Animal tool use: current definitions and an updated comprehensive catalog

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Summary

Despite numerous attempts to define animal tool use over the past four decades, the definition remains elusive and the behaviour classification somewhat subjective. Here, we provide a brief review of the definitions of animal tool use and show how those definitions have been modified over time. While some aspects have remained constant (i.e., the distinction between 'true' and 'borderline' tool use), others have been added (i.e., the distinction between 'dynamic' and 'static' behaviours). We present an updated, comprehensive catalog of documented animal tool use that indicates whether the behaviours observed included any 'true' tool use, whether the observations were limited to captive animals, whether tool manufacture has been observed, and whether the observed tool use was limited to only one individual and, thus, 'anecdotal' (i.e., $N = 1$). Such a catalog has not been attempted since Beck (1980). In addition to being a useful reference for behaviourists, this catalog demonstrates broad tool use and manufacture trends that may be of interest to phylogenists, evolutionary ecologists, and cognitive evolutionists. Tool use and tool manufacture are shown to be widespread across three phyla and seven classes of the animal kingdom. Moreover, there is complete overlap between the Aves and Mammalia orders in terms of the tool use categories (e.g., food extraction, food capture, agonism) arguing against any special abilities of mammals. The majority of tool users, almost 85% of the entries, use tools in only one of the tool use categories. Only members of the Passeriformes and Primates orders have been observed to use tools in four or more of the ten categories. Thus, observed tool use by some members of these two orders (e.g., *Corvus*, *Papio*) is qualitatively different from that of all other animal taxa. Finally, although there are similarities between Aves and Mammalia, and Primates and Passeriformes, primate tool use is qualitatively different. Approximately 35% of the entries for this order demonstrate a breadth of tool use (i.e., three or more categories by any one species) compared to other mammals (0%), Aves (2.4%), and the Passeriformes (3.1%). This greater breadth in

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tool use by some organisms may involve phylogenetic or cognitive differences — or may simply reflect differences in length and intensity of observations. The impact that tool usage may have had on groups' respective ecological niches and, through niche-construction, on their respective evolutionary trajectories remains a subject for future study.

Keywords: tool use, animal, catalog.

Introduction

The definition of 'tool use' is problematic, often arbitrary or subjective, sometimes anthropocentric, and open to interpretation. Over the years, most animal behaviour researchers have relied upon some version of definitions suggested by Hall (1963), van Lawick-Goodall (1970), Alcock (1972) and Beck (1980), but recent attempts to clarify and refine the definition of animal tool use (e.g., Pierce, 1986; Lefebvre et al., 2002; St. Amant & Horton, 2008) have been made. Despite these concerted efforts at removing subjectivity and adding precision and consistency to the definition, a completely objective definition of animal tool use remains elusive. This is, after all, animal behaviour and animal behaviour is interpreted by an observer. This does not mean that the study of tool use is closed to rigorous scientific investigation because of its inherent subjectivity, but it does mean is that there will always be some ambiguous occurrences.

In this paper, we have three objectives. First, we present a brief overview of the development of, and changes in, the definition of animal tool use and the current state of the discussion. Second, we offer an updated, expanded, and comprehensive catalog of tool usage and manufacture for all animals. A catalog such as this has not been attempted since Beck (1980) and has never been presented in a format that clearly differentiates between true vs. borderline use, use in the captive setting, circumstances/categories of tool use, etc. by species in an easily accessible format. The catalog, and the summary tables, provide not only easily accessible data on types of tool use observed in any species, but also provide data on broad trends both within and across phyla/classes — only some of which we explore in this manuscript. Finally, we present some brief remarks regarding areas of research where we see this catalog as potentially providing insight. We believe our work here will be useful to behaviourists, behavioural ecologists, phylogenists and cognitive evolutionists alike.

Tool use defined

There have been numerous attempts to develop and refine the definition of tool use over the past half century. One of the earliest systematic investigations of tool use was that of Hall (1963). While not providing a precise definition of tool use, his examples included social interactions, but excluded "applying a primary object to a secondary object" (Hall, 1963: 479). Additionally, he did not consider tool-using and tool-making as indicators of intelligence, per se. Dissenting voices at that time questioned whether *any* animal behaviour was tool use suggesting the 'tool-user' classification be restricted to hominins (Gruber, 1969).

Van Lawick-Goodall addressed tool use more systematically, defining it as "use of an external object as a functional extension of mouth or beak, hand or claw, in the attainment of an immediate goal" (1970: 195) but also noted that it was not an indicator of intelligence. Soon thereafter, Alcock (1972: 464) expanded upon van Lawick-Goodall's definition to incorporate aspects of Millikan & Bowman's (1967) discussion of woodpecker finch tool use and defined tool use as ". . . the manipulation of an inanimate object, not internally manufactured, with the effect of improving the animal's efficiency in altering the position or form of some separate object". Meanwhile, in a series of papers, Boswall (1977a–d, 1978, 1982, 1983) made the important distinction between 'true' and 'borderline' tool use; true tools were objects not a part of the substrate that were manipulated by the users while borderline tools remained a part of the substrate. For example, a thorn broken from a tree and used by an individual would be a true tool while a thorn that remained a part of the tree would be a borderline tool. Each of these early researchers laid important ground-work for discussions to come.

