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# Preliminary evidence of tool use in an Australian magpie?

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**Abstract**

We investigated tool use in twelve wild-caught Australian magpies. When presented with a tool use apparatus consisting of two transparent walls with a food reward placed in-between, seven magpies pulled the stick out of the apparatus acquiring the food within. On one occasion, one magpie manipulated the removed stick, carried it back to the apparatus, dropped it between the two walls and proceeded to rake out the food within reach of its beak. We believe this observation is important for the field of comparative cognition as it (1) is the first study to report stick tool use in Australian magpies, and (2) shows a novel behaviour in a ground foraging bird that, as far as we know, do not naturally use tools for food extraction. This study provides preliminary evidence that Australian magpies may be added to the list of bird species that can use tools.

**Keywords**

Artamidae, birds, cognition, extractive foraging, innovation, learning, problem solving.

## 1. Introduction

Despite occurring rarely, the use of tools has been observed in a wide variety of species across the animal kingdom, including both vertebrate and invertebrate species (Bentley-Condit & Smith, 2010; Biro et al., 2013; Amodio et al., 2018). Briefly, tool use is defined by Shumaker et al. (2011) as the

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employment of an unattached or manipulable attached environmental object (i.e., the tool) to alter another object, while the user holds and manipulates the tool during or prior to use. Tool use is observed in two different contexts: naturally occurring in the wild or prompted by scientists in a captive environment.

In the wild, sticks and stick-like objects are commonly used by tool-using species for a variety of purposes (Bentley-Condit & Smith, 2010). Sticks are often used for foraging; extending the reach of an animal to allow for the extraction of out-of-reach food from a cavity. This behaviour can be seen in Galapagos woodpecker finches (*Cactospiza pallida*; Eibl-Eibesfeldt & Sielmann, 1962; Tebbich et al., 2002) and New Caledonian crows (*Corvus moneduloides*; Hunt, 1996; Rutz & St Clair, 2012) probing for invertebrates, and in chimpanzees (*Pan troglodytes*; Sanz et al., 2009) fishing for termites. Wild kea (*Nestor notabilis*) insert sticks into baited trap-boxes to access the food within (Goodman et al., 2018). Although less common, animals have also been observed using stick tools in non-foraging goals such as social displays in chimpanzees (Whiten et al., 1999), vocal and visual displays in the form of rhythmic drumming in palm cockatoos (*Probosciger aterrimus*; Wood, 1984; Heinsohn et al., 2017), novel object exploration in New Caledonian crows (Wimpenny et al., 2011), water proofing (through the spreading of preen gland oil over the plumage with a stick-like feather) in a double-crested cormorant (*Phalacrocorax auratus*; Meyerriecks, 1972), and scratching in Atlantic puffins (*Fratercula arctica*: Fayet et al., 2020; but see Auersperg et al., 2020; Farrar 2020; von Bayern et al 2020 for discussions). The routine use of stick tools in the wild is rare, occurring only in a small number of species, and is not ubiquitous across even closely related groups (Amodio et al., 2018). Notwithstanding, in captivity, this behaviour occurs more frequently and in more species.

In recent decades, there have been several studies investigating tool use in captive birds that do not (apparently) show the behaviour in the wild. In Bird & Emery (2009a), rooks (*Corvus frugilegus*) were presented with multiple tests that challenged the birds' ability to use and manipulate tools. The study revealed that these corvids are capable of learning to use and manufacture stick tools, including selecting tools with the appropriate proportions (size and shape) to most efficiently complete the test presented, as well as bending and manipulating tools (straight wire) to create more effective shapes such as hooks. Rooks also learned to use stones as tools to solve a water-raising task

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(Aesop's fable paradigm; Bird & Emery, 2009b), a task that was later also performed by other corvid species in captivity, for example Eurasian jays (*Garrulus glandarius*) and Western scrub-jays (*Aphelocoma californica*); however, Eurasian jays needed more causal clues for better success and Western scrub-jays did not attend to functional differences of objects (Cheke et al., 2011; Logan et al., 2016). The acquisition of tool use behaviours in Eurasian jays was investigated in a later study by Amodio et al. (2020), where they found that jays were incapable of immediately adjusting their choice of tool according to the functionality of the tool on an object-dropping task, but the jays were capable of learning to use sticks as tools. Furthermore, observations of novel tool use by corvids in captivity were seen in ravens (*Corvus corax*) using stones (Kabadayi & Osvath, 2017) and feathers (Gallot & Gruber, 2019) for food acquisition, and in Northern blue jays (*Cyanocitta cristata*) using bits of paper to obtain out-of-reach food and wet paper to pick up (like a sponge) food-dust around a feeder (Jones & Kamil, 1973).

