might be responsible for weakening of the monsoon over Rajasthan, causing massive changes in the biota[9,18,25].

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Pallas's or Great Black-headed gull's (*Larus ichthyaetus*) feeding preference for toxic Lunartail puffer (*Lagocephalus lunaris*)

More than any other group of seabirds, gulls exploit a wide variety of food types and have evolved highly diversified foraging methods and habitats[1]. This has been demonstrated among gulls, both in the family as a whole and within each species, and at all times of the year. As a long-distance migrant, gulls, especially in the non-breeding season, spend more time on large water bodies along the coasts or in the open ocean; as a result they flourish on fish and marine invertebrates as their diet. Gulls in general are thus opportunistic and omnivorous.

Pallas's gull *Larus ichthyaetus* Pallas, 1773, chiefly feeds on fish and particularly on dead fish[1]. Other feeds include crustaceans, insects and small mammals, less often birds and their eggs, reptiles and seeds[2]. The Pallas's gull has an extremely large distributional range. Breeding range of this species extends from the Danube Delta in Romania eastwards across large areas of Central Asia to western China, where the lakes of the Qinghai–Tibet plateau hold most of the Chinese breeding population[3]. The migratory route of this gull is from Central Asia to coastal Bengal, encompassing diverse biome extending from the inland freshwater ponds, lakes to marine saline water[4]. The Bay of Bengal, with extensive areas of coastal mudflats, is an important wintering site for Pallas's gull and other species of gulls, from early November to mid-March[5]. A Pallas's gull captured and marked in China has been recovered in Assam, India, indicating that it may possibly be using many places in India as stopover sites[4–6]. Gulls feeding on a toxic fish species have not been documented, but there are reports on how the predators learn to avoid such toxic prey[7–11]. Nevertheless, an emerging alternative view is that predators should not entirely neglect toxic prey as long as this could increase their opportunity to gain energy[12–15]. A novel toxin-based optimal diet model was developed on the basis of data on prey abundance, diet choice, local survival and number of red knots[16]. Here we report instances of Pallas's gull feeding on toxic Lunartail puffer, *Lagocephalus lunaris*.

Pallas's gulls were observed from December 2013 (post-monsoon) to May 2014 (pre-monsoon) around the coastal

areas of Purba Midnapur, West Bengal to Talsari, Odisha located between 21°33′22″N and 87°25′21″E to 21°37′15″N and 87°30′11″E. The gull colony primarily gathered at the southern part of the study area, where new land masses formed at the mouth of the River Subarnarekha (Figure 1 *a*). Pallas's gull life phases and *L. lunaris* were identified after Grimmett *et al.*[17] and Veeruraj *et al.*[18] respectively. Both non-breeding gulls (Figure 1 *b*) and third summer individuals were observed during post-monsoon (December–February) and pre-monsoon (March–May) season respectively. During April 2014, we noticed one group of third summer gulls predating on Lunartail puffer (Figure 1 *c* and *d*), even though a large number of edible mullet fishes (Mugilidae) were also available in the vicinity as local fishermen caught them using fishing nets. After capturing the live lunartails, gulls engulfed them wholly either in flight or after settling down on the ground at a distant place, approximately 1 km away from the actual fishing site. Seven observations were made on the gulls feeding on both the fresh as well as dead, decaying lunartail puffers along with edible fishes available at the site (Table 1). Gulls had chosen fresh lunartails over mullets on all occasions. At the same time the gulls were also seen avoiding dead, decaying puffers and preferred roughly 33% of fresh mullets in their diet.

Evidence of puffer fish intoxication has been reported in different parts of the world[19–21]. *L. lunaris* contains a potent neurotoxin known as tetrodotoxin (TTX), which has the ability to selectively block the ion transport of the sodium channel[22]. TTX is a colourless crystalline compound ($C_{12}H_{17}N_3O_{10}$), which is slightly soluble in water and acidic solution. Toxicological profiles of *L. lunaris* were observed along with three other puffer fishes available from a previous study[23]. The toxicity of *L. lunaris* was measured to be high in the liver and ovary with respect to the tissues, especially in the monsoon and post-monsoon seasons during the reproductive cycle. *L. lunaris* was also recorded as the third most toxic puffer after *Chelonodon patoca* and *Takifugu oblongus* in the study area.

