Caching food, pilferage and deceiving by Indian common crows (*Corvus splendens*)

Corvid birds, including many species of crows, are known to exhibit behaviours indicative of their superior brain capacity in the avine world[1–5], with high cognitive abilities comparable to the non-human primates[6–9]. In recent years, crows have been the focus of studies by behavioural biologists and animal psychologists who have studied their capacity of context-dependent tool using[4], tool making and metatool use[2,4,9–11], observational learning and cultural transmission[12,13], to discriminate food by nutritional value[14] and conspecific competitors based on their knowledge state[15–17], human face recognition capacity and prolonged episodic memory[17], and size and structure of their brain associated with such behaviours[5,18]. Except the recent works done in Japan on jungle crow (*Corvus macrorhynchos*)[12,16], all these studies are being done on crow species found in Europe, North America and Australia–New Zealand. Crows, especially the Indian common crows or the house crows (*Corvus splendens*), one of the commonest birds encountered by people in most parts of India, are commonly known as intelligent creatures, being characterized so in the general literature and folktales[19,20]. But, studies of their alleged intelligent behaviour are hardly reported in the scientific literature. Ali and Ripley[1] describe the crow as an intelligent bird, even to have a 'distinct sense of humour', though no specific observation is referred to. Its high abundance in urbanized localities ranging from hill stations to coastal plains[1,21,22] suggests its remarkable adaptation to the landscape, habitats and fast dynamics of the urban environment dominated by human activities and artefacts. It is quite habituated to forage on food items thrown off by humans and its diet reflects almost true omnivory[1].

Caching or food hoarding – a behaviour when an animal hides food in order to avoid it from being eaten by others and to eat it later[23], has been documented and studied in many corvids including crow species like American crows (*C. brachyrhynchos*)[14] and ravens (*C. corax*)[13,15]. de Kort and Clayton[24] have categorized different species of corvids based on their caching propensity inferred mostly from the natural history literature. Common crows score as moderate storers of food in their list, although the nature of data used to define it is not specified. Stealing, snatching or scrounging food by crows from the possession of other individuals of the same or other species is well known[25,26]. Pilfering of food items cached in hides by other conspecifics has been documented in crows and other corvids[6,14], though it appears to be much lesser studied in the natural environment. To the best of our knowledge, any field study specific on caching of food or non-food items or attempts to pilfer them by the Indian common crow is yet to be reported in the scientific literature. Here we present some preliminary but systematic observations on the caching and pilferage behaviours of this species in the natural environment and attempt to interpret these observations from behavioural ecology perspectives.

Two permanent feeding stations were maintained from April 2010 to January 2011, one at a central location and another in a peri-urban locality of Kolkata, India, where members of our research team (A.A. and T.B.) fed handmade bread pieces (11–12 sq. cm) for 15 min a day (between 7.30 a.m. and 9 a.m.) to a group of common crows (group size 2–18) attending each feeding station. All behaviours by these crows were noted during a 1 h session starting from the initiation of feeding. Any event of caching or pilferage initiated during this 1 h session was observed at a stretch. No such event, however continued beyond the session limit of 1 h. These observations at the feeding stations (totalling 447 h for 447 feeding sessions at two feeding stations) were supplemented with *ad libitum* observations (estimated to be around 109 h for observing 328 feeding-related events, excluding the ones during feeding sessions at the feeding stations) in the localities around the feeding stations and elsewhere in Kolkata, when events of crows attempting to cache food or non-food items or attempting to pilfer cached items were followed by us. The focal animals were followed during all these events for the entire stretch of an event until it was completed. Otherwise, we could not identify the crows individually, except in a few cases where individuals had distinct morphological deformities or peculiarities (e.g. bent beak, toeless left leg, tumour on the abdomen, etc).

Altogether, 48 events of caching food by common crows were documented at two feeding stations (26 events) and during *ad libitum* observations (22 events; Table 1). Crows were found to cache their food in hiding places like gaps between terracotta tiles on tiled roofs, grooves of bamboo poles, crevices of walls and buildings, leaf axis of coconut palms, or under corrugated sheets used as roof. Some of the grooves/holes or crevices seem to be the preferred site for caching as the crows were observed to use them quite regularly. A typical caching behaviour involves an individual carrying the food in its beak flies away from the spot it got the food and perches at a nearby vantage point, waits there for a few seconds to a minute or so looking around cautiously, flies off to perch at one or two more vantage points before reaching the caching location or flies straight to the caching location after collecting the food. At the caching site, it again looks around cautiously and then starts pushing the food piece into the chosen groove/hole or crevice with its beak. Then, the crow often (in 17, i.e. 35.4% out of 48 food caching events) plugs the hole or crevice by placing leaves, pebbles, twigs, etc. After completing the event the hoarder flies away from the site. During the entire event the crows hardly makes any call, which is in contrast to what crows usually do during feeding in a group at a feeding spot. We could monitor the fate of cached food in 11 events and found them to be retrieved within 15–187 min in 9 of these events. Whether or not the same crow that had cached the food retrieved it from a cache, was difficult to conclude in the absence of individual identity markings, except in three events where the crow involved in caching could be identified due to physical deformity or peculiarity. In two (22.2%) events, cached food was not retrieved for at least three consecutive days. No clue could be obtained to conclude whether the hoarder had forgotten or lost interest in the cached food. As it