Beck (1980: 10) refined and broadened both Alcock's and van Lawick-Goodall's descriptions when he defined tool use as ". . . the external employment of an unattached environmental object to alter more efficiently the form, position, or condition of another object, another organism, or the user itself when the user holds or carries the tool during or just prior to use and is responsible for the proper and effective orientation of the tool". Like Hall (1963), Beck also included 'social tool' use, i.e., the manipulation of another individual, within his definition and argued against the 'chimpocentric' approach to tool use that awarded chimpanzees special status for their tool use capabilities. The latter was important in its recognition of other animals' abilities. His volume not only offered more precise definitions for tool use and

tool manufacture, but also presented a catalog of animal true and borderline tool use and tool manufacture — an update of which has not been attempted until now.

While many researchers have utilized and simply restated Beck's (1980) tool use definition over the years (e.g., Anderson, 2002), others have made modifications. For example, Pierce (1986: 96) excluded social tool use and included "structurally modified inanimate environmental object(s)", which allowed the inclusion of nest and burrow building by insects. St. Amant & Horton (2008: 1203) argued that Beck's (1980) definition required clarification of the rationale for including/excluding various behaviours. They defined tool use as ". . . the exertion of control over a freely manipulable external object (the tool) with the goal of (1) altering the physical properties of another object, substance, surface or medium (the target, which may be the tool user or another organism) via a dynamic mechanical interaction, or (2) mediating the flow of information between the tool user and the environment or other organisms in the environment". The first part of this definition includes most behaviours that have traditionally been classified as tool use. However, the second part includes behaviours where the tool mediates the relationship between the user and the environment — a change from Beck's (1980) work because no object or organism is altered by another object that the user controls. The second part of the St. Amant & Horton (2008) definition also includes using tools to influence or alter another organism's perception of the environment. So, in addition to the alteration of physical aspects of the environment, they explicitly include sensory and communication-related uses of tools. Ultimately, they retained the fundamentals of Beck's (1980) earlier definition but added the 'dynamic' and 'flow of information' components.

Our definition

The definition of tool use that we used in constructing the catalog (see Appendix A) is an amalgamation of those presented in the preceding paragraphs. We begin with Beck's (1980) definition but, like Pierce (1986), we exclude social tool use. If tool use is to remain a useful behavioural classification, some behaviours/categories must be excluded and we firmly believe that social interactions are one such category. For this same reason, we disagree with Pierce (1986) and do not include nest/abode building as

a tool. Thus, we are essentially utilizing St. Amant & Horton's (2008) definition (see above). As such, birds (or other animals) building their abodes from twigs or other materials would not be considered using tools since the abode is not dynamic. However, we disagree with some of St. Amant & Horton's (2008) interpretations of 'dynamic'. By their definition, the stacking of boxes by chimpanzees to retrieve a reward (e.g., Köhler, 1925), a behaviour traditionally classified as tool use, can be decomposed into two separate and static behaviours — stacking and climbing — neither of which are, thus, tool use. Conversely, a chimpanzee using a box to knock a reward to the floor is dynamic and is, therefore, tool use.

This example highlights some of the subjectivity in making tool use behavioural distinctions. St. Amant & Horton (2008) presented another classic experiment (e.g., Köhler, 1925) where chimpanzees fitted two pieces of pipe together to create a pole that could be used to reach a reward as an example of tool manufacture. Using the pole to reach the reward was then considered tool use — unlike the stacking of boxes described previously. This difference in classification of what is and what is not considered tool use is unclear at best. We believe that the stacking of one box on top of another should be classified as tool manufacture and the use of that stack to reach the reward should be tool use. If the assembled pole could be viewed as an artificial 'arm' that extends a chimp's reach, the created tower of boxes could be viewed as an artificial 'leg' that does the same thing. While it is likely that this level of subjective interpretation will not arise often, even new and improved definitions of tool use have their short-comings. Thus, our tool-use definition is very similar to that of St. Amant & Horton (2008) with somewhat more leeway in what constitutes 'dynamic' behaviour.

Tool manufacture defined

Defining tool manufacture is somewhat more straight-forward than defining tool use. Beck (1980) noted four, relatively self-explanatory, types of tool manufacture: detach, subtract, add/combine and reshape. Detaching involves separating or disconnecting the tool from the substrate or another object such as removing a branch from a tree. Subtracting is the removal of something from the object so that it is a more useful tool such as pulling leaves off of a twig so that the twig can be used to fish for termites. Adding/combining is when two or more objects are put together to make a tool such as attaching

two short sticks to make one long stick. Finally, reshaping is a fundamental restructuring of an object such as creating a sponge by crumpling a handful of leaves. Of these four categories, detaching is the most ambiguous since 'manufacturing' may be difficult to distinguish from simply retrieving an object from the substrate. However, key to Beck's (1980) categories of manufacture is that each requires an active act of creation as opposed to the mere acquisition of the object. We use these criteria in determining tool manufacture.