Tool use in captivity is not limited to corvids. Captive parrots have also shown remarkable tool using abilities. Goffin's cockatoos (*Cacatua goffini*) spontaneously manufacture and use tools to access out-of-reach food items (Auersperg et al., 2012), a behaviour that can be learnt through social transmission (Auersperg et al., 2014). The use of tool sets has recently been found in wild-caught birds (O'Hara et al., 2021). Kea use stick tools to solve puzzle boxes (Auersperg et al., 2011a, b), and a disabled kea missing his upper mandible has been observed using pebbles to preen (Bastos et al., 2021). Hyacinth macaws (*Anodorhynchus hyacinthinus*) use pieces of wood and other objects as aid to opening nuts (Borsari & Ottoni, 2005). Finally, vasa parrots (*Coracopsis vasa*) exhibit novel tool using techniques in their use of pebbles and date pits to grind or break off small pieces of seashells for subsequent ingestion (Lambert et al., 2015). In addition, parids have also shown tool using behaviours, such as marsh tits (*Parus palustris*) collecting and storing powdered food by using stickers (Clayton & Jolliffe, 1996). Such observations on captive birds reveal innovation and cognitive flexibility and shows that in the right environment, tool using is within these species' behavioural repertoires.

In this study, we explored whether wild-caught Australian magpies (*Cracticus tibicen*, also known as *Gymnorhina tibicen*) could use a stick as a tool to acquire food. The Australian magpie is a species of large, co-operative breeding songbirds that live in social groups (ca. 2–24) and occupy almost all

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habitats across Australia. They are ground foragers, feeding mainly on invertebrates (Schodde & Mason, 1999; Kaplan, 2019). Despite the name, Australian magpies are not corvids and are instead part of the family Artamidae which also includes butcherbirds, currawongs, and wood swallows (Christidis & Boles, 2008; Kearns et al., 2013; Cake et al., 2018; Gill et al., 2021). There have been some reports from field observations that birds of the family Artamidae exhibit tool using behaviours (Lefebvre et al., 2002; Bentley-Condit & Smith, 2010). Butcherbirds in general (*Cracticus* spp.) use thorns and branches as larders on which they impale their prey. Specifically, grey butcherbirds (*Cracticus torquatus*) use jagged branches and tree forks as a vice when feeding, and there is one report of an Australian magpie exhibiting what might have been anting behaviour, where the bird used ants to clean its plumage (Sedgwick, 1947a, b). Despite these reports of tool use in Artamidae, there are no other records of tool using behaviours in the wild. This may be surprising since Australian magpies are capable of song learning, associative learning, reversal learning, spatial memory, and inhibitory control (Kaplan, 2005; Mirville et al., 2016; Ashton et al., 2018). In addition, similar to corvids, Australian magpies manipulate and use sticks to build their nests (Pizzey et al., 2012). This behaviour may give these species a cognitive predisposition to learn how to use sticks as tools, even though it may not be part of their foraging ecology (Healy et al., 2008; Guillette & Healy, 2015). Here, we report on the successful use of a stick-type tool by an adult female Australian magpie in a captive setting, as well the completion of a stick pulling task by seven adult Australian magpies.

## 2. Methods

### *2.1. Animals and housing*

In 2019, we captured 12 wild adult Australian magpies of the Victorian subspecies *tyrannica* (equally sexed; age and sex based on plumage; Brown et al., 1988) in the City of Melbourne, Australia, and housed them at La Trobe University for seven months to investigate sleep architecture and regulation, and the effects of anthropogenic light and noise pollution on sleep (see Aulsebrook et al., 2020; Connelly et al., 2020; Johnsson et al., 2022). Briefly, magpies were captured using a walk-in trap baited with grated cheese. All birds were non-breeding and non-paired individuals without a territory. Following capture, we banded each bird with a numbered metal band and a plastic leg band for individual identification.

