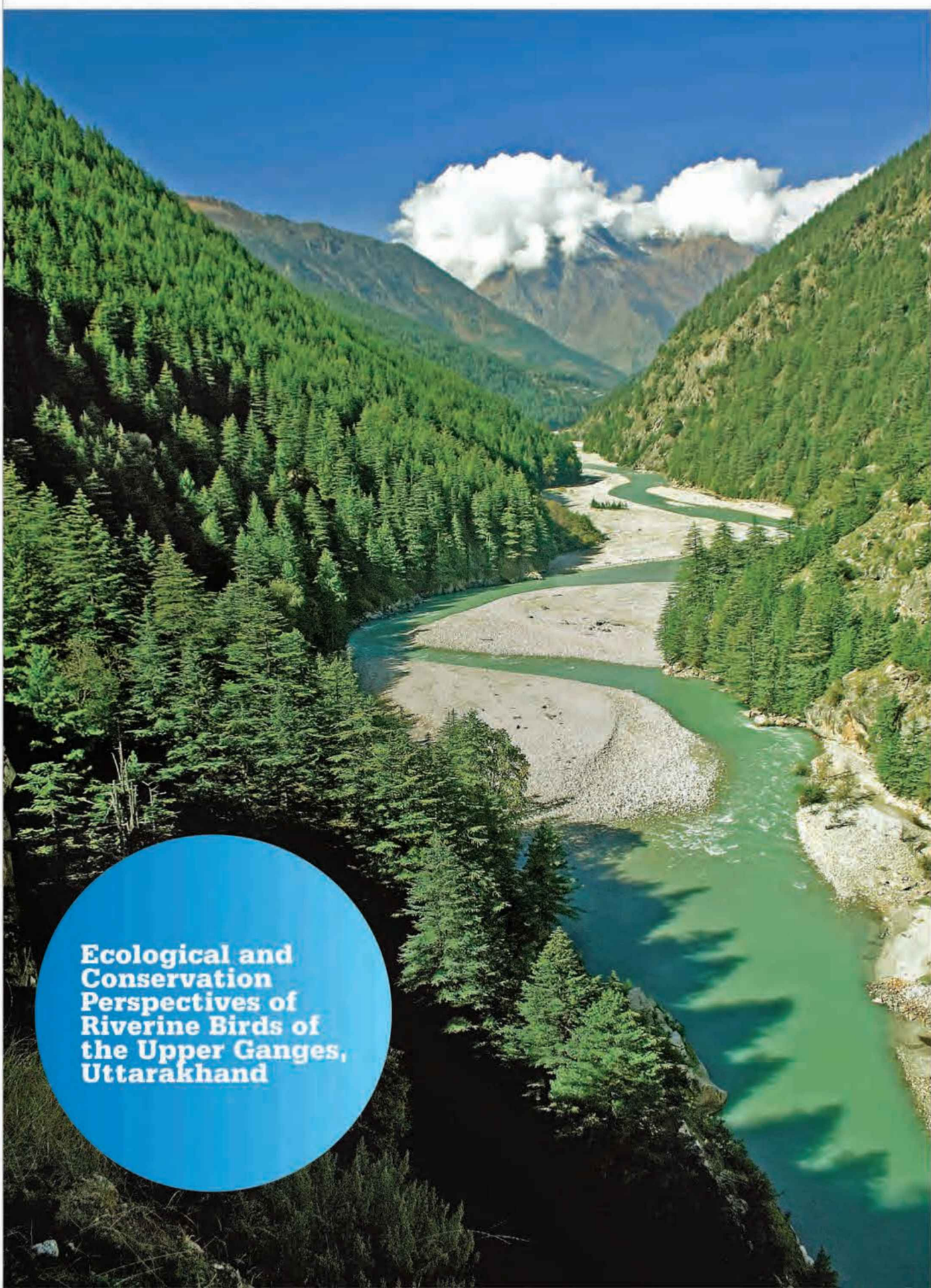

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Abstract

Rivers form very important parts of our natural ecosystems. Riverine systems are fluvial and dynamic, as a result of which they support very rich faunal diversities. Specialist riverine birds are often used to monitor riverine landscape health across the world. The mountainous regions in the riverine landscapes of the Himalaya at latitudes 20-40°N have the greatest richness of riverine avifauna in the world, with 13 species with overlapping ranges. These mountain regions are also the sources of various livelihood and development activities for people, including hydropower projects,which negatively affect the overall integrity of the riverine landscape. In rapidly changing scenarios driven by increasing anthropogenic factors, conservation management of riverine species and their habitats warrants appropriate scientific understanding and action plans.