The catalog

To facilitate ease of use, we present the catalog data in a tabular format as Appendix A. The data are divided into nine sections according to phylum and class by descending size (i.e., class with the most orders first) (e.g., Phylum: Arthropoda, Class: Insecta; Phylum: Arthropoda, Class: Malacostraca, etc.) and listed alphabetically by genus/species within each class. The two exceptions are the Aves Order Passeriformes and the Mammalia Order Primates which have been extracted for ease of reference and to facilitate comparisons similar to those by Marler (1996) and Lefebvre et al. (2004). Each, however, immediately follow their respective class.

We have necessarily forsaken detail for streamlining. Tool use is classified into ten categories. Food preparation (Food Prep) is the use of a tool to prepare, but not extract, food. For example, curlews slamming a large food item against the ground until the item is broken into smaller pieces and that can be swallowed (Marks & Hall, 1992) is classified as an example of food preparation as is the observation of a red-tailed hawk bashing a captured snake against boulders (Ellis & Brunson, 1993). Food extraction (Food Extrac) occurs when a tool is used to gain access to a food item that is enclosed/encased and not immediately accessible. Gulls dropping clams on rocks (Maron, 1982) and macaques using sticks as dipping tools (Babitz, 2000) are clear examples of food extraction. Food transport (Food Trans) is the use of a tool to transport food and/or water. Barber et al. (1989) observed fire ants using sand to absorb and transport honey back to the nest while Antevs (1948) observed Gila woodpeckers to do the same thing using larger objects such as lumps of bark to absorb the honey. Food capture (Food Cap) occurs when a tool is used to acquire food not using extraction. The use of a

stick to pull a food item into reach by chacma baboons (Bolwig, 1961) is an example of food capture, as is the plugging of hibernating ground squirrels' tunnels by hunting badgers (Michener, 2004). Physical maintenance (Phys Main) is the use of a tool to affect one's appearance or body. The use of a thorn by a lion to remove another thorn from its paw (Bauer, 2001) and the use of a towel by a sandhill crane to dry itself (Bartlett & Bartlett, 1973) are tools used in physical maintenance. Mate attraction (Mate Attrac) includes only those cases of tool use where the purpose is unambiguously determined to affect the behaviour of potential mates. There are, thus, relatively few examples. One common example is the decoration of bowers by bowerbirds (Crook, 1960); the use of sound baffles by African tree crickets to amplify their calls (Prozesky-Shulze et al., 1975) is another example. Nest construction (Nest Const) is the use of a tool to construct an abode. Numerous digger wasp species use pebbles to compact the soil around their nests (Brockmann, 1985) while the common octopus builds a 'wall' in front of the entrance to its den from rocks, glass, and other objects (Mather, 1994). Predator defense (Pred Defen) is the use of a tool to defend oneself. Hermit crabs fortify themselves against octopus attack by transferring sea anemones to their shells (Ross, 1971), while sawfly larvae apply pine resin acid to their attackers (Eisner et al., 1974). Agonism (Agon) is the use of a tool in an aggressive encounter with another, often as a threat but not as defense against predation. An African black eagle (Dick & Fenton, 1979), white-faced capuchins (Chevalier-Skolnikoff, 1990), and elephants (Chevalier-Skolnikoff & Liska, 1993) engaged in agonism by directed throwing/dropping of objects at or on another individual. Finally, Other (Other) are those examples of tool use that do not easily fit into any of the previously described categories. A common blackbird was observed to use a twig to clear snow from the ground (Priddey, 1977) while white-handed gibbons have been observed to create their own swings in a cage (Rumbaugh, 1970). These, then, are the ten categories used in the catalog. In each column applicable to a specific entry, we indicate whether the observations were limited to Captive (C), Free Ranging (F), or Semi-free Ranging (S) animals or in a combination of these living conditions. Thus, if a particular species has been observed to use tools in all ten of the conditions described previously and in each of the living situations listed above, that species would have a 'C, F, S' in each of the ten columns. Similarly, observations of a given species limited to food capture in a free ranging living condition would have only an 'F' in that particular column.

We also indicate (a) whether the tool use is limited to captive animals, (b) whether the species has been observed to manufacture tools, (c) whether any of the tool use is considered true tools and (d) if the tool use observations were limited to just one subject (i.e., $N = 1$). It should be noted that we were forced to put a '?' in some of these columns as the original research did not always indicate the number of subjects or whether the animal was captive.