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Magpies were then transported to indoor aviaries where they were housed in two experimental rooms with similar configurations (equal sexes in each room). Magpies were kept in individual aviaries (1.8 × 0.9 × 1.8 m high) that were left uncovered (when not testing), allowing the magpies to both see and communicate with one another. Each aviary contained three perches: two rectangular plank perches (15 cm wide), one 1.3 m and the other 0.45 m above the ground, and a cylindrical wooden perch 0.45 m above the floor. Magpies were fed a mixture of minced meat and an insectivore mix (55 g; Wombaroo Food Products, Australia) once per day. On test days, food was not provided until after the testing period. Water was provided in a large bowl and was changed daily or when needed, providing the magpies a place to both drink and bathe. Aviary floors were covered in woodchips and, to provide enrichment, 15–20 mealworms were scattered daily throughout the woodchips allowing the magpies to forage. Rooms were temperature controlled (22 ± 5°C) and insulated from all external light. Room lighting was set to a 12 h light, 12 h dark photoperiod (0700–1900 h). Night lights mimicking moonlight (average approx. 0.1 lux at sleeping perch) were placed in each room allowing the magpies to move during the dark photoperiod without harming themselves.

Three weeks post-capture (and prior to any sleep experimentation), we gave the magpies a problem-solving task as enrichment and to habituate the birds to close human contact. The task required the birds to acquire food by pulling a pre-inserted wooden stick from between two transparent walls set 25 mm apart (Figure 1).

In July 2019, magpies were released back into parklands (from where they were caught). Following release, nine of the birds were seen alive in the wild over the course of the first few weeks. Five birds established territories near the release point and were observed regularly by F.C. throughout 2020. The most recent observation was made in April 2021 of a single male feeding a juvenile, which suggests this individual had established a territory and had at least one offspring.

All procedures were carried out with permission from the Department of Environment, Land, Water and Planning (permit number: 10008264), La Trobe Animal Ethics Committee (AEC18034), and the Australian Bird and Bat Banding Scheme (No. 1405).

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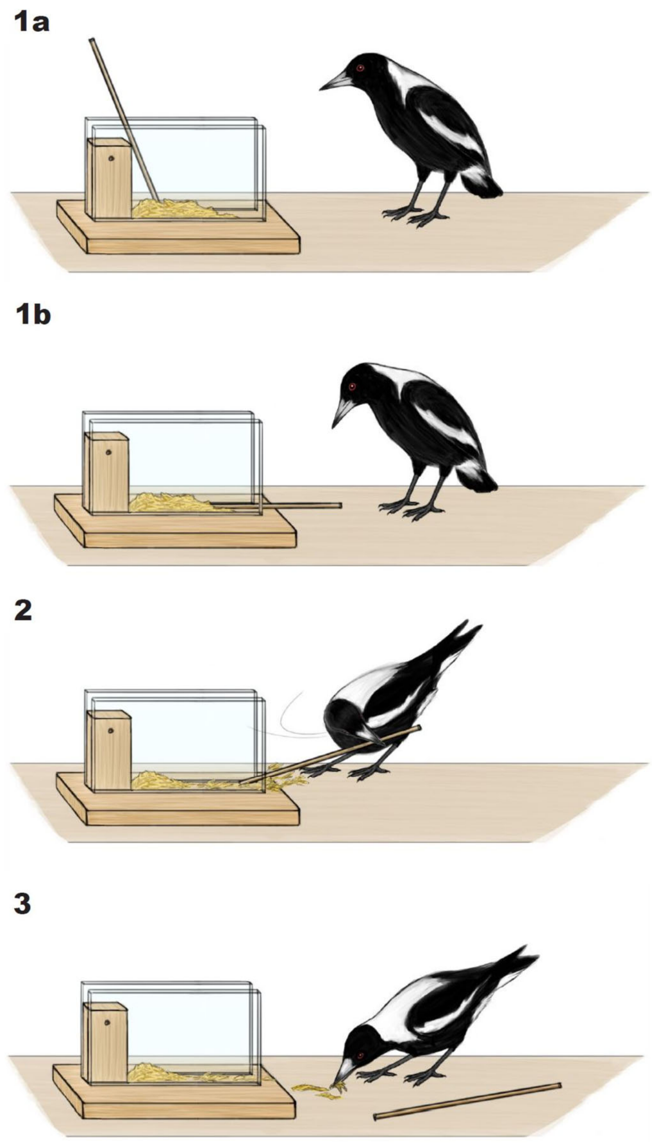


**Figure 1.** Tool-use test. Australian magpie inspecting the tool use apparatus with a (1a) vertical or (1b) horizontal stick configuration. (2) Australian magpie pulling the stick to (3) successfully acquire the food reward. Illustration by Laura X. Tan.

