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# A Holistic Approach to the Conservation of the Indus River Dolphin (*Platanista minor*) (Owen, 1853)

**Ghulam S Gachal [a]* and F M Slater [b]**

[a]*Department of Zoology, University of Sindh, Jamshoro, Sindh, Pakistan*

[b]*School of Biosciences, Cardiff University, Field Centre, Llysdinam, Newbridge-on-Wye, Powys, LD1 6NB, UK.*

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The Indus River Dolphin is one of the world's most endangered cetaceans with a total population of just a few hundred individuals. Ecological interest in the species was aroused in the 1970's and intermittent but largely uncoordinated monitoring of numbers has continued ever since. Barrages cutting the river into biologically upstream isolated segments combined with the pressures associated with a growing population in a Third World country pollution such as over-fishing and illiteracy, combine to put the species under threat. The establishment of a Dolphin Reserve between the Guddu and Sukkur barrages in Sindh has made a positive contribution to dolphin conservation but a more holistic approach is advocated here. Accepting that little can be done to change the nature of the barrages, approaches reducing the pollution load of the river water, particularly in low flows, by natural filtration are advocated.

***Key words:*** River dolphin, *Platanista minor*, Indus, Barrages, Pollution, Wetland filtration.

## Introduction

It is only within historic times that topographic changes including river capture have separated the catchment of the rivers Ganges and Indus into their present form. It is therefore, perhaps not unexpected in view of their very recent isolation, that the river dolphins of the two catchments are two very closely related species, or indeed sub-species of the same species (Reeves *pers. com.*).

In often very poor and underdeveloped areas along much of the Indus, the presence of legal protection for the dolphin is effectively a paper exercise having, in effect, no means of enforcement. Nevertheless the animal was first protected in Pakistan by Schedule II of the Sindh Wildlife Protection Ordinance 1972 (amended 1993), the Wildlife Acts of Punjab, 1974 and of the Northwest Frontier Province in 1975. The 170 km of river between the Sukkur and Guddu barrages in Sindh was declared a Dolphin Reserve in 1974 to give added protection to the species through monitoring and raising awareness, largely following the work of Georgio Pilleri. Internationally it has been included, since 1976, in the IUCN (International Union for the Conservation of Nature) Red List of Threatened Species and is on Appendix I of the Convention of International Trade in Endangered Species (CITES).

Historically this species was distributed throughout the Indus including its main tributaries, the Jehlum, Chenab, Ravi and Sutlej from the foothills where the rivers enter the plains through to the Indus delta (Anderson, 1879). However, there are now six barrages on the Indus River, namely, in downstream order, Jinnah barrage (commissioned 1946), Chashma Barrage (commissioned 1971), Taunsa Barrage (commissioned 1959), Guddu barrage (commissioned 1962), Sukkur barrage (commissioned 1932) and the Kotri barrage (commissioned 1954). There are another nine barrages on the major Indus tributaries and three high dams used for hydroelectric power in more upland areas (Fig 1). These barrages have been built as low dams designed to divert water into the 58,000 km of canal system which uses Indus water to irrigate the fertile but arid lands of the Indus Plain. These dams have effectively artificially isolated the original metapopulation of the Indus Dolphin into four or five sub-populations, individuals of which might be swept downstream when the barrage gates are open during summer floods but no effective upstream movement is possible.

In spite of the work of Pilleri and a few subsequent authors, studying a rare animal in highly turbid waters with minimal available infrastructure, means that relatively little is known about the in-stream biology of the dolphin. It is the authors' objective to ensure that as many obvious threats to its survival are removed to allow others in the future to fill in gaps in our understanding of its general biology.