Despite our best attempts to include all documented cases of both true and borderline tool use, there are probably examples that we have missed. We have limited our examples to published sources. Thus, tool use reported by others as 'personal communication' is not included. As stated previously, we have also excluded social interactions/behaviours, abodes, and abode construction as examples of tool use. Consequently, we limit our catalog entries to published reports of individuals utilizing objects in the ten categories described above. These observations of tool use, thus, represent a species' material culture reported to date — less the excluded abodes (see McGrew, 1992a; van Schaik et al., 1999, 2003a; Malaivijitnond et al., 2007, for discussions of the evolution of material culture). We utilized numerous sources in compiling the catalog — including extensive database searches and published reviews (see Appendices B and C). From the reviews, we used the bibliographies to acquire copies of the original works to determine if the example should be included. For each of the taxa listed in the catalog, we have included representative references to every different type of tool use and/or every different population that we were able to locate. However, where multiple authors report the same behaviour, we have limited the number of entries. We have also limited the entries of any one author who has written extensively on tool use in a species to those references on different populations or different uses of tools. While we have endeavored to include every species and every different type of tool use reported, we have not tried to include every article ever written on animal tool use. Our goal was to provide a survey of the extent of tool use, not in-depth case studies of particular species.

There are three other catalog caveats. First, McGrew's (1992b) statement that there is a positive correlation between the number of reports of tool use by a population, the length of the study, and the degree of habituation of the group undoubtedly applies to this catalog. Thus, it is not surprising that decades-long studies of continuously monitored chimpanzee populations report many examples of tool use and manufacture. On the other hand, while some species have been observed extensively and demonstrated very little

tool use (e.g., *Papio* primates), it is possible that even extensive observations may have missed population-specific tool use due to the specific individuals or classes of individuals observed (see, for example, Tebbich et al. (2002) on locale-specific tool use by *Cactospiza pallida* and Higuchi (1988) on individual variation in *Butorides striata* tool use dependent upon feeding-site quality). Second, the observation of tool manufacture is likely to be even more difficult and rare than the observation of tool use. Thus, an 'N' in the tool manufacture column does not prove that manufacture never occurs, merely that manufacture has not been observed. Finally, the indications of whether data reported for a species are actually limited to only one individual (i.e., $N = 1$), and, thus, an 'anecdote', are provided following Sarringhaus et al.'s (2005) caution that reports on tool use often gloss over this information. In doing so, the reported behaviour can easily become reified as a population/genus/species characteristic when no such pattern may actually exist. It is not that anecdotal information is not useful (see, for example, Reader & Laland's (2002) and Lefebvre et al.'s (2004) use of such data to discuss innovations), but it should be identified. Thus, we have labeled the entries for species where the tool use was limited to only one individual by placing a 'Y' in the '$N = 1$?' column and these entries account for almost 28% of the catalog (see Table 1). However, any species with more than one citation cannot be classified as anecdotal ($N = 1$) since there are reports on more than one individual or population. However, it is still possible that each of those referenced studies reported on only one subject.

Discussion

In the following paragraphs, we summarize some of the patterns and trends we observed in the catalog. It should be noted that these summaries are speculations, not inferences. To test these patterns/trends would require the use of phylogenetic controls; that testing is beyond the scope of this manuscript.

One point that arises from even a cursory examination of the catalog is that tool use occurs in a wide variety of species and in a diversity of contexts. Three phyla of the animal kingdom, Arthropoda, Mollusca and Chordata, and seven classes, Insecta, Malacostraca, Gastropoda, Cephalopoda, Actinopterygii, Aves and Mammalia, are represented. Numerically, there are more Aves entries (including Passeriformes; $N = 277$) followed by Mammalia (including Primates; $N = 65$) and then Insecta ($N = 53$) (see Table 1

Table 1. Frequency data from tool use catalog (yes/present).

Phylum/class (N, No. of entries; G, No. of genera)	$N = 1$?	Captive only?	Tool manuf.?	True tool use?	Food Prep	Food Extrac	Food Transp	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred Defen	Agon	Other
Arthropoda/Insecta ($N = 53$; G = 30)	4	4	0	47	0	0	10	12	0	4	20	6	0	1
Arthropoda/Malacostraca ($N = 6$; G = 5)	1	3	3	6	0	0	0	1	0	0	0	4	2	0
Mollusca/Gastropoda ($N = 3$; G = 2)	0	2	0	3	0	0	0	0	0	0	0	1	0	2
Mollusca/Cephalapoda ($N = 1$; G = 1)	0	0	0	0	0	0	0	0	0	0	1	1	0	0
Chordata/Actinopterygii ($N = 13$; G = 11)	1	3	0	3	0	4	0	3	0	0	6	3	0	0
Chordata/Aves ($N = 83$; G = 58)	38	14	3	28	21	33	5	14	12	1	0	0	3	5
Chordata/Aves Passeriformes ($N = 194$; G = 100)	55	65	15	140	37	34	2	5	116	4	17	1	7	8
Chordata/Mammalia ($N = 22$; G = 19)	8	11	5	16	0	8	0	5	6	0	3	0	2	1
Chordata/Mammalia Primates ($N = 43$; G = 21)	10	18	16	41	8	18	9	22	18	1	0	2	14	10
Totals ($N = 418$; G = 247)	117	120	42	284	66	97	26	62	152	10	47	18	28	27