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### 2.2. Procedure

This study took place over a three-week period in February 2019, beginning three weeks after the first bird was brought into captivity. Australian magpies were independently tested in their respective aviaries, and on test days, curtains were hung between cages to eliminate the possibility of social learning. Birds were presented with a novel tool-using task to determine their ability to innovate using a stick. However, it is important to note that the test was originally intended as enrichment, therefore exposure to the apparatus varied across birds, although during exposure we noticed interesting behaviour that warranted further investigation. The test apparatus was comprised of two transparent walls ($20 \times 1 \times 10$ cm) glued 2 cm apart on a wooden base (making the apparatus in total: $25 \times 10 \times 2$ cm; Figure A1 in the Supplementary materials that can be accessed at 10.6084/m9.figshare.20745502). Food treats (mealworms and cheese) were placed between the two walls, out of the reach of the magpies. The birds had access to a wooden stick (19 cm long, 5 mm diameter) that could be used to extract the food items, which was the only way to obtain the food within. To stimulate interaction, the apparatus was presented in three different positions: stick positioned vertically, horizontally, or in both positions simultaneously using two sticks. Both the stick and test apparatus were placed on the floor of the enclosure allowing the birds to explore the task from every angle. The tool was often placed back in the apparatus multiple times by the researchers during a single testing trial to stimulate interaction. This occurred when birds continued to interact with the apparatus after they had removed the tool. During testing, the experimenters left the room, but could still observe the magpies from a window and via video cameras. Ultimately, we were only able to gather data from 11 of the 12 birds, as the 12th bird would not interact with the test apparatus.

### 2.3. Analysis

We recorded magpies with a Sony HDR-PJ430VE camera mounted on a tripod outside the aviaries. Recordings started when the test was presented and continued until the bird had finished interacting with the apparatus. All videos were analysed and behaviours displayed by the magpies towards the testing apparatus were classified into six different categories (Table A1 in the Supplementary materials that can be accessed at 10.6084/m9.figshare.20745502). Timing for each testing trial began when the test was first presented (set in the cage) and time-to-success was calculated for

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**Table 1.**
Time elapsed (h:min:s) until birds ($N = 11$) performed three behaviours with the tool testing apparatus.

| Bird ID | First stick interaction | Stick pulling | Preliminary tool use |
|---|---|---|---|
| Cox (466) | 0:00:24 | 0:00:24 | – |
| Darcy (478) | – | – | – |
| Degoey (146) | 0:14:10 | 0:27:22 | – |
| Goldsack (167) | – | – | – |
| Grundy (156) | 0:01:07 | 0:38:27 | – |
| Pendlebury (182) | 0:06:23 | 0:06:23 | – |
| Sidebottom (152) | 0:02:06 | 0:02:06 | – |
| Swan (173) | 0:02:34 | 0:04:22 | 01:00:29 |
| Taylor (424) | – | – | – |
| Treloar (467) | 0:06:03 | 0:07:28 | – |
| Tufty (196) | – | – | – |
| Average | 00:06:49 | 00:12:22 | 01:00:29 |

three behaviours: first stick interaction/manipulation, stick pull, and tool use (Table 1).

## 3. Results

Seven of the eleven magpies manipulated the stick with their beaks, pulling it out to extract food (Figure 1; Table A1–A3 and Video 1 in the Supplementary materials that can be accessed at 10.6084/m9.figshare.20745502). This behaviour was consistently repeated by all seven magpies, however it only occurred when the stick was placed in the apparatus by the researchers. On average, magpies completed the task on the first day it was presented and required only 12 min and 22 s (quickest taking 24 s and the longest approx. 38 min) to complete the task (Table 1).