## Materials and Methods

*Survival pressures.* The number of dolphins counted in the Dolphin Reserve since 1974 are shown in Table 1. Because

*Author for correspondence

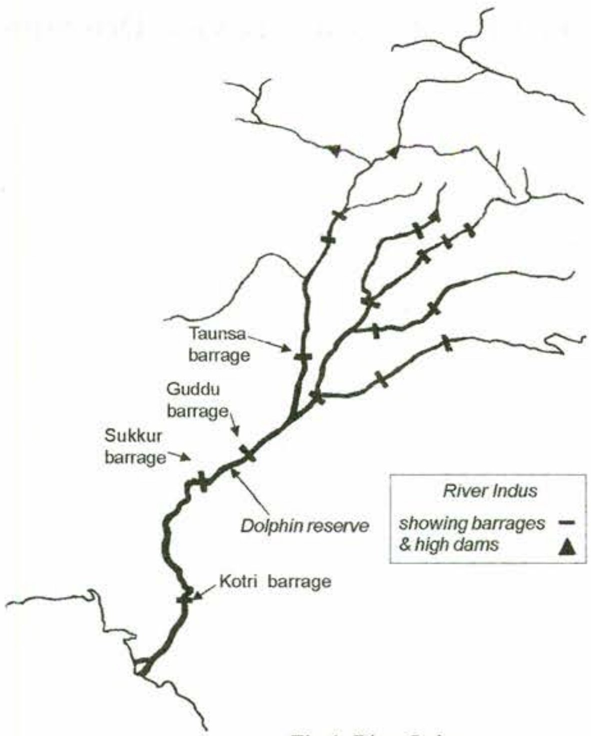


**Fig 1.** River Indus.

**Table 1**
Survey data for Platinista minor between Sukkur and Guddu barrages from 1974

| Month | Year | No. of Dolphins | Source | |
|---|---|---|---|---|
| January | 1974 | 138 | Pilleri and Zbinden, | 1974 |
| December | 1974 | 233 | Kasuya and Nishiwaki, | 1975 |
| February | 1977 | 171 | Pilleri and Bhatti, | 1978 |
| April-May | 1977 | 187 | Pilleri and Bhatti, | 1978 |
| October | 1977 | 168 | Pilleri and Bhatti, | 1978 |
| Feb-March | 1978 | 191 | Pilleri and Bhatti, | 1978 |
| May | 1978 | 241 | Pilleri and Bhatti, | 1978 |
| April | 1979 | 240 | Pilleri and Bhatti, | 1980 |
| June | 1979 | 292 | Pilleri and Bhatti, | 1980 |
| September | 1979 | 291 | Pilleri and Bhatti, | 1980 |
| February | 1980 | 291 | Bhatti and Pilleri, | 1982 |
| April | 1980 | 346 | Bhatti and Pilleri, | 1982 |
| March | 1986 | 429 | Khan and Niazi, | 1986 |
| March | 1987 | 437 | Reeves & Chandhry, | 1998 |
| March | 1989 | 370 | Reeves & Chandhry, | 1998 |
| November | 1992 | 439 | Reeves & Chandhry, | 1998 |
| April-May (upstream count) | 1996 | 339 | Mirza and Khurshid, | 1996 |
| April-May (downstream count) | 1996 | 458 | Mirza and Khurshid, | 1996 |
| May | 1999 | 104 | Gachal & Sindh Wildlife Department | |
| June | 1999 | 220 | Gachal & Sindh Wildlife Department | |
| August | 1999 | 367 | Gachal & Sindh Wildlife Department | |

*(in part after Mirgza & Khurshid, 1996)*

of the distance between the barrages it is not logistically possible to replicate the counts due to the constraints of time, cost and labour, therefore the numbers given are for single counts over the time period indicated.

Although the methodology of counting is relatively crude consisting of two observers counting surfacing animals from a boat travelling steadily downstream with all the inaccuracies which that is likely to entail (missed animals, multiple counts, weather, effects of distance, state of river, time of year etc.) it has been fairly consistently used through-out the years as there has been some continuity of field staff throughout this time particularly in the Sindh Wildlife Dept. They are the only data available and therefore, although they are quantitatively weak, they are qualitatively somewhat more robust, but further study is required.

It would seem that, since the establishment of the Dolphin Reserve in 1974, numbers within the reserve have increased and may by now have reached a plateau.

Outside the Dolphin Reserve, Reeves (1998) reported about 50 dolphins between Chasma and Taunsa and a further 170 between Taunsa and Guddu. Below Sukkur one of the authors (GSG) reported 30 animals and none below Kotri barrage.