below). However, comparison across classes by number of entries alone is extremely limited as 11 of the entries for Insecta each represent an entire genus and, thus, hundreds of entries at the species level. Still, the distribution is informative. First, there has been a tendency over the years to focus upon primate tool use (chimpanzees, in particular). In fact, Marler's (1996) comparison of primate and avian tool use and manufacture showed that birds used tools in the same primary categories — food preparation/acquisition, against intruders/predators, sexual display/mate acquisition, and self-maintenance — and as often as primates. Similarly, Lefebvre et al. (2002) documented 125 cases (39 true, 86 borderline) of tool use in 104 avian species. Our catalog is consistent with these works as it demonstrates that Aves and Mammalia use tools in all ten of the categories, followed by Insecta with six, Actinopterygii with four, Malacostraca with three, and Gastropoda and Cephalapoda with only two each. This complete overlap in tool-use categories between Aves and Mammalia and 60% overlap with Insecta certainly speaks to the widespread distribution, and varied forms, of tool use within the animal kingdom.

However, even complete (100%) or extensive (60%) overlap in tool use categories does not mean that tool use by these classes is identical. For example, the distributions of tool use within the ten tool use categories differ for Aves and Mammalia. Aves used tools primarily (i.e., $\geqslant$20% of entries) for physical maintenance (46.2%), food extraction (23.8%) and food preparation (20.9%), while Mammalia observations were primarily of food capture (41.5%), food extraction (40.0%), physical maintenance (36.9%) and agonism (24.6%). It is important, though, to remember the potential bias in tool use observations that arises from a concentration of long-term studies (McGrew, 1992b).

Second, the distribution of true tool use is also broad — occurring in all three plyla. Although comparisons are difficult, some patterns emerge. For Insecta, Malacostraca, Gastropoda and Mammalia, the proportion of true tool use is quite high (e.g., Mammalia: 87.7%; Insecta: 88.7%). However, for Cephalopoda, Aves and Actinopterygii the proportion is much lower (e.g., Aves: 60.6%), suggesting that much of the observed behaviour is borderline tool use. For the two orders, Primates and Passeriformes, the difference is striking (i.e., Primates: 95.3%, Passeriformes: 72.2%).

Finally, when the data are examined by the distribution of tool use categories we find that most animals use tools in only one category (84.7% of catalog entries). These data are summarized in Table 2. Lancaster (1968)

Table 2. Comparison of catalog entries by breadth of tool use.

Phylum/class/order	Number and % of entries by number of tool use categories										
	1	2	3	4	5	6	7	8	9	10	Total
Arthropoda/Insecta	53 (100)	0	0	0	0	0	0	0	0	0	53
Arthropoda/ Malacostraca	5 (83.3)	1 (16.7)	0	0	0	0	0	0	0	0	6
Mollusca/Gastropoda	3 (100)	0	0	0	0	0	0	0	0	0	3
Mollusca/ Cephalapoda	0	1 (100)	0	0	0	0	0	0	0	0	1
Chordota/ Actinopterygii	10 (76.9)	3 (23.1)	0	0	0	0	0	0	0	0	13
Chordota/Aves (w/o Passeriformes)	74 (89.2)	7 (8.4)	2 (2.4)	0	0	0	0	0	0	0	83
Chordota/Aves/ Passeriformes	167 (86.1)	21 (10.8)	4 (2.1)	1 (0.5)	1 (0.5)	0	0	0	0	0	194
Chordota/Mammalia (w/o Primates)	19 (86.4)	3 (13.6)	0	0	0	0	0	0	0	0	22
Chordota/Mammalia/ Primates	23 (53.5)	5 (11.6)	6 (14.0)	3 (7.0)	1 (2.3)	3 (7.0)	1 (2.3)	0	1 (2.3)	0	43
Total	354 (84.7)	41 (9.8)	12 (2.9)	4 (1.0)	2 (0.5)	3 (0.7)	1 (0.2)	0	1 (0.2)	0	418

noted that most tool-using animals use only one type of tool, and our catalog supports this view. In Table 1, the category with the highest number of entries is Physical Maintenance, followed by Food Extraction, Food Preparation, and Food Capture. These data tell us that not only are most of the taxa observed to use tools in only one context but, for most, they are doing so either in self-care or the acquisition/preparation of food.

If we expand the examination of taxa to include one or two types of tool use, then 97.1%–100% of the entries in all classes are accounted for with the exception of Mammalia where only 76.9% of the entries documented either one or two categories of tool use. Closer inspection reveals that it is the Primate order that is responsible for the difference between Mammalia and the other taxa. Without the Primates, all of the entries for Mammalia are with either one or two categories of tool use. For the Order Primates, one or two categories of tool use accounts for only 65.1% of tool use and it is entries demonstrating only one type of tool use in particular (53.5% compared to $\geqslant$76.9% for all of the other classes/orders) that is responsible for

the difference. While Aves (without Passeriformes) has some entries demonstrating three categories of tool use, only the Passeriformes and Primates have entries with four or five — and only Primates has entries with greater than five. The proportion of entries with three or more tool use categories is much higher for the Primates than for other mammals, Aves, or Passeriformes. When combined, 34.8% of the Primates taxa use tools in three or more categories compared to the other mammals (0%), Aves without Passeriformes (2.4%), and the Passeriformes (3.1%). From these data, it appears that some primates have the edge in the breadth of their tool use.