Following stick extraction via pulling, excess food was often left in-between the walls of the apparatus and out of reach for the magpie. On one occasion, a female magpie (named Swan) picked up the stick that she had previously pulled out of the apparatus, carried it back over to the apparatus, and after two attempts (the first failed and required her to restart) brought the stick to the front of the test apparatus, and successfully dropped it back between the two walls atop the remaining food. She then proceeded to pull out the stick and successfully extracted some of the remaining food that was out of reach of her beak (see Video 2 in the Supplementary materials that

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can be accessed at 10.6084/m9.figshare.20745502). This moment could be the first evidence of spontaneous and innovative stick tool use in an Australian magpie, or, alternatively, it could have been accidental. Nonetheless, the extent of this finding is further emphasised by the quickness by which she completed this task. Swan solved the task in just 2 days, having only been presented the test for a total of 1 h and 29 s. Following this observation, we continued to deploy the same testing apparatus to Swan to see if she could repeat this behaviour. Unfortunately, she was unable to do so during the time we had left before the planned aforementioned sleep studies began. In total, Swan was exposed to the test for 12 days during which the test was presented for 16 h 43 min 58 s.

## 4. Discussion

In this study, we provide preliminary evidence that Australian magpies have the potential to use sticks as tools. That said, the behavioural rarity of the action could be interpreted as evidence for a behavioural accident, rather than intentional tool use. We show that magpies can repeatedly solve a stick pulling task when food is attached to, or in contact with, the stick; and we provide a single observation of an adult female magpie (nicknamed “Swan”) manipulating a stick to retrieve food, in what we believe could be tool-use behaviour. Despite only performing the behaviour once, Swan’s display of ostensible tool use is important as all reports of tool use in new and different species are invaluable for the field of comparative cognition and suggests the need for further exploration into Australian magpies. Australian magpies are part of the Artamidae family (Kearns et al., 2013) and therefore offers a new group of species to compare to the already well-established list of non-human animal tool users. To date, most research on spontaneous tool-using abilities, in species that do not use tools in the wild, has focused on corvids and parrots (Jones & Kamil, 1973; Bird & Emery, 2009a, b; Cheke et al., 2011; Auersperg et al., 2011a, b, 2012, 2014; but see O’Hara et al., 2021). Australian magpies could fit well into this collection of birds because they might be behaviourally ill-adapted for tool use in the wild as their foraging ecology does not require such a behaviour, but their cognition (Ashton et al., 2018; Kaplan, 2019) allows for behavioural flexibility in a captive setting.

Importantly, while not identical, magpies have a straight bill shape similar to New Caledonian crows and rooks that could potentially allow them

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to manipulate a stick tool. Had we presented our magpies with a thinner stick, like those presented to rooks and New Caledonian crows (Chappell & Kacelnik, 2004; Bird & Emery, 2009a; Taylor et al., 2011), it might have been easier for the birds to manipulate the stick and increase the likelihood of repeated tool use. Despite this potentially limiting factor, Swan manipulated the presented stick not just once, but twice (in succession) before successfully dropping it back into the apparatus. Her successive attempts to place the stick back into the apparatus may have been purposeful. Regardless, following her one successful trial, she failed to repeat the behaviour. Unfortunately, this study was limited to just over three weeks. Had we been able to continue testing Swan, and the other birds, over a longer time period it could have increased our likelihood of observing more occurrences of tool use. However, it is also possible that the length of time available is not the limiting factor, and that offering a range of tool and apparatus shapes and sizes, could help to determine whether the lack of replication is due to dexterity, motivation, or cognition.

The nature of the observation reported here share one similarity with the observations from Fayet et al. (2020) who suggest puffins use tools to scratch themselves. Observations of a puffin and magpie alike were both of short duration and one-off occurrences. It is equally possible that Swan's apparent tool use was accidental. Swan may have picked up the stick and either thrown or dropped it, causing it to serendipitously land between the two walls of the apparatus. Once inside the apparatus, Swan may then have demonstrated a conditioned behaviour of pulling the stick, and food along with it, out of the apparatus. If Swan had used the stick as a tool intentionally, she would have likely learnt from that experience and repeated it in subsequent sessions, which she did not. Thus, while reports of ostensible tool use provide important contributions to our understanding of animal cognition, we acknowledge that behavioural rarities should be interpreted with caution, and that simpler explanations should be given thoughtful attention (Auersperg et al., 2020; Dechaume-Moncharmont, 2020; Farrar, 2020; Sándor & Miklósi, 2020). With this in mind, further investigation into tool use in Australian magpies is warranted.

