A novel form of spontaneous tool use displayed by several captive Greater vasa parrots (*Coracopsis vasa*)

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Abstract

Parrots are frequently cited for their sophisticated problem-solving abilities but cases of habitual tool use among psittacines are scarce. We report the first evidence of tool use by Greater vasa parrots (*Coracopsis vasa*). Several members of a captive population spontaneously adopted a novel tool-using technique by using pebbles and date pits to either a) scrape on the inner surface of seashells, subsequently licking the resulting calcium powder from the tool, or b) as a wedge to break off smaller pieces of the shell for ingestion. Tool use occurred most frequently just prior to the breeding season, during which time numerous instances of tool transfer were also documented. These observations provide new insights into the tool-using capabilities of parrots and highlight the Greater vasa parrot as a species of interest for studies of physical cognition.

INTRODUCTION

Despite occurring in a range of taxa, the use of tools by nonhuman animals remains an exceedingly rare phenomenon [1, 2]. Descriptions of tool-using behaviour in new species add intriguing new pieces to this puzzle and help to broaden our understanding of the neuroanatomical, social and ecological predictors of tool use across the animal kingdom. While frequently cited for their sophisticated problem solving abilities, cases of habitual tool use (the recurring use of tools by several members of a population) among psittacines are surprisingly scarce. Among over 300 parrot species, only hyacinth macaws (*Anodoryhnchus hyacinthinus*) and black palm cockatoos (*Probosciger aterrimus*) have been reported using tools habitually, with the former using leaves and small sticks as wedges to open nuts [3], and the latter using rocks and empty nutshells to drum on trees during social displays [4]. More recently Goffin cockatoos (*Cacatua goffini*) and kea (*Nestor notabilis*) have shown competency for using and/or making tools in a laboratory setting, although it is unknown whether this behaviour persists outside of an experimental context [5, 6].

Vasa parrots are endemic to Madagascar and possess a range of characteristics that make them unique among parrots, including a polygynandrous breeding system [7] and high degrees of social tolerance among group members. Vasas also frequently explore and manipulate objects in captivity, even creating complex relationships among them such as threading a twig sequentially into the open links of a chain (movie S1). Combining objects during play may serve as a phylogenetic or developmental precursor to advanced problem-solving and flexible tool use as it provides greater opportunities for the generation of novel behaviours and learning of object affordances. This is supported by recent comparative studies that have found that habitually tool-using species tend to spend more time manipulating and combining objects than their closely related, but non-tool-using counterparts [8, 9].

We report the first evidence of spontaneous tool use in a group of captive Greater vasa parrots (*Coracopsis vasa*). We present data on the frequency, duration and nature of tool use in addition to the frequency and nature of tool transfers between conspecifics.

METHODS

Observations took place at the Lincolnshire Wildlife Park, UK. Subjects were ten adult vasa parrots (M:6, F:4) ranging in age from 1 to >14 years. Birds were housed together in an aviary consisting of an outdoor (9x5x5m) and heated indoor section (2.4x4.9x2.4m), where feeds (30% seed, 70% fruit) were provided twice daily. The floor of the outdoor enclosure consisted of soil, cockle shells (a known source of calcium for birds and reptiles [10]), wood chippings and pebbles.

Tool-using behaviour was primarily recorded during ongoing focal observations that occurred throughout the day between occurred between 08:00 and 19:00 from March to October 2013. Tool-using behaviour was not identified until the 18th focal observation session. During subsequent observations, all interactions with the shells by any bird, focal or non-focal (in which case the focal observation was paused and the tool-using bird was filmed for the duration of the tool-using behaviour) were recorded on an all-occurrence basis [11]. The first 17 focal observations were retroactively coded for any tool use that could be observed in the background of the video, and an additional 16 tool use bouts were video recorded *ad libitum* outside of focal observations.

Interactions with the shells were placed in the following categories:

Pebble-seashell: Bird places pebble inside of seashell and either a) uses tongue to grind pebble against seashell (see movie S2) or b) uses as a wedge to break apart seashell.

