Stream macroinvertebrate assemblages in the Bagrot Valley of Central Karakoram National Park, Pakistan

Ejaz Hussain[1], Babar Khan[2], Valeria Lencioni[3], Samina Mumtaz[1], Farasat Ali[2]

[1] *Karakoram International University, Gilgit, Pakistan*
[2] *WWF - Pakistan, NLI Colony, Shahrah-e-Quaid-i-Azam, Jutial, Gilgit, Pakistan*
[3] *Natural Science Museum of Trento, Italy*

Corresponding author: Ejaz Hussain (Email: hussainwwf@gmail.com)

K E Y W O R D S

Aquatic insects
Macroinvertebrate assemblages
High-altitude streams
Biodiversity
Species richness
Station
Bagrot Valley
Central Karakoram National Park

A B S T R A C T

The study was conducted in Bagrot Valley, in the buffer zone of Central Karakorum National Park, to assess diversity and distribution of zoo-benthic taxa in relation to habitat type and environmental factors. Fourteen stations were sampled twice in two field surveys. Nine stations were selected on the glacier fed streams (Kryal and Glacio-rhithral), one on a spring-fed stream (Krenal), and three on springs (Limnokrenal and Rheokrenal) and one in a glacial pond. In an additional "terrestrial" station, only adults were collected. At each station, environmental factor (air, temp, pH and conductivity) and faunal samplings (kick and drift samples) were carried out. Adults were collected by sweep net and by Malaise trap. In all stations, 7,991 aquatic specimens were counted of which Diptera and Ephemeroptera were abundant respectively 53 % and 29 % of individuals. Representatives of eight families of Diptera were found, among them family Chironomidea as dominant. Within non-insects, Oligochaeta and Crustacea (Amphipoda and Ostracoda) were best represented i.e. 54 % and 37 % of the non-insect fraction respectively. The highest number of individuals and taxa was recorded in the Krenal streams and springs respectively. Kryal and Rheokrenal habitats were dominated by Chironomidae, Glacio-rhithral and Krenal by Baetidae. The longitudinal pattern was analysed in Dubani stream, considering a distance of approximately four kilometers. Richness and abundance increased with increasing distance from the glacier, with Chironomidae remaining dominant within the first two kilometers downstream of the glacial snout. Baetidae prevailed more in the downstream regions. The highest diversity and abundance were recorded in autumn in the glacier-fed stream, while the contrary in springs. The changes were mainly due to a significant increase of Baetidae and the appearance of many other insects (mainly Plecoptera) in October and November.

Introduction

The class Insecta is composed entirely of insects and is the largest group in the animal kingdom, with 29 orders and 800,000 known species. It is estimated that there may be up to 50,000,000 species of insects on Earth, most of which have not yet been discovered (http://amazinginsects.org/). Benthic macro-invertebrates are considered one of the best biological indicators of water quality. At the beginning of this century, Kolwitz and Marsson (1902) clearly formulated the relationship of aquatic organisms to the purity and pollution of water. Since then, many methods are employed to assess biological water quality; using different organisms (viruses, bacteria, fungi, lichens, algae, plants, protozoa, macro-invertebrates and fishes). However, most of the methodologies are based on macro-invertebrates (Hellawell, 1986; DePauw *et al.,* 1992; Rosenberg and Resh, 1993; Ghetti, 1997). Their response to organic or inorganic pollutants has been used to develop biotic indices (Duran, 2006), because presence of particular species, taxa and/or communities reflects the environmental history and condition of an area (Fureder *et al.*, 2006). Benthic macro-invertebrates vary in their sensitivity and tolerance of pollutants occurring in surface water. These organisms respond to long-term impairments of stream water. Thus, as bio-indicators, aquatic insects are excellent and reliable determinants of stream health. Members of the orders Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) are mostly intolerant of pollutants; their relative abundance indicates good water quality. The biological index of Ephemeroptera -Plecoptera - Trichoptera also known as EPT, calculates the taxa richness of a sampling site. Midge flies, and Black flies (both are in the order Diptera) are tolerant of pollution; their occurrence in high numbers is indicative of organic water impairment (Bohlman *et al.,* 2009).