While often used to describe animals with advanced cognition, tool use does not imply higher cognition and is not necessarily more cognitively challenging than other behaviours. A good example of this is nest building, which

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is not considered tool use but nonetheless requires fine motor skills and perhaps some technical understanding of the physical environment, much like using a stick tool (Guillette & Healy, 2015). Comparative studies between closely related species that use tools in the wild with those that do not supports the idea that tool use does not tell us how cognitively 'advanced' a species might be. Finches that are habitual tool users do not exhibit higher levels of general cognition than non-tool using relatives (Teschke & Tebbich, 2011; Teschke et al., 2011, 2013). Similarly, New Caledonian crows do not appear to be more cognitively advanced than other species of corvids (Teschke et al., 2013; Kabadayi et al., 2016). On the other hand, laboratory studies conducted on species that do not habitually use tools in the wild can tell us a lot about cognition. Corvids, like rooks and ravens, show behavioural flexibility in captivity where they can learn or innovate tool use (Bird & Emery, 2009a, b; Kabadayi & Osvath, 2017; Gallot & Gruber, 2019). Therefore, observations of tool use in a species does not necessarily reveal advanced cognition but, instead, should elicit further research into the origin of this behaviour.

To conclude, we have provided a case report for preliminary tool use capabilities of Australian magpies. When presented with a stick-tool use apparatus in captivity, eleven out of twelve magpies interacted with the apparatus. Seven out of those eleven magpies successfully acquired out-of-reach food from the apparatus by pulling out a stick placed in the apparatus by a researcher. In addition, one of the seven magpies managed to reinsert a removed stick back into the apparatus and subsequently pulled out the stick, extracting additional food; however, this behaviour was only observed once. We believe this behaviour warrants further, and longer, investigations which are necessary before we can determine if Australian magpies use tools. To this end, replication is essential, within- and between-individuals, either in captivity or in the wild, to see whether tool use is observed, and whether that tool use is innate, innovated, and can be socially learned.

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## Supplementary materials

These materials can be accessed at 10.6084/m9.figshare.20745502.

**Figure A1.** Tool-use apparatus. (a) Tool-use apparatus seen from the side with stick tool inserted between the transparent walls. (b) Apparatus seen from above next to the stick tool and digitally inserted ruler.

**Table A1.** Ethogram of behaviours displayed towards the tool use set-up and average occurrences of the behaviours observed during the study ($N = 11$ birds; mean $\pm$ standard deviation). Tool use as a behaviour was not included in the ethogram because it was only displayed once by a single bird.