Relevant to the patterns described in the previous paragraphs, Lefebvre et al. (2002: 961) argued that true tool using birds have a larger average brain size than borderline tool users, and that true and borderline tool using may be indicative of 'different degrees of cognitive ability'. There are also data showing that tool use has a direct impact on the brain (e.g., Cardinali et al., 2009). *Corvus*, some members of which are reported in our catalog as using tools in four or five categories, is generally recognized as being a large-brained bird genus. Lefebvre et al. (2002) also stated that the independent, parallel co-evolution of large brains and tool use may have arisen not only in different vertebrate lines but, potentially, at least six times in different avian taxa. Within the primate family tree, tool use may have arisen at least three different times — on the great ape/human branch, the macaque/baboon branch, and the capuchin branch (van Schaik et al., 1999; Panger, 2007). The nine catalog entries with four or more tool-using categories observed within the Primates (see Table 2) represent seven primate genera — one from the capuchin branch, two from the macaque/baboon branch, and four from the ape/human branch. A detailed analysis of comparative brain development, phylogeny, and the degree and types of tool use exhibited by various animals is beyond the scope of this paper, but we believe our catalog may be a useful tool in these future discussions.

While it is tempting to think that breadth of tool usage is indicative of 'better adapted' forms, the true 'adaptiveness' of each type of tool use requires further study. Alcock (1972: 472) stated that woodpecker finches, sea otters, and humans, all 'major tool-using species', have invaded new niches. A meta-analysis of niche-expansion and tool use would be of considerable interest in this regard. Furthermore, the extensive studies of some species (e.g., New Caledonian crows, black-capped capuchin monkeys, woodpecker finches, long-tailed macaques) is particularly fertile ground for the study of

niche-construction through tool usage on the 'ecological inheritance' of a population (see Odling-Smee et al., 2003) or how an acquired characteristic such as tool usage may shape the environment which, in turn, acts selectively on the population. It is likely that innovation rate, positively correlated with variety of tool use, may have played a role in evolutionary diversification (Reader & Laland, 2002; Lefebvre et al., 2004), an idea that is currently being explored regarding the great ape-early hominin divergence. See, for example, Boesch et al.'s (2009) discussion of chimpanzees using complex, multi-function tools in collecting honey and similarities with tool use by early hominins. What is evident from our catalog is that observations of taxa demonstrating a breadth of tool usage are quite limited and, in that sense, these taxa are different.

In compiling this catalog, our primary goal was to present a concise, user-friendly, updated resource for researchers interested in animal tool use that would illustrate trends in animal tool use within and across taxonomic classifications. We did not expect to resolve the issue of what is or is not tool use but we believe this updated catalog to be a significant contribution. In creating the catalog, we have obviously used our definition of tool use and our interpretations of the available data, including some behaviours while excluding others. By highlighting breadth of tool use among Passeriformes and Primates, we made the choice to bring to the forefront this particular aspect of tool use and these two groups of tool users over others. It is these types of patterns and comparisons that make further exploration of animal tool use an exciting topic worthy of continued investigation.

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Appendix A: Animal tool use catalog

Key: Y = Yes; N = No; C = Captive; F = Free ranging; S = Semi-free ranging; Food Prep = Food Preparation; Food Extrac = Food Extraction; Food Trans = Food Transport; Food Cap = Food Capture; Phys Main = Physical Maintenance; Nest Const = Nest Construction; Pred Defen = Predator Defense; Agon=Agonism; Other = Other.

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Phylum: Arthropoda, Class: Insecta																
Ammophila aberti	Digger wasp	N	N	N	Y							F				Evans, 1959; Brockmann, 1985
Ammophila aureonotata	Digger wasp	N	N	N	Y							F				Evans, 1959; Brockmann, 1985
Ammophila breviceps	Digger wasp	Y	N	N	Y							F				Brockmann, 1985
Ammophila gryphus	Sand wasp	N	N	N	N							F				Pergande, 1892; Wheeler & Wheeler, 1924
Ammophila harti	Digger wasp	N	N	N	Y							F				Evans, 1959
Ammophila juncea	Digger wasp	N	N	N	Y							F				Evans, 1959
Ammophila pictipennis	Digger wasp	N	N	N	Y							F				Brockmann, 1985
Ammophila placida	Digger wasp	N	N	N	Y							F				Evans, 1959
Ammophila procera	Digger wasp	N	N	N	Y							F				Hartman, 1905; Evans, 1959
Ammophila urnaria	Digger wasp	N	N	N	Y							F				Evans, 1959; Brockmann, 1985
Ammophila wrightii	Digger wasp	Y	N	N	Y							F				Brockmann, 1985
Ammophila xanthroptera	Digger wasp	N	N	N	Y							F				Evans, 1959
Aphaenogaster famelica	Japanese ant	N	N	N	Y			C, F								Tanaka & Ono, 1978
Aphaenogaster fulva	Myrmicine ant	N	N	N	Y			F								Fellers & Fellers, 1976; Forrest, 1982
Aphaenogaster rudis	Forest ant	N	N	N	Y			C, F								Fellers & Fellers, 1976; Banschbach et al., 2006