Table 1. Frequency of caching, pilferage and non-food caching events

Type of observation	Total volume of observations	Total number of caching events	Number of cases cached of foods pilfered	Number of cases of non-food items cached
Feeding stations	447 feeding events totalling 447 h	26	12 (46.15%)	2 (33.3%)
Ad libitum	Approximately 109 h for 328 feeding events observed outside the feeding stations	22	4 (18.2%)	4 (66.7%)
	Total	48	16 (33.3%)	6

was possible to identify the particular individuals in case of five food caching events, it could be documented that the same crows used more than one location to cache food, but preferred a few specific ones. Although we cannot quantify it at present, we noted that crows usually tend to cache food when it is available to them in excess. All the caching observed was done by morphologically adult birds. Only once a juvenile was seen attempting to catch food and was unsuccessful.

Of the 48 cases of food caching observed by us, in 16 cases (33.3%) pilferage of these cached food by other crows took place immediately (within 2–7 min after the cacher flew away on completing caching) (Table 1). In these cases, typically the pilferer crow had not joined those engaged in collecting food at the feeding spot. When after collecting food an individual started caching it in a nearby hide, the pilferer observes the caching activity with full attention. As soon as the cacher flies away completing the caching, the pilferer came down straight to the spot where the food had been cached and started retrieving it after unplugging (in the case of plugged hole/crevice) or straightway by sneaking its beak into the hole/crevice. The pilfered food item is mostly eaten at the spot itself. We also observed crows searching for food in a hide that was a preferred caching site in our study, even though no event of caching had taken place immediately before. It also seems that there might be some crows that pilfer food cached by others. Two of the crows identified individually at the feeding stations seem to have had such a habit. However, we could not confirm whether crows adopt the strategy of 'pilfering food cached by others instead of fighting for food in a group' as an exclusive one or follow it opportunistically, since all crows could not be identified individually in our study and also our observations on the two suspects mentioned above were too little to conclude anything substantial.

We observed six distinct events between August and December 2010, in which a crow was caching non-food items like small pebbles, leafs, a small piece of cloth in a potential or regular caching site (hole/groove or crevice). The behaviour was exactly the same as in case of food caching. In three (50%) of these six events, other crows were found watching them from a vantage point, exactly the way a pilferer does for pilfering food cached by others. Once the storer crow had flown away after finishing the caching, one of them came down immediately and started retrieving the cached item. Once the cached non-food item was retrieved, the deceived pilferer took a few seconds trying to be sure about the non-food nature of the retrieved item by pecking and/or tearing it, and then flew away leaving behind the item. We had later checked the holes/crevices in all six cases to be sure that no food item had indeed been cached there. Both caching of food items and pilferage attempts on them, especially the latter one, indicate the cognitive capacity of common crows to strategise for the future. Caching or hoarding of food items by individuals has been documented in many birds and animals and has been explained by means of evolutionary models[23]. Both caching of excess food for future consumption and pilfering other's cached food can be easily explained as adaptive strategies. But, caching of non-food items in a similar fashion is complicated to explain. Observations (all six) of caching of non-food items during non-nesting season (August–December) rule out the possibility of caching of items like twigs or leaves as potential nesting materials. We have seen crows collecting and gathering such materials at secluded but open spots on roofs and cornices of buildings and in gardens during the pre-nesting period since the first half of January. We have not seen them cache potential nest materials in secret hides which are potential sites or those used for caching foods. Also, materials like pebbles or pieces of cloth can hardly be considered as potential nesting materials of common crows. Ravens and other crows are reported to cache shiny objects with no apparent motive[27], but there is no such report in common crows yet and most importantly, none of the cached objects documented in the present study was shiny.

Is it then nothing but an instinct-driven fixed action pattern released by a false cue that resembles a food item? The exploratory and manipulative nature of the behaviours observed during food caching and pilfering of cached food suggests that these are unlikely to be blindly programmed ones. Or, is it some sort of practice for perfecting the programme of food caching behaviour? Grodzinski and Clayton[6] suggest that corvids may have a motivationally controlled compulsion to cache, which develops ultimately into a more cognition-driven plastic caching behaviour in adults. They report observations on caching of non-food items in the case of unavailability of food by young birds in some corvids including ravens. We did not observe any juvenile bird catching non-food items. Rather, two individually identifiable birds involved in caching non-food items were found to pair (with different partners) for breeding in January 2011. Also, food scarcity was not apparent in and around our feeding stations as well as at other spots where we observed caching events of non-food items. Or, this could be a motivated, highly cognitive behaviour by birds that are trying to deceive their conspecific members habituated to pilfer their hard-earned cached food. The cacher, if can frustrate pilferer by such deceit, would actually gain as the pilferer is expected to be discouraged in attempting pilferage after

experiencing such deceits. Caching of excess food is adaptive when the chance of pilferage is reduced by counter-pilferage strategies. Marzluff and Angell[27] claim that caching corvids including ravens are often 'deceitful' and 'fake' and 'capable of deception albeit in a non-vocal manner', while trying to protect their cached food from pilferage. Reports of various counter-pilferage strategies adopted by ravens and other corvids that claim the presence of a high level of cognitive power[6,8,13,27] including 'theory of mind'[16] and capacity to design 'tactical deception'[13] in the corvid birds provoke us to consider this hypothesis.