The importance of this research is revealed by the fact that it is the first ever scientific research on macro-invertebrates in upper Indus Basin (Gilgit-Baltistan). In Pakistan, especially in Gilgit-Baltistan, research on these organisms was neglected in the past, resulting in lack of scientific data and literature, but in developing countries a lot of progress has been achieved on macro-invertebrates on various aspects. The assemblage of freshwater macro-invertebrate with special regard to diversity and distribution of Diptera: Chironomidae (Insecta), the dominant taxon in all aquatic habitats is focused in Bagrot Valley (CKNP) in relation with environmental parameters is great intervention at Gilgit-Baltistan level rather at Pakistan's level. This data would help upcoming research programme on alpine stream, rivers, and springs and associated fauna and will serve as baseline information in Gilgit-Baltistan.

Material and Methods

Study area

CKNP is the largest Protected Area in Pakistan, stretches along the Karakoram mountain ranges located in four Districts, Gilgit, Hunza-Nagar, Skardu and Ghanche of Gilgit-Baltistan and covers an area of 10,000 km^2. A total of 231 villages with cultural and dialect diversity of indigenous communities inhabit these villages and dependent on the natural resources of park to meet their livelihood. Its main attractions are largest glacier's concentration, second largest peak K2, several other peaks are the most prestige destination for trekkers, mountaineers, and climbers. Beyond its scenic natural beauty, it also hosts great floral and faunal diversity.

The recent study was carried out in Bagrot Valley (Fig. 1) a buffer zone valley of CKNP. The valley lies at 36°1'4" N 74°33'19" E surrounded by Karakoram mountains. Outstanding physical features in the vicinity of the valley include the Rakaposhi (7,788m) and Diran (7,269m) peaks in the northwest and northeast respectively, and Dubani peak (6,143m) in the east.

Bagrot valley forms part of the CKNP buffer zone and is the model region for CKNP, due to its socio-ecological significance. Bagrot valley is one of the potential buffer zone valleys in CKNP hosting productive summer pastures, glaciers, faunal and floral diversity. The biodiversity includes pine, birch, juniper and various herbs and shrubs, key wildlife species such as Snow Leopard, Ibex, Woolly Flying Squirrel, Stone Marten, Snow Partridge, Snow Cock and Chukar.

Data Collection

Record of Environmental Data

Before sampling, environmental parameters including water, air temperature, pH and conductivity were recorded; using different instruments like thermometer, Multiprobe Water Sampler.

Benthic Fauna (Sampling and identification)

Macro-invertebrates were collected by means of a pond net (250μm mesh size) with the technique of kick sampling according to Lencioni and Rossaro (2005). Samples were washed through a funnel with the same size to remove excess water and then preserved in 75 % ethanol. Other specimens were collected by tweezers and drift nets (100 μm mesh size).

Samples were transported to the Section of Invertebrate Zoology and Hydrobiology of the Natural Science Museum of Trento, Italy, and analysed by Dr. Valeria Lencioni and Dr. Alessandra Franceschini. Sorting was carried out to family or higher taxonomic level according to Campaioli *et al.,* (1994). Adults were collected by means of a sweep net and a Malaise trap.

Data analysis

The relative composition of the macro-invertebrate community of 14 stations was analysed. The longitudinal pattern was considered for the Dubani stream (st. 2,3,5), while a temporal pattern was considered for the station 3. Significant differences among stations were found by applying univariate parametric analysis (ANOVA-test), using the STATISTICA 6.0.

Results

Environmental data

The Kryal and Glacio-rhithral stations appeared to be colder from those located on small tributaries of the Hinarche stream (st. 9 in Fig. 1). This is due to the low discharge of the stream, and the high air temperature recorded especially in June (27.5°C at st. 9)

The highest temperature recorded was of station 9 (Fig. 2), which is a small and shallow pond with brighter sunshine resulting in increase in temperature of water. Station 6 is the one with lowest temperature i.e. about 10^{o}C.