**Table A2.** Total amount of time (min) each bird was presented the tool use apparatus.

**Table A3.** Number of times each bird pulled the stick to acquire food.

**Video 1.** Australian magpies pulling a stick to acquire food.

**Video 2.** Australian magpie using a stick tool to extract food.

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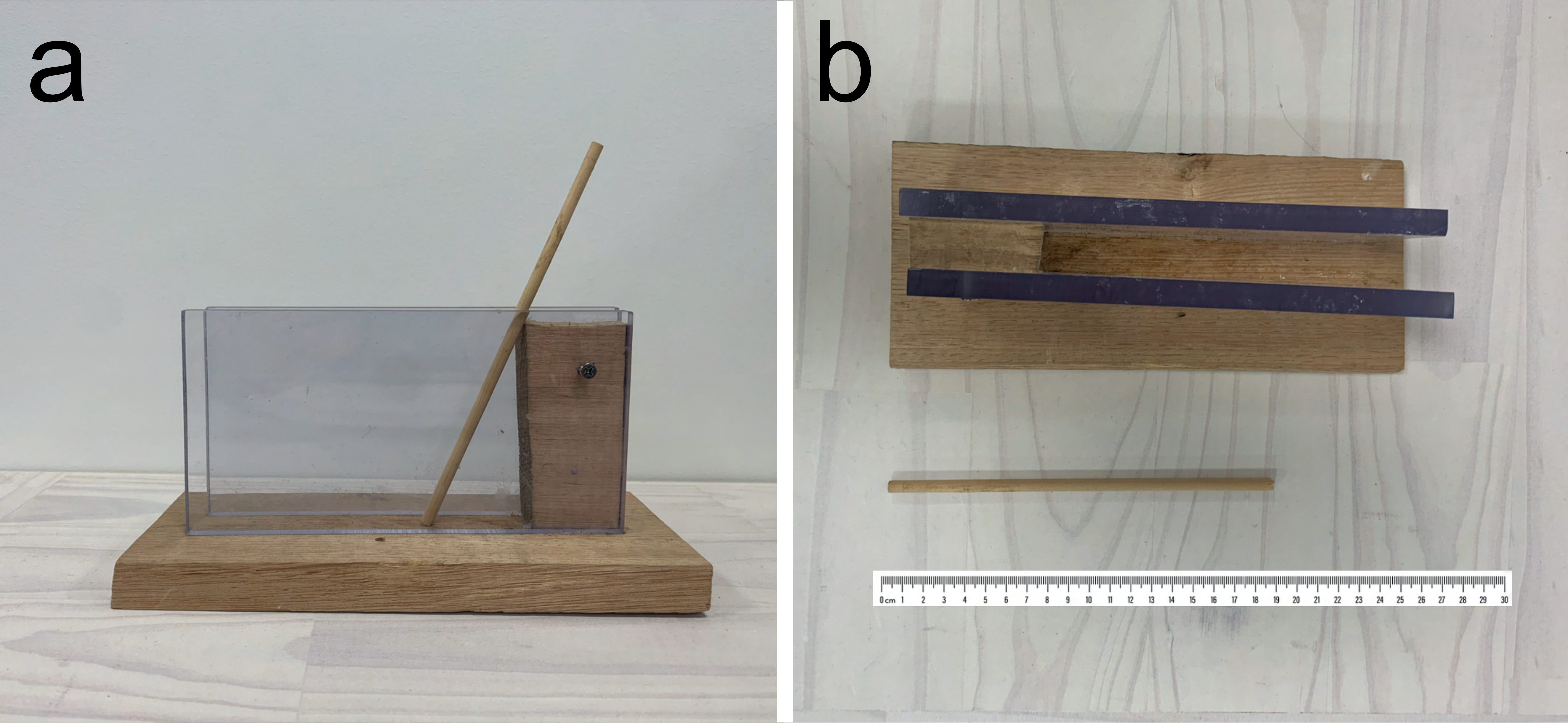
a
b
0 cm 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

**Table A1.** Ethogram of behaviours displayed towards the tool use set-up and average occurrences of the behaviours observed during the study ($N$ = 11 birds; mean ± standard deviation).

| Behaviour | Explanation | Average occurrences |
|---|---|---|
| Pull | Pulling an already inserted stick and successfully getting food | 6.0 ± 6.53 |
| Handle | Handling a stick with the beak | 21.2 ± 35.3 |
| Peck | Pecking at acrylic wall to reach food | 81.0 ± 63.0 |
| Inspect | Close visual inspection with one or both eyes near the acrylic walls without a subsequent peck | 22.1 ± 28.8 |
| Foot | Grabbing the acrylic wall with a foot or perching on the acrylic wall | 7.27 ± 14.8 |
| Eat | Eating food of off the set-up, e.g., usually when a mealworm escaped | 17.6 ± 23.0 |

Tool use as a behaviour was not included in the ethogram because it was only displayed once by a single bird.

**Table A2.** Total amount of time (min) each bird was presented the tool use apparatus.

| Bird ID | Time test presented (min) |
|---|---|
| Cox (466) | 127 |
| Darcy (478) | 25 |
| Degoey (146) | 147 |
| Goldsack (167) | 28 |
| Grundy (156) | 45 |
| Pendlebury (182) | 21 |
| Sidebottom (152) | 180 |
| Swan (173) | 1004 |
| Taylor (424) | 65 |
| Treloar (467) | 43 |
| Tufty (196) | 32 |

**Table A3.** Number of times each bird pulled the stick to acquire food.

| Bird ID | Number of stick pulls |
|---|---|
| Cox (466) | 14 |
| Darcy (478) | 0 |
| Degoey (146) | 15 |
| Goldsack (167) | 0 |
| Grundy (156) | 4 |
| Pendlebury (182) | 2 |
| Sidebottom (152) | 13 |
| Swan (173) | 14 |
| Taylor (424) | 0 |
| Treloar (467) | 4 |
| Tufty (196) | 0 |