**Table 2**
Pollution levels in fatty tissue of a dolphin found dead at Sukkur (original data)

| Compound Types (wet weight) | Amount (μg/kg) |
|---|---|
| DDE | 452 |
| Endosulphan A | >499 |
| Endosulphan B | >249 |
| Aldrin | <87.3 |
| HCH-Alpha | 198 |
| HCH-Beta | 538 |
| HCH-Gamma | 224 |
| Dieldrin | 890 |
| DDT (OP) | 918 |
| DDE (PP) | >49,900 |
| DDT (PP) (Clofenotane) | 5,430 |
| TDE (PP) | 14,500 |
| TDE (OP) | 1,560 |
| PCB No. 101 | 494 |
| PCB No. 118 | 928 |
| PCB No. 138 | 826 |
| PCB No. 153 | 593 |
| PCB No. 180 | 367 |
| PCB No. 105 | 1,020 |

Although there are many pressures potentially limiting the dolphin population, pollution is a non-specific problem for which general solutions might exist. As the dolphin is at the top of the food chain, the level of pesticide bioaccumulation gives a perspective on the problem in the river as a whole. The level of pollution in tissues of a dolphin found dead at Sukkur are shown in Table 2. These represent a non-exhaustive range of substances which the authors believed might be found within the Indus environment. Because dolphins are rarely found dead the data here is of necessity from material from a single individual supplied by Sindh Wildlife Dept. Pesticide contents of fatty tissues from a dolphin found dead at Sukkur. Cause of death unknown.

## Results and Discussion

It appears that the isolated populations decrease in size in the upstream order of Sukkur to Guddu barrage, Guddu to Taunsa barrage and Taunsa to Chashma barrage with few below Sukkur itself. Possible reasons for this gradient in numbers might include:

Natural carrying capacity of the river.
*Predation pressure:* possibly by fishermen as by-catch.
*Drift*: assumed one way (downstream) movement through barrages, lateral drift of animals into irrigation canals.
*Food resources*: may naturally vary along the river.
*Pollution*: from agricultural, industrial chemicals and human waste which might have physiological effects on dolphins or their prey or in extreme cases might prove fatal although this might be expected to have an increasing downstream effect.

However the dams and barrages on the river may adversely affect all aquatic wildlife including dolphin populations (Reeves and Leatherwood 1994b) by: Causing genetic isolation of sub-populations. Reducing prey by blocking migratory routes. Possible lower diversity and lower biomass upstream of dams. Effects on prey caused by changes in patterns of flow and sedimentation. Barrages change upstream impoundment from a lotic to a lentic environment. Undefined effects of regulated flows on life activities e.g. are particular flow regimes required for breeding or rearing young? Inability to escape natural catastrophes. Reduced ability of river to rapidly flush through pollution episodes.

*Additionally*: The presence of irrigation canals adds thousands of kilometres to the availability of water channels, some albeit seasonal, which adds habitat to natural fish and invertebrate distribution and adds a resource exploitable by local fishermen away from, and possibly reducing, fishing pressure on the main river.

Dolphins occasionally and inadvertently get swept into such canals and unless rescued are lost to the breeding population and often die or are occasionally killed in low flow conditions. In November 1999, the Sindh Wildlife Service rescued a dolphin from a canal near Sukkur and transported it back to the main river. Although regarded as a rare occurrence, we suspect that dolphins in canals are more common than generally accepted as in a second separate canal only 100m from the dolphin rescue site a second larger specimen was observed and the Sindh Wildlife Department expressed the intention of attempting to move this animal back to the Indus. Subsequently several other rescues have been attempted (Gachal and Slater 2001). At the Taunsa barrage commercial fish landings increased from 75,000 kg in 1980 to 170,000 kg in 1989 and although fishing methods have changed little in recent years (Ahmad 1996,1998) the reasons for this increase might be due to increased fishing effort, increased fish production or better reportage (Reeves *et al* 1991). If it is due to increased fishing activity, the increased use of nets increases the chance of dolphin entanglement. Consequently fish abundance and dolphin safety may come into conflict. Conversely, pollution on an Indus tributary, the River Ravi - into which the city of Lahore discharges its untreated waste water - has caused a drop in fish production of 5,000 tonnes per year, a consequence of pollution which will be reflected throughout the food chain (Chaudhry *et al* 1999).