According to conductivity data collected, station 14 and station 15 have the highest conductivity measurements ranging from 540 to 580 (μS/cm). These two stations are the springs located on lowest altitude, while station 13 which is the highest station of our study area has lowest conductivity (Fig. 3.). pH data showed variation among stations except st. 4 Krenal and st. 5 Glacio-rhithral which are located close to each other and no significant change in pH in all 14 sampling stations of the study area was observed (Fig. 4).

Benthic fauna

In all, almost 8,453 individuals were collected from 15 stations (Fig. 5) of which 90 % belonged to Insects, mainly as larvae (about 7,000 specimens). In station 6 no animals were found in the sample. With the exclusion of terrestrial instars of Insects (adults of Diptera, Trichoptera, Plecoptera) and terrestrial taxa accidentally fallen in the water (Tysanoptera, terrestrial Coleoptera), 7,991 aquatic specimens were counted. In all, 25 taxa were identified, of which 22 were Insects. Diptera and Ephemeroptera form the two most abundant taxa, accounting respectively 53 % and 29 % of individuals. Within Ephemeroptera, two families were identified, of which Baetidae prevailed (= 29% of total fauna). Diptera was found with eight families (some specimens were not recognised as known family and were named as "other Diptera"). Among these, Chironomidae was dominant (= 39% of total fauna). Within non-Insects, Oligochaeta and Crustacea (Copepoda and Ostracoda) were the best represented (54 % and 37 % of the non-Insect fraction respectively) (Fig. 5).

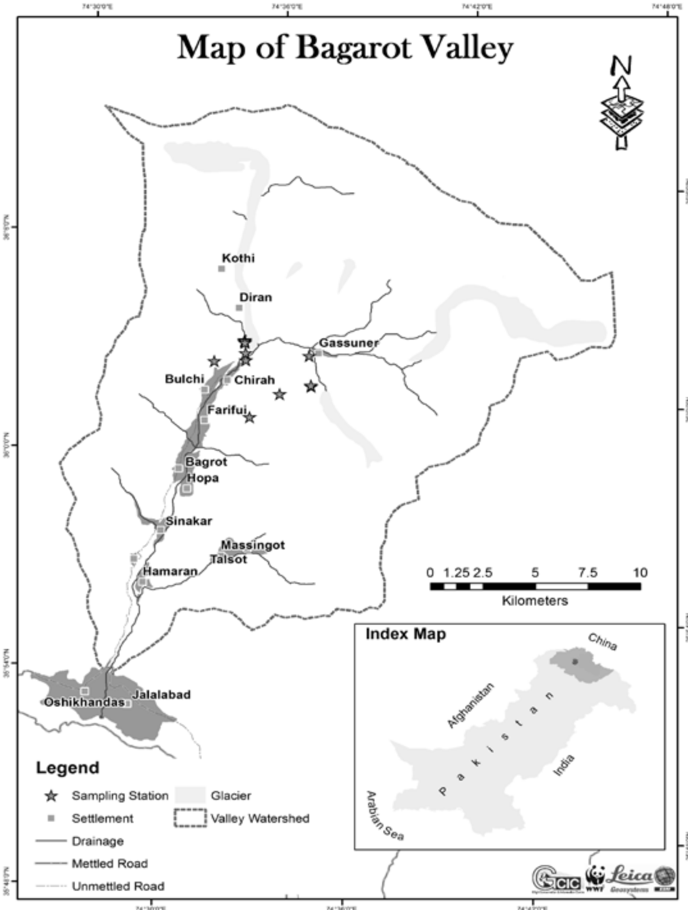

Figure 1: Map of Bagrot Valley, Central Karakoram National Park

The two stations with the highest number of individuals and taxa were st. 4 and 14, dominated by Ephemeroptera: Baetidae (30 %) and Chironomidae (59 %) (Fig. 6).