Keywords : *Riverine Landscapes, Specialist Riverine Birds, Himalayan Mountains, Ganges, Indicators*

Introduction

A lot of work has been carried out in different river systems of the world on the status of riverine birds and their role in riverine systems(Bryce *et al.*2002,Buckton & Ormerod 2002, Sullivan *et al.* 2006). Here, we attempt to review the importance of riverine birds and their surrogate values in monitoring crucial riverine landscapes and discuss aspects such as:-

(i) Riverine landscapes and their role in supporting biodiversity.

(ii) Riverine birds.

(iii) The status of the Bhagirathi Basin (Upper Ganges), in the state of Uttarakhand.

Riverine Landscapes

Riverine landscapes are interactive, open systems, characterized by high levels of natural disturbance and interconnected ecotones (Ward 1989, Ward and Weins 2001). River corridors consist of a dynamic mosaic of spatial elements and ecological processes arrayed hierarchically (Ward *et al.* 2002). Although they forma small part of natural ecosystems, riverine habitats play a critical role in maintaining regional and biological diversity, by acting as significant biological corridors (Naiman *et al.* 1993). A holistic understanding of the spatio-temporal heterogeneity of the structure and function of river ecosystems is essential for successful protection and restoration. Rivers represent a well-defined succession of landscape mosaic features with high habitat heterogeneity (Wissinger 1999) and a complex land-water coupling enhancing the exchange of energy and matter (Stanley *et al.* 1997). The interplay among these landscape elements has a direct bearing on the generation, distribution and maintenance of riverine biodiversity (Junk 2000,Tockner *et al.* 2000).

Rivers grade into many other habitat types across several different ecotones, and 'terrestrialization' processes being very dominant in riverine landscapes, they offer habitats for organisms whose evolutionary origins are not exclusively riverine (Ward 1998, Ward and Tockner 2001). Hence, constant challenges have been faced in categorically defining riverine organisms across the world.

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Riverine Birds

Here we define riverine birds narrowly as those which both:-

(i) Exclusively occur along stream or river channels, and within the river corridor, during a significant part of their breeding or non-breeding life cycle.

(ii) Feed on production wholly or partly of aquatic origin, following Bucktonand Ormerod (2002).

Riverine birds have a well-recognized place in river ecological studies. Birds, being good indicators of habitat quality, provide opportunities to examine how organisms use their environment and interact ecologically. A better understanding of the complex interaction between landscape components and biotic properties is necessary for more effective, dynamic and integrative resource management (Stanford *et al.* 1996). The abundance, distribution and structure of riverine bird communities can serve as key factors in an integrative understanding of riverine landscapes and can serve as a valuable tool for ecological monitoring of entire river basins (Sullivan *et al.* 2006). Rivers are open systems with interactive pathways along four dimensions: longitudinal (head water riverine-estuarine), lateral (riverine-riparian/floodplain), vertical (riverine-ground water), and temporal (time scales) (Ward and Stanford 1989). The mobility of birds facilitates their use of myriad stream corridor habitats, hence making them successful operators at multiple spatial scales globally, filling up many ecological roles. Specifically, the structural and functional attributes of riverine birds closely relate to the habitat correlates at the site (i.e. river attributes in terms of extent and quality) and this has significant relationship with bank characteristics, riverine forest stricture and landuse pattern in the entire region, thus reflecting multiple scale effects. The riverine fauna also provides important feedbacks that can influence the spatio-temporal dynamics of the landscape over long time periods (Naiman *et al.* 2000). Birds that use both riparian and in-stream resources may be integrators of linkages between streams, river banks and watersheds (Sullivan *et al.* 2007).

Specialist riverine birds, typical of riverine landscapes and dependent wholly or partly on production from river ecosystems, occur in 16 families. There are an estimated 60 species divided equally between the passerines and non-passerines (Buckton & Ormerod 2002).

Significant radiation has occurred among different families on different continents, indicating that the birds have evolved several times into the niches provided by riverine landscapes (Figure 1).