Date pit-seashell: Bird places date pit inside of seashell and either a) uses tongue to grind date pit against seashell or b) uses as a wedge to break apart seashell (see movie S2).

Seashell-unknown: Bird either a) has an object in mouth while holding seashell that cannot be identified or b) it is unknown whether bird has object in mouth while holding seashell.

Seashell-no tool: The bird has picked up a seashell with the beak and it is clear that there is no tool involved.

Instances of tool use were recorded as one discrete event until the bird dropped both items from the beak for more than five seconds or switched to a new behaviour.

Any tool transfers between birds were recorded, including the identity of the donor and recipient, the object transferred and the type of transfer (i.e. protested theft, tolerated theft or active offer; see supplementary material for detailed descriptions and movie S2 for examples).

All video recordings were coded in the Observer XT. As tool-using behaviour was not identified until the 18th observation session, all observations prior to this were retroactively coded for any tool use that could be observed in the background of the video. The objects used as tools are relatively small and difficult to identify without close-up filming; consequently, of the 50 individual bouts extracted from these first 17 observations, 40 were coded as “seashell-unknown” (seashell-pebble: n=5, seashell-no tool: n=5).

RESULTS

Tool-using behaviour was coded from a total of 107 hours of video observation data which included focal observations (105 hours) and ad libitum recordings (2 hours). Interest in the shells was greatest from March to mid-April 2013 (88% of tool-using bouts; mid-April to October: 12%). From April 2nd to April 11th, when data on shell interactions were coded on an all-occurrence basis, there were, on average 2.6 tool-using bouts in the group per hour (excluding cases of seashell-unknown).

Table 1. All occurrences of recorded seashell interaction (tool use, no tool use or unknown). Table shows individual and group frequency for each of the behaviours, as well as mean bout duration (MD) of the observed behaviour at an individual and group level. Italicised subjects are those with no confirmed instances of tool use (only ‘seashell-unknown’ or ‘seashell-no tool).

		Date pit – seashell		**Pebble – seashell**		**Seashell – unknown**		**Seashell – no tool**	
Subject	Sex	Freq	MD (s)	Freq	MD (s)	Freq	MD (s)	Freq	MD (s)
TI	M	3	253	5	34	3	177		
JD	M	17	55	16	139	16	56	6	13
WD	M	2	18			15	23		
CI	M	1	34	3	72	5	95	5	50
PL	F	10	40	4	100	6	11	1	6
CL	F					4	20		
UF	M							2	14
GO	F					4	38		
BW	F							1	43
TH	M					5	48	1	8
Total (N)		33	400	28	345	58	468	16	134
Group Mean		6.60	80.00	7.00	86.25	7.25	58.50	2.67	22.33
Group SD		6.80	97.61	6.06	44.57	5.18	54.62	2.25	19.20

All ten birds interacted with the shells, and five of these birds were documented using tools, although this number is conservative as three additional birds in the ‘seashell-unknown’ category may have been using tools (Table 1). All five tool-using birds used date pits on the shells, and four of these five individuals also used pebbles. The majority of confirmed tool-using birds (4/5) were male. Table 1 depicts clear individual variation in frequency of tool use with one bird, JD, emerging as the most prolific tool user in terms of both duration and frequency of occurrence.

A total of 16 successful tool transfers took place (see movie S2) and were exclusively from two tool-using males to the single tool-using female, PL. In 12 of these cases JD was the donor (date pit: 8, pebble: 4; tolerated theft: 11, theft: 1), whereas WD was the donor in the remaining 4 cases (date pit: 4, tolerated theft: 3, active offer: 1).

DISCUSSION

The greater vasa parrot joins the small minority of extant species documented as tool users. While other species are known to ingest seashells as calcium supplements [10, 12], this birds' method for doing so appears to be entirely unique. Although archaeological records document grinding tool use by humans up to 30,000 years ago [13], to our knowledge this is the first report of a nonhuman using a tool for grinding [2, 14].