The highest number of individuals was collected in the Krenal streams, followed by the Glacio-rhithral habitats. The highest taxa richness was found at the springs (17) and in the spring-fed streams (16), followed by the Glacio-rhithral (15); the lowest in the glacier-fed streams (Kryal) (6). Finally, four taxa were found exclusively in the Rheokrenal springs: Dixiidae, Gastropoda, Hydrophilidae and Planariidae (Fig. 7 & 8).

The longitudinal pattern was analysed in the Dubani stream (Fig. 9) from st. 2 to st. 5. Richness and abundance increased with increasing distance from the glacier (st. 2, st. 3) with Chironomidae remaining dominant. Their dominant role remained at st. 5, where taxa coming from the spring-fed tributary occurred (tributary effect) such as Simuliidae, Tipulidae and Ostracoda (Fig. 9).

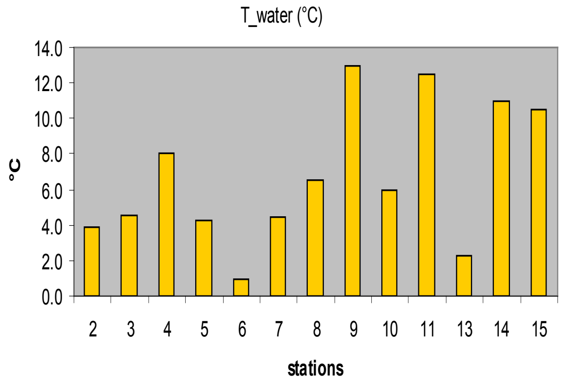

Figure 2: Results of water temperature at all sampling stations of the study area