Conversely reptiles and amphibians such as the several species of turtle, frog and toad found in and around the river probably benefit from the increased habitat created by the irrigation canals and the land they serve.

Because of its conservation importance, the Indus River dolphin focuses international attention on its habitat and the problems it faces as exemplified by the South Asia River Dolphin Workshop, Lahore, November 1999 sponsored by WWF – Pakistan. Without the dolphin, the ecology of the River Indus would receive even less attention but, because an endangered species is present, the biodiversity of the river and the effects of fragmentation by barriers receive some consideration.

*The contribution of dolphin studies to the holistic understanding of biodiversity and barrages.* Mirza and Khurshid (1996), as part of their Sindh dolphin survey, recorded the mammals, birds, fish, reptiles, amphibians and aquatic invertebrates of the survey area from the mouth of the Indus to the Guddu barrage. This provides a non-exhaustive list of the wildlife of the lower Indus some of which such as fish are obligate river dependent species whilst others such as birds have a looser relationship with the river. Chaudhry *et al* (1999) have produced similar lists for water birds and fish as part of their dolphin survey of the Punjab.

Although some interest in the conservation status of the dolphin exists, which has undoubtedly added to understanding of the wider biodiversity, due to the fact that the dolphin has no commercial value - indeed there is an Islamic injunction against eating dolphin flesh - their survival was not a consideration when the barrages were constructed (Reeves *et al* 1991). Swimways for dolphins to pass barrages have been suggested and designed (Reeves *et al* 1993) but it is not known if they would use them even if constructed and here there is a clear need for further study. In addition to dolphins the barrages have affected other species: The commercially valuable anadromous shad *(Hilsa ilisha)* necessitated the construction of fish ladders within some barrages in spite of these ladders, which the species rarely uses and are perversely used in places as convenient fishing sites the species has declined due to the physical change of the river and its breeding sites by the barrage impoundments, having, since 1932 lost about 900 km of accessible river due to barrages (Ahmad, 1999: Hussain and Suji, 1962).

The dolphin is not the only top mammalian predator on the river which could be affected by the general uncontrolled use of agricultural and industrial chemicals. The Smooth Otter *(Lutra perspicillata)* occurs sparsely throughout the area. Faecal markings (spraints) have been found by one author (GSG) in the Sukkur to Guddu area and they are more frequent around Taunsa. Foster-Turley *et al* (1990) regard it as restricted to "water reservoirs at dams and barrages". Other factors also threaten this, the most widely distributed otter in Pakistan, including the fact that, on Indus tributaries such as the Jhelum, Chenab, Ravi and Sutlaj, major parts of these rivers remain effectively dry for much of the year leaving only polluted water around the dams and little continuity of suitable otter habitat. Increasing human population in Pakistan (predicted to double within 25 years) together with persecution by fishermen and hunters also reduce numbers (Meadows and Meadows, 1999).

Although the river in inter-barrage areas may appear, incorrectly, largely structurally unchanged, the flow regime has been both regulated by high dams in upper tributaries and by flow reduction, diverting of up to three quarters of the river's flow into irrigation canals (IUCN, 1989). Future changes in structure, however, could well happen due to the elimination of the "freshet effect," a plug of fresh water, which, in many wild rivers, renews the flood plain and contributes to meandering (Reeves & Leatherwood, (1994b).

However, water regulation alters, but does not prevent, river floods and for birds, the Indus valley is a major migratory flyway. It is probable, therefore, that the barrages themselves have little direct effect on bird biodiversity. Although most of the riverine forests have gone lateral seepage from canals does result in extensive areas of waterlogged land of little agricultural use but well used by birds such as Little Grebe, Pond Heron, Little Egret, Coot, Black-winged Stilt, Red-wattled Lapwing and reptiles such as soft shelled turtles. This is certainly a way in which biodiversity is increased by the indirect effects of irrigation canals.