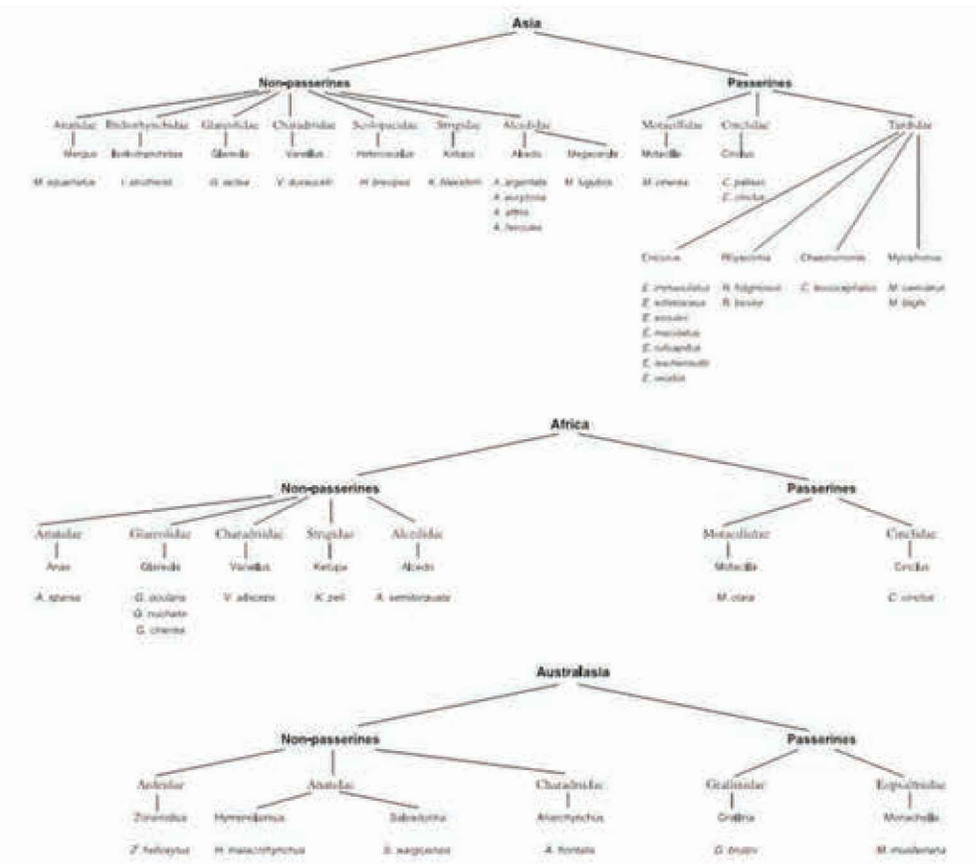

Figure1 : *Taxonomic tree showing points of radiation in riverine birds at the family, genus and species levelsin each of the six continents (Source:Buckton and Ormerod (2002).*

Studies conducted in the past have established that mountainous regions in the riverine landscapes of the Himalaya at latitudes 20-40°N have the greatest riverine avifaunal richness in the world, with 13 species with overlapping ranges (Buckton & Ormerod 2002).

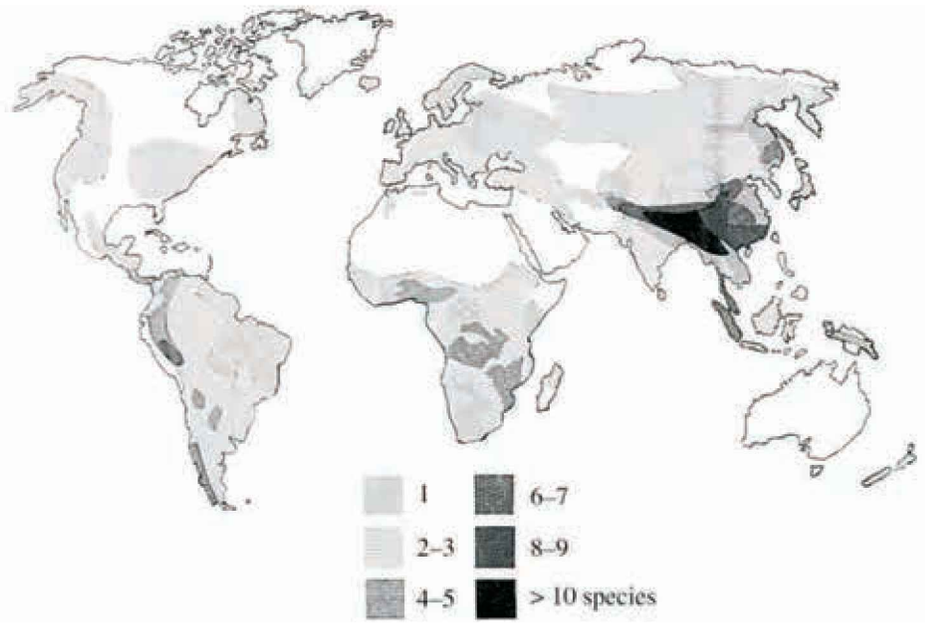

Figure 2 : *Map of the world showing the species richness of specialist riverine birds*

Source : Buckton and Ormerod (2002)