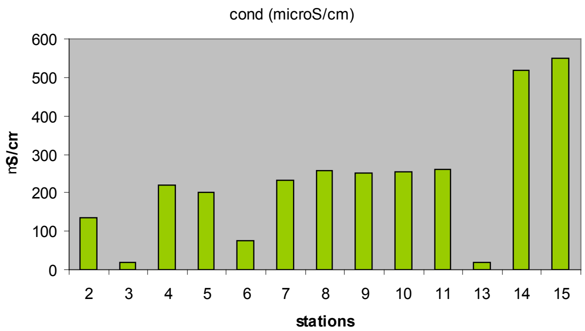

Figure 3: Results of conductivity at all sampling stations of the study area

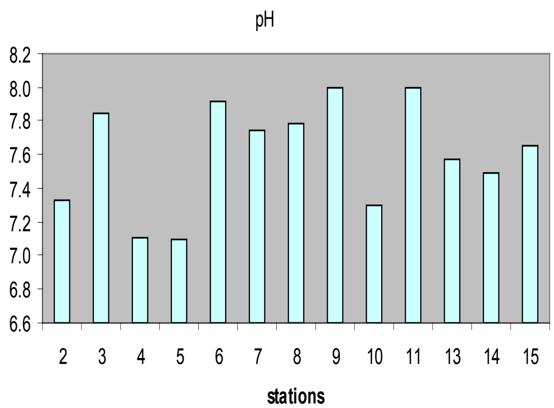

Figure 4: Results of pH in all 14 sampling stations of the study area

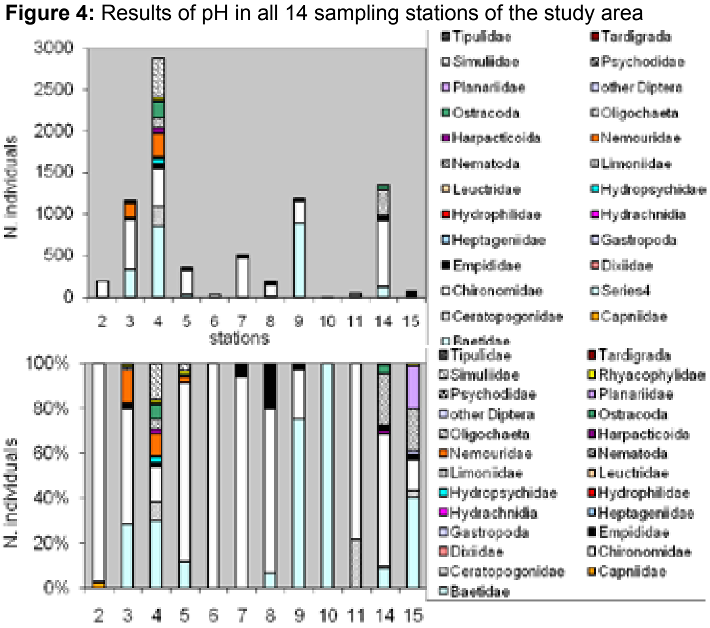

Figure 5: Relative abundance of macro-invertebrates at sampling stations

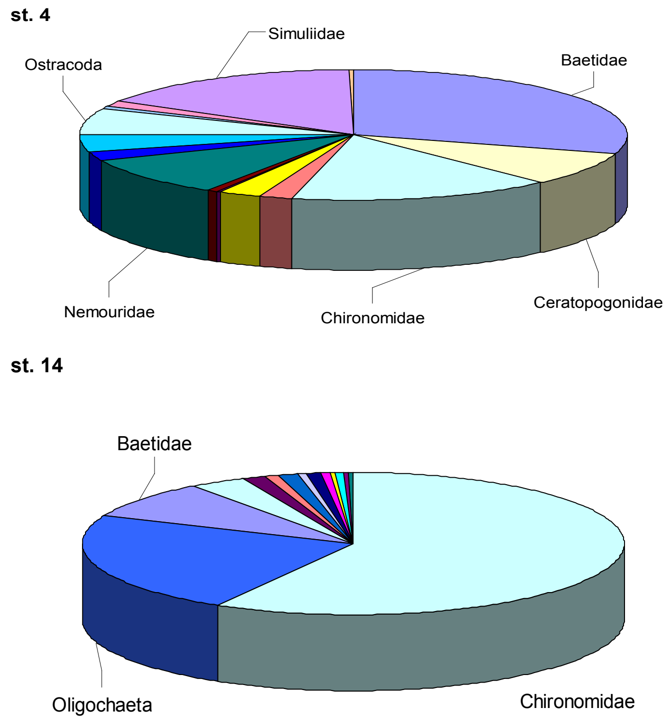

Figure 6: Relative composition of the two richest stations (labels only for taxa accounting >5% of individuals found in the station