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Aphaenogaster senilis	Myrmicine ant	N	Y	N	Y			C								Agbogba, 1985
Aphaenogaster subterranea	Myrmicine ant	N	Y	N	Y			C								Agbogba, 1985
Aphaenogaster tennesseensis	Myrmicine ant	N	N	N	Y			F								Fellers & Fellers, 1976
Aphaenogaster treatae	Myrmicine ant	N	N	N	Y			F								Fellers & Fellers, 1976
Ariadna segestriidae	Corolla spider	N	N	N	Y				F							Henschel, 1995
Camponotus spp.	Weaver ant	N	N	N	Y							F				Hölldobler & Wilson, 1977
Cladomelea akermani	African bola spider	N	N	N	Y				F							Akerman, 1923
Dendromyrex spp.	Weaver ant	N	N	N	Y							F				Hölldobler & Wilson, 1977
Dicrostichus furcatus	Hairy imperial spider	N	N	N	Y				F							McKeown, 1936
Dicrostichus magnificus	Angler spider	N	N	N	Y				F							Longman, 1922
Glossoma spp.	Caddisfly larvae	N	N	N	Y								F			Ross, 1964
Gryllotalpa vinaea	Burrowing cricket	N	N	N	N						F					Forrest, 1982
Hydropsyche spp.	Caddisfly larvae	N	N	N	Y								F			Ross, 1964
Lampromyia spp.	Worm-lion	N	N	N	Y				F							Wheeler, 1930
Limnephilus spp.	Caddisfly larvae	N	N	N	Y								F			Ross, 1964
Mastophora cornigera	Bola spider	N	N	N	Y				F							Gertsch, 1955
Myrmeleon crudelis	Antlion	N	Y	N	Y				C							Lucas, 1982
Myrmeleon immacualatus	Antlion	N	N	N	Y				F							Topoff, 1977
Myrmeleon spp.	Antlion	N	N	N	Y				F							Wheeler, 1930; De Beer, 1948

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Neodiprion sertifer	Sawfly	N	N	N	N								F			Eisner et al., 1974
Novomessor albisetosus	Ant	N	N	N	Y			F								McDonald, 1984
Ochrotrichia spp.	Caddisfly larvae	N	N	N	Y								F			Ross, 1964
Oecanthus burmeisteri	African tree cricket	Y	N	N	N						F					Prozesky-Schulze et al., 1975
Oecophylla spp.	Weaver ant	N	N	N	Y							F				Hölldobler & Wilson, 1977
Ordgarius cornigerus	American bola spider	N	N	N	Y				F							Hutchinson, 1903
Podalonia pubescens	Digger wasp	N	N	N	Y							F				Brockmann, 1985
Pogonomyrmex badius	Florida harvester ant	Y	N	Y	Y			F								Morrill, 1972
Polyrhachis spp.	Weaver ant	N	N	N	Y							F				Hölldobler & Wilson, 1977
Rhyacophila spp.	Caddisfly larvae	N	N	N	Y								F			Ross, 1964
Salyavata variegata	Assassin bug	N	N	N	Y				F							McMahan, 1982; McMahan & Mendez, 1983
Scapteriscus acletus	Mole cricket	N	N	N	N						F					Nickerson et al., 1979; Forrest, 1982
Scapteriscus vicinus	Mole cricket	N	N	N	N						F					Nickerson et al., 1979; Forrest, 1982
Solenopsis invicta	Fire ant	N	Y	N	Y			C								Barber et al., 1989
Sphex ichnuemoneus	Great golden digger wasp	N	N	N	Y							F				Brockmann, 1985
Sphex pensylvanicus	Steel-blue cricket hunter wasp	N	N	N	Y							F				Brockmann, 1985