Some avian species are highly sensitive to environmental changes at both fine and coarse scales(Saab 1999, Buckton & Ormerod 2002, Mac Faden & Capen 2002, Clear *et al.* 2005). Riverine landscapes are very vulnerable to habitat fragmentation, on account of flood regimes and anthropogenic effects along the vertical and horizontal axis in the catchment areas. Birds contribute to nutrient cycling in all habitats, but most impressively do so in these interesting landscapes, where terrestrial and aquatic systems interact so well. Therefore, use of birds as ecological indicators in these crucial systems has drawn increasing attention (Collier & Wahelin 1996, Canterbury *et al.* 2000, O'Connell *et al.* 2000, Buckton & Ormerod 2002; Feck & Hall 2004). Some pioneering studies have established that within a stream corridor, riparian-obligate birds might be expected to respond to changes in the surrounding habitats before aquatic organisms do (Bryce *et al.* 2002). In many food webs, birds occupy higher trophic levels and reflect functional impairments at lower levels (Petersson *et al.* 1995,Steinmetz *et al.* 2003, Sullivan *et al.* 2006). For these reasons, bird indices are used as measures of riparian habitat condition (Croonquist & Brookks 1993, Elias 1997, Loegering & Anthony 1999, Popotnik & Givliano 2000, Bryce *et al.* 2002, Inman *et al.* 2002).

Ganga : The Himalaya, the youngest mountains of the world, has played a dominant role in the biogeographic evolution of the subcontinent (Mani 1974).The Himalaya encompass a vast altitudinal gradient, causing a distinct zonation of the climate and consequently the vegetation and avifauna. Variations in species diversity along environmental gradients have always been a major topic of ecological investigation around the globe.

Mountain ecosystems around the globe usually have distinct biological communities and high levels of endemism due to their topography and history. Interestingly, the Himalayas are the origin of a number of important river systems in the Indian subcontinent. Globally, richness peaks at mid-altitudes, with 40%of riverine bird species being found between 1300 and 1400 m a.s.l., above which the richness declines (Buckton & Ormerod 2002). The Ganga is the largest river in the Indian subcontinent. The river has the second greatest water discharge in the world, and its basin is the most heavily populated in the world. The Ganga rises in the Garhwal Himalaya (30°55'N, 79°07'E) in the state of Uttarakhand as the Bhagirathi. The ice cave of Gaumukh, at the snout of the Gangotri Glacier (3892 m a.s.l.), is known as the traditional source of the Ganga, the river flowing hence in the name of "Bhagirathi". The Bhagirathi joins another head stream, the Alaknanda, at Devaprayag. From this confluence, the river becomes known as the Ganga.

Bhagirathi : The Bhagirathi is a turbulent stream in the state of Uttarakhand, one of the head streams of the Ganga, originating at the Gaumukh. The Bhagirathi Basin includes the mountainous section from the river's source to Rishikesh. From here begins the era of human settlements all along the banks of the river. The Bhagirathi flows in the form of small

braided streams through Harsil, finally entering a deep gorge and flowing along till Uttarkashi, with narrow valleys at some places. All along its way from Gangotri to Rishikesh, the River Bhagirathi has a steep altitudinal gradient. Due to this reason, the river has been extensively harnessed for generation of hydro-electric power in the last few years. As a result, the natural substratum and flow of the river are undergoing continuous transformations along its entire stretch. Such transformations of the natural substratum, flow, temperature and other physical and hydrological factors have an integrated impact on the chemical, biological and ecological status of the River Bhagirathi.

Status of Riverine Avifauna in the Bhagirathi Catchment

Field surveys were carried out along the Bhagirathi through trail walks along the river in all the accessible areas on the banks. Data on the distribution, use of the river corridor, feeding behaviour and diet of the different species of bird found was collected. Field work was carried out in spring and autumn at an altitudinal range from 350 m to 3200 m a.s.l. along the banks of the Bhagirathi between Rishikesh and Gangotri.

During the surveys, over 13 species of riverine birds were found. Of these, the riverine obligate species included the Plumbeous and White-capped redstarts, Brown Dipper, Little and Spotted forktails, Crested and Pied kingfishers and Ibisbill (a rare record), while among the non-obligates,the White-browed Wagtail, White Wagtail, Grey Wagtail, Blue Whistling Thrush and Common and White-throated kingfishers were encountered. The Plumbeous and White-capped redstarts appeared to be the most abundant and widely distributed birds, followed by the Blue Whistling Thrush. The Brown Dippers were unique in preferring pristine and less disturbed areas with a fast flow, unlike the redstarts, which were found in moderate flows, having adapted well to human-modified river banks also. In general, the species were found to be decreasingly aquatic and increasingly riparian in habitat use in the order Brown Dipper>Little Forktail>Spotted Forktail>Plumbeous Water Redstart>White-capped Water Redstart (Tyler & Ormerod 1994). Table 1 lists the birds found during the surveys, with their elevational and habitat preferences.