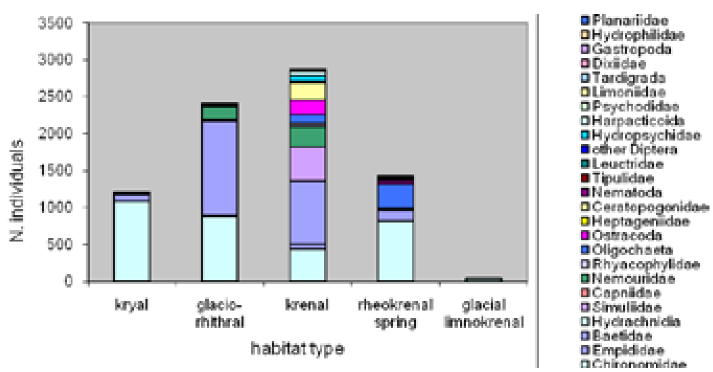

Figure 7: Habitat type characterisation

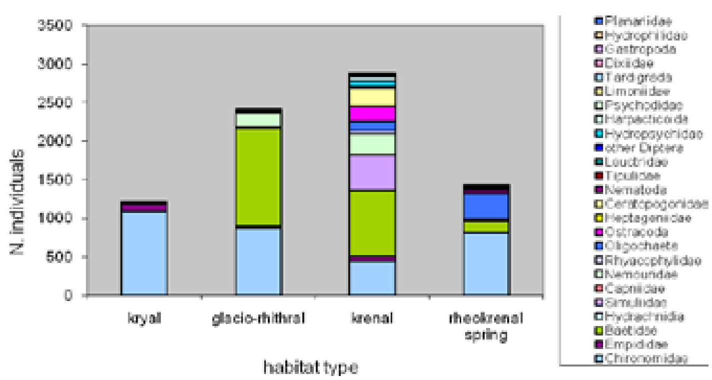

Figure 8: Habitat type characterisation

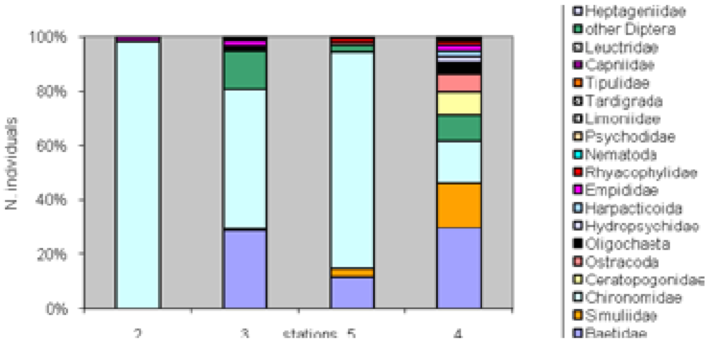

Figure 9: Longitudinal pattern (Dubani stream)

Temporal pattern was analysed in Stations 3 and 15 (Fig. 10), which were sampled twice. Significant differences ($p < 0.05$) were found between the macro-invertebrate community in terms of taxa, individuals and relative composition. In st. 3, a Glacio-rhithral site, highest diversity and abundance were recorded in autumn, whereas the contrary was observed in st. 15. Here only two taxa were collected in October and 8 in June, in st. 3, three taxa in June and 12 in November. In this station, the changes are mainly due to the significant increase ($p < 0.05$) of Baetidae and the appearance of many other insects (mainly Plecoptera) in November. Overall, higher abundance and diversity was recorded in autumn (3,410 individuals and 18 taxa in early summer, 4,581 individuals and 21 taxa in autumn) thus showing significant increase ($p < 0.05$) in Baetidae, Ceratopogonidae, Simuliidae and Psychodidae.

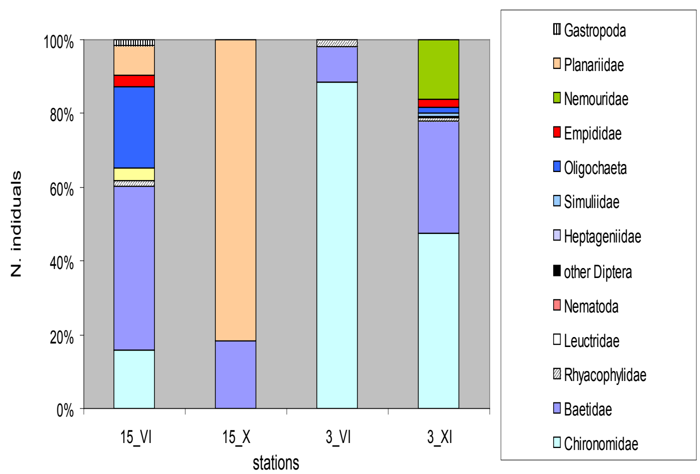

Figure 10: Temporal pattern (st. 15 and st. 3)

Discussion and conclusion

As expected (Lencioni, 2000; Castella *et al.,* 2001; Lencioni and Rossaro, 2005), Kryal habitats were characterised by the lowest faunal abundance and taxa richness, with Diptera: Chironomidae as the dominant taxon. The finding of *Hydrurus foetidus* was also expected. This chrysophyte was found, until now, common in the Alps as well as in Northern Scandinavia (Ward, 1994). It provides support, food source and protection from currents and abrasive sediments and can act as refugia for Diamesinae and Orthocladiinae in the Kryal section of glacial streams. The "glaciality" of the investigated sites was so highlighted. Always as expected (Ward, 1994), springs and springs-fed streams were richer, being characterised by milder environmental features than Kryal habitats in terms of lower channel instability, higher water temperature, lower discharge and lower flow fluctuations.