The tool use observed appears to be flexible in several ways: firstly, individuals used more than one tool type on the shells; secondly tools were used in different manners, to either grind or as a wedge to break off small pieces of shell and lastly individuals were selective in when they engaged in tool use with this permanent feature of their environment in terms of season.

In our 6-month observation period, tool use was observed most frequently just prior to the breeding season from March to mid-April, after which point interaction with the shells – tool using or otherwise - became a rare occurrence. The concentration of tool-using events and overall interest in the shells just prior to breeding may be associated with the calcium requirements of egg production. Like eggshells, seashells are made almost entirely of calcium carbonate. Calcium supplementation prior to breeding season is critical for many passerine species, which are unable to store calcium in the skeleton and instead must increase their intake of calcium-rich foods such as snail shells or seashells prior to egg laying [10]. If shell interactions have this function in vasa parrots, it is unclear why males appeared to show the greatest overall interest in the shells. During courtship, copulation and incubation, males feed females extensively through regurgitative feeding [7], and thus it may be possible that the benefits of calcium ingestion are conferred to females indirectly, or females may actively prefer calcium rich regurgitation. Further longitudinal research is needed to first determine whether tool use and shell ingestion regularly occur primarily before each breeding season and if so, whether calcium intake is in any way related to copulation or breeding success for both sexes.

Our observations of tool transfer are particularly intriguing as it is rarely observed in other species and outside of mother-offspring dyads. Transfers occurred exclusively from males to females. This pattern is similar to that reported for chimpanzees, where females primarily obtained tools from males by means of tolerated theft, and in some cases females were in oestrus and transfer took place a short time before or after copulation [15]. The two males who transferred tools in the present study were the primary copulatory partners of the female recipient, however further data is needed to determine the various social factors that may influence tool transfer in this species.

Given the novelty of this behaviour both in this species and in general, there are a number of questions that remain unanswered. For instance, it is unknown whether vasa parrots interact with seashells or use tools in the wild, or whether this behaviour has arisen solely in this group, possibly as an artefact of captivity (e.g. lowered predation pressure and increased free time and energy). Additionally, as not all birds used tools on the seashells, the precise function of the tools requires further investigation. One possibility is that the use of a tool may mitigate discomfort from scraping the beak against the rough surface of the shell or prevent rapid wear of the beak. Alternatively it may increase foraging efficiency; for example, research within the poultry industry suggests that the particle size of calcium ingested from other molluscan shells affects absorption and retention of calcium both *in vitro* and in adult chickens, with small or ground particles being retained more efficiently than coarse particles [16]. Dietary analyses are needed to determine the relative calcium intake of tool-using versus non tool-using birds.

It is also unclear whether tool use in this population of birds reflects an innate predisposition, individual trial and error learning or some form of social learning. Whilst all five birds may have independently learned to use the tools on the seashells, the cases of tool transfer between individuals suggest that there is a social component to this behaviour, and therefore tool use may have been learned socially. The high social tolerance of these birds would certainly support social transmission of behaviour by allowing individuals greater opportunity to observe tool-using behaviour.

Recent studies of technical problem solving in kea and Goffin cockatoos show parrots to be an exciting new avenue for physical cognitive research [17], but additional species are needed in order to make broader comparisons. Our preliminary observations demonstrate a novel form of tool use in multiple members of a species previously unknown to use tools, and raise intriguing questions regarding the function of this behaviour, particularly in its relation to reproductive behaviour. Given their unique tool-using behaviour and complex object play, the Greater vasa parrot represents a promising new species of interest for studies of physical cognition in nonhuman animals.

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FOOTNOTES

Ethics statement

Ethical approval for this study was granted by the Department of Biology Ethics Committee, University of York.

Data accessibility statement

All supporting data are included in the main text.

Author contributions

M.L.L. collected the data and coded the videos, M.L.L., A.M.S. and K.E.S. interpreted the data, provided intellectual input and wrote the paper. All authors gave final approval for publication and acknowledge joint accountability for its content.

Competing interests

The authors have no competing interests.

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