Discussion

River birds represent an excellent focal taxa because river flow is a key predictor of patterns of species occurrence (Vaughan *et al.* 2007). These species are often at the top of food chains and so are sensitive to disturbance at lower trophic levels, including spatial and temporal mismatches in the availability of their prey (Chiu *et al.* 2008, 2013) and pulses in the flow may determine the timing of foraging (Cumin *et al.* 2012) and breeding (Arthur *et al.* 2012) behaviours. In rivers where the natural flow pattern has been altered by humans, all the ecological components are likely to change, compared with the historical conditions. The degree to which this happens reflects the severity of the flow manipulation. The occurrence of river birds is strongly influenced by elements of river flow variability, with their being sensitive to spatial and phenological mismatches with aquatic prey after flow disturbances (Alexander *et al.* 2013). Anthropogenic climate change adds a major pressure to nations that are already confronting the issue of sustainable freshwater use (Wong *et al.* 2007). Regulation of river flows may influence the abundance (Jonsson *et al.* 2012), breeding success and survival (Strasevicius *et al.* 2013) of river birds through modification of aquatic insect emergence and consequent prey availability (Jonsson *et al.* 2013). Moreover, seasonal fluctuations in invertebrate prey fluxes from aquatic to terrestrial habitats subsidize the diets of river birds (Nakano & Murakami 2001), resulting in dramatic shifts in aquatic prey use and foraging behaviour according to species-specific foraging tactics (Murakami & Nakano 2001). This may include a shift in species' seasonal distributions, wherein species move upland to take advantage of the post-breeding increase in terrestrial prey production relative to lowland aquatic production (Jonsson *et al.* 2012,Murakami & Nakano 2001). However, previous investigations of river flow-avian relationships have been spatially and temporally constrained, with most focusing on a single water shed after a specific flood event. The influence of low flows (i.e. drought) on river birds is also not well researched. River birds also have pragmatic advantages for routine monitoring, including their basic ecology being relatively better known and many species being easily and reliably surveyed without specialist equipment (D'Amico 2002, D' Amico & Hemery 2003) and being sensitive to pollutants (e.g. Ormerod *et al.* 1986; Sorace *et al.* 1999; Ormerod *et al.* 2000).

The Bhagirathi valley is predominantly a human dominated landscape and is subject to severe human-land interaction for various purposes. These activities over decades have resulted in significant modification in the landscape structure and have caused barrier effects across the terrestrial and aquatic systems. The Bhagirathi system is also in the seismic zone, experiencing landslides on regular basis affecting the bank characteristics. Similarly, climate change effects are also very pronounced in the landscape, given the evidence that the glaciers in the mountain region has receded significantly, causing modification in the flow regimes. These anthropogenic and natural effects have specific ramification in the way the river systems could be used by the riverine species. The habitat quality including movement pattern of birds has been affected. It is expected that while the distribution range has widened, there is potential shift in