The key role of Diptera: Chironomidae was confirmed, as highlighted for many other arctic and alpine freshwaters (Lencioni and Rossaro, 2005; Lodsz-Crozet *et al.,* 2007). It is known that their relative abundance decreases with increasing distance from the glacier (Castella *et al.,* 2001). The second group for abundance was represented by Ephemeroptera: Baetidae, occasionally dominant but more typical of Rhithral habitats.

The seasonal trend of taxa such as Diptera: *Simuliidae* and Plecoptera: *Nemouridae* were comparable with the same families found in the Alps (Schutz, 1999; Lencioni, 2000). Mountain headwaters are traditionally characterised by low level of human impact, pristine and harsh landscapes and isolation from major industrial centres (Ward, 1994). All this has made these remote regions valued for the purity of their landscape and for their surface and groundwater quality. Today, this water purity is threatened by atmospheric acid deposition, and by erosion and pollution associated with water diversions for hydro-electric power developments, land use changes, road constructions and tourism development. Headwater regions, so fragile and sensitive to environmental changes, may also be of major importance as conservation areas for natural ecosystems and wildlife.

Few literatures are available for now on alpine streams and the associated fauna and flora located in East Asia, especially in the Karakoram mountain group. Some references were published on river fauna of Afghanistan and Pakistan (Kitamura and Yosii, 1966), and Nepal Himalaya (Roback and Coffmann, 1987). Most part refers to taxonomical descriptions of new species (Singh, 1958; Makarchenko and Kobayashi, 1997; Willassen, 2007), more than ecological surveys. This background makes our work original, describing spatial and seasonal trends of macro-invertebrate fauna in glacial and non-glacial streams, and in springs located in an unknown Valley from this point of view, the Bagrot valley. These data are preliminary (species identification remains the main goal for the future) but would implement the general knowledge on alpine fauna in streams, rivers and springs from Karakoram and give useful tools for management purposes in this protected but human-exploited area of the CKNP.

Acknowledgements

The authors are very much grateful for support provided by the Ev-K2-CNR Committee, in collaboration with three Italian research Institutes: the University Bicocca of Milan, the Natural History Museum of Verona (MCSNV) and the Natural Science Museum of Trento (MTSN). We wish to extend our gratitude to Dr. Alessandra Franceschini (technician MTSN) for samples sorting. Our special thanks go to Mr. Garee Khan, GIS expert for map preparation and for entire WWF - Pakistan Gilgit staff for their cooperation. We would like to thank Mr. Yasir Abbas, ecologist CKNP and Mr. Riaz for extending cooperation and support during the field survey.

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Some Observations on Threatened and Near Threatened avifauna of Pakistan

Muhammad Jamshed Iqbal Chaudhry, Masood Arshad, Ghulam Akbar

WWF - Pakistan, House No. 451, Street No. 2, Sector F-11/1, Islamabad, Pakistan

Corresponding author: Muhammad Jamshed Iqbal Chaudhry (jamshedchaudhry@yahoo.com)

K E Y W O R D S

Threatened
Near Threatened
Avifauna
Midwinter waterfowl census
Classification
Wetlands
Baseline assessments
Pakistan

A B S T R A C T

Sixteen Threatened and Near Threatened species of birds belonging to 12 families and sub-families and 8 orders were recorded at 50 different sites from December 2006 to January 2012 during studies conducted under Pakistan Wetlands Programme for baseline assessments and midwinter waterfowl census in Pakistan. Of the total recorded species, nine are Near Threatened, five Vulnerable, one Endangered and one Critically Endangered. Classification of birds on the basis of their occurrence and visit to the study area shows that of the total recorded species, four are resident; four are winter visitors; passage migrant and irregular year round visitors; three are winter visitors; two are resident; passage migrant and year round visitors; two are passage migrant and irregular year round visitors and one is resident and winter visitor. Similarly of total bird species, nine are omnivorous and seven are carnivorous. A brief account of each species and their sightings is given. Recommendations are made to conserve the population of these threatened bird species.