Whether a cognition-driven motivational action or a programmed one to practice for perfecting the food-caching behaviour, pilfering attempts of cached items – if non-food, would result in frustrating the pilferers and contribute to the fitness value of caching hard-earned food for later consumption in a frequency-dependent selection scenario. Maybe, this kind of behaviour by Indian common crows provoked Ali and Ripley[1] to consider these crows to have a 'sense of humour'. More experimental and/or field observations on individually marked crows are required to test all these hypotheses.

1. Ali, S. and Ripley, S. D., *Handbook of the Birds of India and Pakistan, Vol. 5*, Oxford University Press, 2001, pp. 244–246.
2. Bird, C. D. and Emery, N. J., *Curr. Biol.*, 2009, **19**, 1410–1414.
3. Taylor, A. H., Hunt, G. R., Holzhaider, J. C. and Gray, R. D., *Curr. Biol.*, 2007, **17**, 1504–1507.
4. Taylor, A. H., Hunt, G. R. and Gray, R. D., *Biol. Lett.*, published online, 7 September 2011.
5. Mehlhorn, J., Hunt, G. R., Gray, R. D., Rehkämper, G. and Güntürkün, O., *Brain Behav. Evol.*, 2010, **75**, 63–70.
6. Grodzinski, U. and Clayton, N. S., *Philos. Trans. R. Soc. London, Ser. B*, 2010, **365**, 977–987.
7. Emery, N. J. and Clayton, N. S., *Science*, 2004, **306**, 1903–1907.
8. Valerie, D., Wascher, C. A. F., Braun, A., Miller, R. and Bugnyar, T., *Biol. Lett.*, published online, 14 September 2011.
9. Hunt, G. and Gray, R. D., *Proc. R. Soc. London, Ser. B* (*Suppl.*), 2004, **271**, S88–S90.
10. Hunt, G., *Nature*, 1996, **379**, 249–251.
11. Hunt, G., *Emu*, 2002, **100**, 109–114.
12. Izawa, Ei-Ichi and Watanabe, S., In *Avian Cognition and Social Interaction* (ed. Pepperberg, I. M.), John Benjamins, Amsterdam, 2011, pp. 281–303.
13. Bugnyar, T. and Kotrschal, *Anim. Behav.*, 2002, **64**, 185–195.
14. Cristol, D. A., *Anim. Behav.*, 2001, **62**, 331–336.
15. Bugnyar, T. and Heinrich, B., *Proc. R. Soc. London, Ser. B.*, 2005, **272**, 1641–1646.
16. Izawa, Ei-Ichi and Watanabe, S., *Behav. Proc.*, 2008, **78**, 44–52.
17. Marzluff, J. M., Walls, J., Cornell, H. N., Withey, J. C. and Craig, D. P., *Anim. Behav.*, 2010, **79**, 699–707.
18. Seed, A., Emery, N. and Clayton, N., *Ethology*, 2007, **115**, 401–420.
19. Twain, M., www.twainquotes.com
20. www.Panchatantra.org
21. Puttoo, M. and Archer, T., Report, Food and Agriculture Research Council, Reduit, Mauritius, AMAS, pp. 299–309.
22. Sangha, H. S. and Naoroji, R., *Forktail*, 2003, **19**, 141–142.
23. Vander Wall, S. B., *Food Hoarding in Animals*, University of Chicago Press, Chicago, 1990.
24. de Kort, S. R. and Clayton, N. S., *Proc. R. Soc. London, Ser. B*, 2006, **273**, 417–423.
25. Ha Robinette, R. and Ha, J. C., *Anim. Behav.*, 2001, **62**, 447–452.
26. Ha Robinette, R. and Ha, J. C., *Anim. Behav.*, 2003, **66**, 309–316.
27. Marzluff, J. M. and Angell, T., *In the Companies of Crows and Ravens*, Yale University Press, New Haven, 2005, p. 216 and p. 232.

ACKNOWLEDGEMENTS. We thank Saikat Chakraborty for useful comments on the manuscript. A.A. and T.B. participated in the study as a part of their dissertation project for the M Sc course at the West Bengal State University, Barasat.

Received 3 October 2011; revised accepted 15 June 2012

ANAMIKA AUDDY
TANDRA BISWAS
SILANJAN BHATTACHARYYA*

Behaviour, Ecology and Evolution Lab,
Department of Zoology,
West Bengal State University,
Barasat,
24 Parganas-North 700 126, India
**For correspondence.*
e-mail: silanjan@gmail.com