Table 1 : Riverine avifauna found along the Bhagirathi

Species	Distribution[1]	Elevational Preference[2]	Preferred Habitat[1]
Plumbeous Water Redstart (*Rhyacornis fulliginosa*)	Breeds in the Himalaya and hills of north-eastern India; winters down in Sub-Himalayan country south to Bangladesh	S: (600) 1200-4400 W: 1000-1800(2400)	Mountain streams and rivers
White-capped Redstart (*Chaimarrornis leucocephalus*)	Breeds in the Himalaya and hillsof north-eastern India; winters down in Sub-Himalayan country south to Baluchistan and Bangladesh	S: 1800-5300 W: foothills, 1500(2600)	Water margins, river bed rocks, grasslands at edges ofriverine forests
Spotted Forktail (*Enicurus maculatus*)	Resident in the Himalayan and north-east Indian hills	S: (600)1200-3000 W: 600-2300	Running mountain streams, often near waterfalls; also slower-moving streams and rivers in winter
Little Forktail (*Enicurus scouleri*)	Resident in the Himalayan and north-east Indian hills	S:(1000)1800-3300(3700) W: (300) 900-2000	Rocky streams in forests and shadowed, wooded ravines
Blue Whistling Thrush (*Myophonus caeruleus*)	Resident in North Baluchistan, the Himalaya and north-east India	S:(1000)1500-2400(treeline) W: foothills-2700	Forests and wooded areas, usually close to streams
Brown Dipper (*Cinclus pallasi*)	Resident in the Himalaya, north-east India and Bangladesh	S: 450-4000(4950) W: <2700 (3600)	Mountain streams
Citrine Wagtail (*Motacilla citreola*)	Breeds in Baluchistan and the Himalaya; widespread in winter	S: (1500)3000-4600	Breeds in high-altitude wet grasslands
Yellow Wagtail (*Motacilla flava*)	Widespread in winter	S: 3600-4500 W: <1500	Damp grasslands
White Wagtail (*Motacilla alba*)	Breeds in the Himalaya; widespread in winter	S: 800-4500 W: <1800 (5500 on passage)	Breeds by running waters in open country in hills and mountains; winters near water in open country
Grey Wagtail (*Motacilla cinerea*)	Breeds in Baluchistan and the Himalaya; widespread in winter	S: (1200)1800-3900 W: <2000	Riverine grasslands, wet river margins;in winter, also away from rivers but invariably close to wet damp patches
White Browed Wagtail (*Motacilla maderaspatensis*)	Widespread resident	<2200	Banks of rivers, pools, canals and irrigation barrages
Wallcreeper (*Tichodroma muraria*)	Resident to the Himalaya; winters down to the foothills and plains	S: >3300 W: plains, 5000(5730)	Rock cliffs and gorges; also ruins and stony river beds
Common Kingfisher (*Alcedo atthis*)	Widespread resident in India	<1850(3100)	Freshwater in open country; also mangroves and seashore in winter
White-throated Kingfisher (*Halcyon smyrnensis*)	Widespread resident in India	<2300(3050)	Wide-ranging habitat, often far from water, freshwater and coastal wetlands
Pied Kingfisher (*Ceryle rudis*)	Widespread resident in India	<900(1800)	Still freshwaters, slow-moving rivers and streams
Crested Kingfisher (*Megaceryle lugubris*)	Resident in the Himalaya, north-east India and Bangladesh	<2000(3000)	Rocky, fast-flowing mountain rivers and larger rivers in foothills, rarely by lakes

[1]**Source :** *Grimmett et al. 2011*
[2]**Source :** *Kazmierczak & Perlo 2000;* **S:** *Summer,* **W:** *Winter; elevation in paranthesisdenotes occasional record, unusual record or potential range.*

the median range of the distribution has also shifted. In this context, it would be important to know the long-term viability of these species in the modified and changing anthropogenic and climate effects in the landscape. Thus, we advocate the further development of birds as indicators in riverine landscapes that could convey the importance of the ecological integrity, biological production and conservation value of river systems to a wider audience.

Conclusions

The riverine avifauna of India has not received much academic attention as of date. The focal area, the River Ganga, is a major life support system for a rich biodiversity and a large human population. Any negative influence on the system is likely to manifest in large-scale impacts, not only on biodiversity values, but also the human population. The base line established by this study and indicator species analysis will be useful in recognizing priority areas for devisingan adaptive strategy. Therefore, quantification of the relationships between river flow variability and riparian ecology is an urgent and important research challenge in the context of unravelling and projecting the impacts of climate change-induced flow alteration. Given that riverine birds are understudied in India and river systems of the country are undergoing adverse climatic and anthropogenic effects, concerted monitoring strategies to understand the conservation status of these birds are called for. Regular and long-term ecological monitoring is a critical conservation tool. Aside from providing basic information about the status of target species, changes in distribution and abundance can reveal the state of different environments, help identify conservation priorities and monitor the effects of broad-scale policy or environmental change (Balmford *et al.* 2003, Greenwood 2003). Given that the national priority in India includes a clean Ganga, the focus of the present efforts will augment the scientific understanding and management strategies in the short-term and long-term towards conservation management of wildlife species and their habitats.

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References

Alexander, R., Hannah, D. M., Reynolds, S. J., Noble, D. G. & Sadler, J. P. (2013) Avian community responses to variability in river hydrology. *Plos One* 8 (12).

Arthur, A. D., Reid, J. R. W., Kingsford, R. T., Mcginness, H. M., Ward, K. A. & Harper, M. J. (2012). Breeding Flow Thresholds of Colonial Breeding Waterbirds in the Murray-Darling Basin, Australia. *Wetlands* 32: 257-265.

Balmford, A., Green, R. E. & Jenkins, M. 2003 Measuring the changing state of nature. *Trends in Ecology and Evolution* 18: 326-330.

Bryce, S. A., Hughes, R. M. & Kaufmann, P. R. (2002). Development of a bird integrity index: Using bird assemblages as indicators of riparian condition. *Environmental Management* 30: 294-310.