Introduction

The article gives the account of the Threatened and Near Threatened bird species observed during different studies conducted under Pakistan Wetlands Programme for baseline assessments and midwinter waterfowl count in Pakistan. These species can be considered as indicators of ecosystem health. The IUCN/SSC (1999) classifies threatened species as “all full species categorised at the global level as Critically Endangered, Endangered or Vulnerable”. Critically Endangered (CR), Endangered (EN) and Vulnerable (VU) taxa are considered to be facing an extremely high, very high, and high risk of extinction in the wild, respectively.

Threatened species lists are designed to set priorities for resource allocation for species recovery, to inform reserve system design, to constrain development and exploitation, and to report on the state of the environment (Possingham *et al.,* 2002). Moreover, in many countries, there is a direct connection between threatened species lists and legislation [e.g. the Convention on International Trade in Endangered Species (UNEP-WCMC, 1998) and the US Endangered Species Act], leading to political and social considerations in the listing protocol. Conserving populations of threatened species often derives and simplifies reserve system planning. For example, Ceballos *et al.*, (1998) and Noss (2000) recommend using threatened species lists as one of several factors identifying high-risk ecosystems. Given the social and legal importance of threatened species, protecting such species might take precedence over other criteria. In addition, a pragmatic view is that threatened species may serve best to attract public attention as well as funding (Williams *et al.,* 2000). A common presumption, shared by both global and national schemes for determining priority areas for conservation based on the occurrence of threatened species, will also prove appropriate to protect most of the other species within the target taxon (Bonn *et al.,* 2002).

In most countries, environmental impact processes evaluate the likelihood that development will affect any threatened species. Threatened species lists are one of the few tools at the disposal of regulatory agencies and the public to limit adverse environmental impacts of development. When a proposed development action is judged to increase risks to threatened species, that activity might be modified or postponed. If there is no evidence that listed species are present, or impacts are negligible, development can proceed (Possingham *et al.,* 2002). Listing might increase threats to a species. When the presence of a threatened species in an area is viewed as an impediment to a particular land use, land managers might destroy habitat, deny the presence of the species or deny access to the area for researchers or government officials. This is an unintended consequence of a threatened species list when incentives for landowners to conserve threatened species on their properties are lacking (Possingham *et al.,* 2002).

Although simplifying complex problems makes sense, there is no biological justification for using threatened species alone as an umbrella group for all biodiversity (Possingham *et al.,* 2002). The use of threatened species as surrogates for biodiversity is limited, because most invertebrate animals and nonvascular plants do not appear on any threatened species lists. The use of single threatened species as umbrella species for biodiversity conservation is particularly problematic (Berger, 1997; Andelman and Fagan, 2000; Rubinoff, 2001).

The global population sizes of species vary by many orders of magnitude. Amongst the birds, the rarest presently numbers just a handful of wild individuals (BirdLife, 2000), whilst the most abundant (Elliott, 1989) has many hundreds of millions. Numerous reasons can be suggested for these differences, including the influences of body size, life history, trophic group, phylogeny and history (Damuth, 1981; Peters & Wassenberg, 1983; Pimm, 1991; Brown, 1995; Blackburn *et al.,* 1996; Gaston & Blackburn, 1996; 2000).

One obvious potential reason for the limited progress in explaining variation in the abundance of bird species has been the heavy emphasis placed on their intrinsic characteristics, rather than on differences in extrinsic factors, such as the environments that they occupy and the influence that human activities have had on their populations. Of course, it is generally understood that environments differ in the opportunities that they provide for birds, because of variation in their productivity, temporal and spatial stability, and geographical extent (Blackburn and Gaston, 2002). However, many, arguably perhaps most, macroecological comparative studies have failed to take explicit account of such issues. Likewise, it is evident that the vast majority of those species presently regarded as having a high risk of becoming extinct in the near future are listed as such