Conversely, the fact that much aquatic pollution tends to be pulsed rather than continuous, means that samples taken between such pulses will give an over optimistic view of true pollution status. Although monthly water samples (unpublished data GSG) showed relatively low pesticide levels, the one dolphin corpse found on the river in 1999 contained levels of DDT (dichlor-diphenyl-trichloroethane) and its derivaties at exceptionally high levels (Table 2). This value was about 4-10 times higher than found by Kannan *et al* (1993) from Ganges dolphins. BOD (biochemical oxygen demand) levels, reflecting organic pollution was highest in low flow conditions but within the range 2.74-4.61 mg/l in the period April to September and both authors noted large quantities of faecal material floating on the river surface upstream of the Sukkur barrage in December 1999, material inevitably elevating both BOD and bacterial coliform values.

The natural biodiversity of the Indus basin has been altered by the construction of barrages. As a subject for study it has received scant attention and if it were not for the presence of the River Dolphin it would possibly have been totally neglected. Concerns relating to the dolphin in terms of human pressures, pollution and isolation also apply to other biota and there would seem to be value in addressing the generalities of biodiversity by reference to a specific high profile species.

*A Holistic solution.* A holistic approach to river enhancement will attempt to treat the main underlying solvable problem affecting all the people and wildlife along the Indus, believing that, what will provide general benefit, will also be of specific benefit to the dolphin.

The key problem faced by the River Indus and its tributaries is that of potentially damaging levels of pollution, some continuous as in the case of sewage, and other sources are pulsed, e.g. pesticides which may be missed in spot samples of water but are evident in the bioaccumulation of such substance in the dolphin at the top of the food chain.

Conventional approaches to dolphin conservation such as legislation, by-catch reduction, relocation from canals, pos-sible barrage swimways may be helpful, but it is suggested that a more wide ranging approach might be of more value. If the pollution load of the river can be reduced then it would benefit both humans and wildlife dependent upon the river.

A solution to the pollution problem needs to be relatively low cost and it is the authors' opinion that such a solution might exist. Wherever there is human habitation and/or industry along the river there is a generally untreated foul water discharge into the waterway. In many parts of the world, particularly in Europe and North America polluted waters are treated by passing them through natural or constructed wetlands (Perttu, 1993). In Sweden it was estimated that a wetland area of 2 $km^2$ would reduce the amount of nitrogen leaking into adjacent waters by about 2000 tonnes per year, a service valued in 1990 at US $200,000 per hectare (Maltby 1991). Maltby *(op. cit.)* also notes that the use in the USA of Florida's cypress swamps to treat domestic waste water removed 98% of all nitrogen and 97% of all phosphorus before it entered the ground water.

In a number of areas along the Indus, particularly in upper Sindh, sewage or industrial discharges could be diverted away from the river into underutilised areas peripheral to the river.

Depending on the volume and pollution load of the effluent, the water could be allowed to rejoin the main river at varying distances from the input point having passed through this peripheral treatment area. The treatment area should be initially planted with wetland plants, and these allowed to develop and where possible to be harvested successionally as fuel. The giant reed, *Arundo donax*, is a plant of conser-vation concern in Pakistan (Meadows *et al*, 1999) but is a species which is used elsewhere for treating sewage with an annual biomass production of up to 50 tonnes per hectare per year (Vecchiet and Jodice, 2000). Such a filter system would reduce the BOD, COD as well as bacterial and chemical pollutants to an environmentally acceptable level. The area would also have value as a fuel resource and as a wetland for wildlife. This holistic approach of cleaning the environment to the benefit of all river users could have a positive effect upon the dolphin population by controlling pollution in the whole food chain. The technique would not solve all the conservation problems of the dolphin, indeed no single measure would do this, but because it is not just a conser-vation measure but an environmental improvement for people as well, it could attract more substantial funding than is often the case for purely conservation work. It may well be that if these measures were implemented, dolphin conservation would be seen to be for the good of the whole community along the river. This might then give new impe-tus to further research into the general ecology and biology of this species stimulating interest in improved census methods, the possibility of workable swimways through barrages, a well organised and adequately funded rescue service for dolphins in canals and ultimately an eco-tourism industry where live dolphins could bring material benefit to local people.

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