Buckton, S. T. & Ormerod, S. J. (2002). Global patterns of diversity among the specialist birds of riverine landscapes. *Freshwater Biology* 47:695-709.

Canterbury, G. E., Martin, T. E., Petit, D. R., Petit, L. J. & Bradford, D. F. (2000). Bird communities and habitat as ecological indicators of forest condition in regional monitoring. *Conservation Biology* 14:544-548.

Chiu, M. C., Kuo, M. H., Hong, S. Y. & Sun, Y. H. (2013). Impact of extreme flooding on the annual survival of a riparian predator, the Brown Dipper *Cinclus pallasii. Ibis* 155: 377-383.

Chiu, M.C., Kuo, M. H, Sun, Y. H., Hong, S.Y. & Kuo, H.C. (2008). Effects of flooding on avian top-predators and their invertebrate prey in a monsoonal Taiwan stream. *Freshwater Biology* 53: 1335-1344.

Clear, D. F. R., Genner, M. J., Boyle, T. J. B., Setyawati, T., Angraeti, C. D. & Menken, S. B. J. (2005). Associations of bird species richness and community composition with local- and landscape scale environmental factors in Borneo. *Landscape Ecology* 20: 989-1001.

Collier, K. J. & Wakelin, M. D. (1996). In-stream habitat use by blue duck *(Hymenolaimus malacorhynchos)* in a New Zealand river. *Freshwater Biology* 37:277-287.

Croonquist, M. J. & Brooks, R. P. (1993). Effects of habitat disturbance on bird communities in riparian corridors. *Journal of Soil and Water Conservation* 48: 65-70.

Cumming, G. S., Paxton, M. , King, J. & Beuster, H. (2012). Foraging guild membership explains variation in water bird responses to the hydrological regime of an arid-region flood-pulse river in Namibia. *Freshwater Biology* 57: 1202-1213.

Elias, J. E. (1997). Avian species richness and abundance levels in different habitats along the Band River Corridor, northern Wisconsin. *Passenger Pigeon* 59: 21-44.

Feck, J. & Hall, R. O. J. (2004). Response of American dippers *(Cinclus mexicanus)* to variation in stream water quality. *Freshwater Biology* 49: 1123-1137.

Greenwood, J. J. D. (2003). The monitoring of British breeding birds: A success story for conservation science? *Science of the Total Environment* 310: 221-230.

Grimmett, R., Inskipp, C. & Inskipp, T. (2011). *Birds of the Indian Subcontinent.* Oxford University Press, UK.

Inman, R. L., Prince, H. H. & Hayes, D. B. (2002). Avian communities in forested riparian wetlands of southern Michigan, USA. *Wetlands* 22: 647-660.

Jonsson, M., Strasevicius, D. & Malmqvist, B. (2012). Influences of river regulation and environmental variables on upland bird assemblage in northern Sweden. *Ecological Research* 27:945-954.

Jonsson, M., Deleu, P. & Malmqvist, B. (2013). Persisting effects of river regulation on emergent aquatic insects and terrestrial invertebrates in upland forests. *River Research and Applications* 29: 537-547.

Junk, W. J. (2000). Mechanisms of development and maintenance of biodiversity in Neotropical floodplains. Pp. 119-139 in Gopal, B., Junk, W. J. & Davis, J. A. (eds.) *Biodiversity in Wetlands: Assessment, Function and Conservation.* Backhuys Publishers, Leiden, The Netherlands.

Kazmierczak, K. & Perlo, B. V. (2000). *Birds of India, Sri Lanka, Pakistan, Nepal, Bhutan, Bangladesh and the Maldives.* Om Field Guides.

Loegering, J. P. & Anthony, R. G. (1999). Distribution, abundance, and habitat associations of riparian-obligate and -associated birds in the Oregon Coast Range. *Northwest Science* 73: 168-185.

Macfaden, S. W. & Capen, D. E. (2002). Avian habitat relationships at multiple scales in a New England forest. *Forest Science* 48: 243-253.

Mani, M. (1974). *Ecology and Biogeography in India.* Dr. W. Junk Publishers, The Hague.

Alternate Hydro Energy Centre, Indian Institute Of Technology, Roorkee. (2009). Status Paper on River Ganga. State of Environment and Water Quality National River Conservation Directorate, Ministry of Environment and Forests, Government of India.

O'connell, T. J., Jackson, L. E. & Brooks, R. P. (2000). Bird guilds as indicators of ecological condition in the Central Appalachians. *Ecological Applications* 10: 1706-1721.

Murakami, M. & Nakano, S. (2001). Species-specific foraging behaviour of birds in a riparian forest. *Ecological Research* 16: 913-923.