Selection of abundant versus rare species can greatly alter the magnitude of a predator's impact on the ecological community[24]. Here, the feeding behaviour of Pallas's gull involving fresh toxic diet over local edible fishes, and selection of edible fishes over decaying puffers raises questions on the availability of food essential for later physical development, as well as, typical pattern of feeding choices. Nevertheless, the possible dietary choices of gulls in terms of functional response to the prey (prey value to predator) remain unexplained. Though we recorded incidences of gulls feeding on toxic fish species only recently, how long the Pallas's gulls feasted on them and what could have been the effect remain unclear. Studies on Pallas's gulls migrating to the east coast of India from neighbouring China have reported that many of them died en-route to their breeding sites in Xinjiang, China, including a few that wintered in Assam in March 1984. Our observations of Pallas's gulls feeding on the toxic Lunartail puffers during April 2014 and the death of a few gulls en-route to their breeding grounds[5] around the same period support, to some extent, the possible link between the effect of toxic diet to sustain long-distance migration and mortality of the gulls. Though Guo-Gang *et al.*[5] could not establish any factors responsible for the decline in breeding numbers of these gulls other than degradation of wetlands in their stopover sites, our finding of gulls feeding on toxic puffer fishes may prove to some extent the possible adverse effect of toxic diet in their metabolism during return migration. However, more studies are needed to firmly establish this assumption, especially with the migrating Pallas's gulls from their breeding sites in China. Furthermore, an outbreak of highly

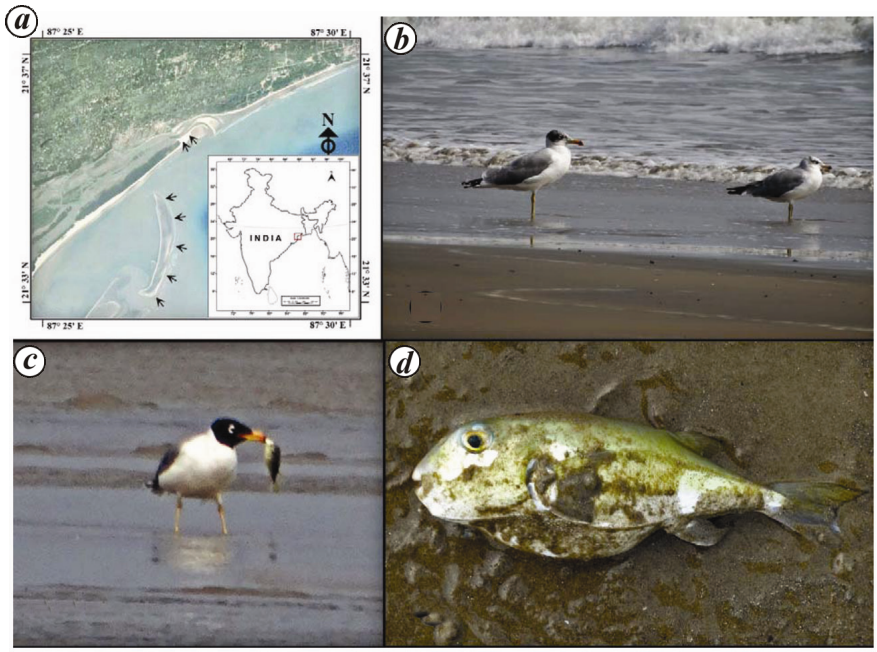

Figure 1. ***a***, Study area. Arrows indicate resting place of Pallas's gulls. (Inset) Location of the study area on the map of India. ***b***, Pallas's gull, non-breeding. ***c***, Pallas's gull predating on lunartail puffer, *Legocephalus lunaris.* ***d***, *L. lunaris* caught by local fisherman.

Table 1. Feeding preference of Pallas's gull

Observation no.	Fresh lunar-tail puffer with fresh mullets	Dead, decaying lunar-tail puffer with fresh mullets	Food preference of Pallas's gull
1	+	–	Lunar-tail puffer
2	+	–	Lunar-tail puffer
3	+	–	Lunar-tail puffer
4	+	–	Lunar-tail puffer
5	–	+	No
6	–	+	Mullet
7	–	+	No

+, Presence; –, Absence; No, No preference.

pathogenic avian influenza (HPAI H5N1) in Qinghai Lake, China in 2005 resulted in the death of over 6000 water-birds, including over 1500 gulls of two species (Brown-headed Gull *Larus brunnicephalus* and *L. ichthyaetus*) in the breeding area[25]. These deaths could add to the already declining gull population, especially in China.

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