Naiman, R. J., Decamps, H. & Pollock, M. (1993). The role of riparian corridors in maintaining regional biodiversity. *Ecological Applications* 3(2): 209-212.

Nakano, S. & Murakami, M. (2001). Reciprocalsubsidies:Dynamic interdependence between terrestrial and aquatic food webs. *Proceedings of the National Academy of Sciences of the United States of America* 98: 166-170.

Petersson, R. P., Ball, J. P., Renhorn, K., Esseen, P. & Sjoberg, K. (1995). Invertebrate communities in boreal forest canopies as influenced by forestry and lichens with implications for passerine birds. *Biological Conservation* 74: 57-63

Popotnik, G. J. & Giuliano, W. M. (2000). Grazing and riparian birds. *Journal of Wildlife Management* 64: 972-998.

Saab, V. 1999. Importance of spatial scale to habitat use by breeding birds in riparian forests: A hierarchical analysis. *Ecological Applications* 9: 135-151.

Stanford, J. A., Ward, J. V., Liss, W. J., Frissell, C. A., Williams, R. N., Lichatowich, J. A. & Coutant, C. C. (1996). A general protocol for restoration of regulated rivers. *Regulated Rivers: Research and Management* 12: 391-413.

Stanley, E. H. & Fisher, S. G. & Grimm, N. B. (1997). Ecosystem expansion and contraction in streams. *Bioscience* 47: 427-436.

Steinmetz, J., Kohler, S. L. & Souluk, D. A. 2003. Birds are over looked top predators in aquatic food webs. *Ecology* 84:1324-1328.

Strasevicius, D., Jonsonn, M., Nyholm, N. E. I. & Malmqvist, B. (2013). Reduced breeding success of pied fly catchers *Ficedula hypoleuca* a long regulated rivers. *Ibis* 155: 348-356.

Sullivan, S. M. P., Watzin, M. C. & Hession, W. C. (2006). Differences in the reproductive ecology of belted kingfishers *(Ceryle alcyon)* across streams with varying geomorphology and habitat quality. *Waterbirds* 29: 258-270.

Sullivan, S. M. P., Watzin, M. C., & Keeton, W. S. (2007). A riverscape perspective on habitat associations among riverine bird assemblages in the Lake Champlain Basin, USA. *Landscape Ecology* 22(8): 1169-1186.

Tockner, K., Malard, F. & Ward, J. V. (2000). An extension of the flood pulse concept. *Hydrological Processes* 14: 2861-2883.

Tyler, S. J. & Ormerod, S. J. (1994). The ecology of river birds in Nepal. *Forktail* 9:59-82.

Vaughan, I. P., Noble, D. G. & Ormerod, S. J. (2007). Combining surveys of river habitats and river birds to appraise riverine hydromorphology. *Freshwater Biology* 52: 2270-2284.

Ward, J. V. (1989). The four-dimensional nature of lotic ecosystems. *Journal of North American Benthological Society* 8: 2-8.

Ward, J. V. & Stanford, J. A., (1989). Riverine ecosystems: the influence of man on catchment dynamics and fish ecology. D. P. Dodge (ed.) Proceedings of the International Large River symposium. *Canadian Special Publication of Fisheries and Aquatic Sciences.* 106: 56-64.

Ward, J. V. (1998). Riverine landscapes: Biodiversity patterns, disturbance regimes, and aquatic conservation. *Biological Conservation* 83: 269-278.

Ward, J. V. & Tockner, K. (2001). Biodiversity: Towards a unifying theme for river ecology. *Freshwater Biology* 46: 807-820.

Ward, J. V. & Wiens, J. A. (2001). Ecotones of riverine systems: Role and typology, spatio-temporal dynamics, and river regulation. *Ecohydrology Hydrobiology* 1:25-36.

Ward, J. V., Malard, F. & Tockner, K. (2002). Landscape ecology: A framework for integrating pattern and process in river corridors. *Landscape Ecology* 17: 35-45.

Wissinger, S. A. (1999). Ecology of wetland invertebrates: Synthesis and applications for conservation and management. Pp. 1043-1086 in Batzer, D. P., Rader, R. B. & Wissinger, S. A. (eds.) *Invertebrates in Freshwater Wetlands of North America: Ecology and Management.* John Wiley and Sons, New York.

Wong, C. M., Williams, C. E., Pittock, J., Collier, U. & Schelle, P. (2007). *World's Top 10 Rivers at Risk*. WWF International, Gland, Switzerland.

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Ecological and Conservation Perspectives of Riverine Birds of the Upper Ganges, Uttarakhand