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category										References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Sphex urnarius	Thread-waisted wasp	N	N	N	Y							F				Peckham & Peckham, 1898; Frisch, 1940
Tetramorium caespitum	Pavement ant	N	N	N	Y										F[1]	Lin, 1964-1965
Vermillio spp.	Worm-lion	N	N	N	Y				F							Wheeler, 1930
Phylum: Arthropoda, Class: Malacostraca																
Dardanus arrosor	Hermit crab	N	Y	N	Y								C			Ross, 1971
Dardanus callidus	Hermit crab	N	Y	N	Y								C			Ross, 1971
Dromia spp.	Decorator crab	N	N	Y	Y								F			Duerden, 1905
Melia tessellate	Melia crab	N	N	Y	Y				C, F					C, F		Duerden, 1905
Polydectus cupilifera	Teddy bear crab	Y	Y	N	Y									C		Duerden, 1905
Stenorhynchus spp.	Decorator crab	N	N	Y	Y								F			Duerden, 1905
Phylum: Mollusca, Class: Gastropoda																
Tegula brunnea	Brown turban snail	N	Y	N	Y										C[14]	Weldon & Hoffman, 1975
Tegula funebralis	Black turban snail	N	Y	N	Y										C[14]	Weldon & Hoffman, 1975
Xenophora conchyliophora	American carriersnail	N	N	N	Y								F			Berg, 1975
Phylum: Mollusca, Class: Cephalopoda																
Octopus vulgaris	Common octopus	N	N	N	N							F	F			Mather, 1994
Phylum: Chordata, Class: Actinopterygii																
Aequidens coeruleopunctatus	South American cichlid	N	N	N	Y							F	F			Barlow, 1974
Aequidens paragyuayensis	South American cichlid	N	Y	N	Y							C	C			Timms & Keenleyside, 1975; Keenleyside & Prince, 1976

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category										References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Cheilinus fasciatus	Wrasses	N	N	N	N		F									Fricke, 1971
Cheilinus lunulatus	Wrasses	N	N	N	N		F									Fricke, 1971
Colisa spp.	Labrynth fish	N	Y	N	N				C							Vierke, 1973
Coris angulata	Wrasses	N	N	N	N		F									Fricke, 1971
Exoglossum maxillingua	Cut-lips minnow	N	N	N	N							F				van Duzer, 1939
Halichoeres garnoti	Yellowhead wrasse	Y	N	N	N		F									Coyer, 1995
Hoplosternum thoracatum	Armored catfish	N	Y	N	Y							C	C			Armbrust, 1958
Malacanthus plumier	Sand tilefish	N	N	N	N							F				Colin, 1973
Opistognathus aurifrons	Yellowhead jawfish	N	N	N	N							F				Colin, 1972
Pseudobalistes fuscus	Triggerfish	N	N	N	N				F							Fricke, 1975
Toxotes jaculatrix	Archer fish	N	N	N	N				C, F							Luling, 1966
Phylum: Chordata, Class: Aves (except Order: Passeriformes)																
Actitis hypoleucos	Common sandpiper	Y	N	N	N	F										Simmons, 1950
Alectura lathami	Australian brush turkey	N	N	N	Y									F		Dow, 1980
Amazona ochrocephala	Yellow-crowned parrot	Y	Y	N	Y			C								Boswall, 1982
Anhinga anhinga	Anhinga darter	Y	N	N	Y	F										Wellenstein & Wiegmann, 1986
Anodorhynchus hyacinthinus	Hyacinth macaw	N	Y	N	Y		C									Bertagnolio, 1994; Borsari & Ottoni, 2005
Aquila chrysaetos	Golden eagle	N	N	N	N		F									Leshem, 1979

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Aquila verreauxii	African black eagle	Y	N	N	Y									F		Dick & Fenton, 1979
Ardea cinerea	Grey heron	N	N	N	N	C, F										Jones, 1979; Banks, 1982; Bowey, 1997
Ardea goliath	Golaith heron	Y	N	N	N				F							Hunter et al., 2004
Ardea herodias	Great blue heron	Y	N	N	N	F			F							Otnes, 1977; Zickefoose & Davis Jr., 1998
Ardeola ralloides	Squacco heron	N	N	N	N				F							Crous, 1994
Athene cunicularia	Burrowing owl	N	N	N	Y				F							Levey et al., 2004
Buteo jamaicensis	Red-tailed hawk	Y	N	N	N	F										Ellis & Brunson, 1993
Butorides/Ardeola striata	Green-backed heron	N	N	N	N				F							Walsh et al., 1985; Wood, 1986; Foxall & Drury, 1987; Robinson, 1994
Butorides virescens	Green heron	N	N	N	N				F							Lovell, 1958; Norris, 1975; Keenan III, 1981; Harvey, 2000
Cacatua moluccensis	Moluccan cockatoo	Y	Y	N	Y					C						Boswall, 1983
Cacatua sanguinea	Bare-eyed cockatoo	Y	Y	N	Y					C						Smith, 1970
Cacatua sulphurea	Lesser sulphur-crested cockatoo	Y	Y	N	Y					C						Boswall, 1982
Calidris alpina	Dunlin	N	N	N	N	F										del Hoyo et al., 1996
Calidris ferruginea	Curlew sandpiper	N	N	N	N	F										del Hoyo et al., 1996
Callipepla squamata	Scaled quail	Y	N	N	Y					F						Thomas, 1957
Cariama cristata	Crested cariama	N	Y	N	N		C									Kooij & van Zon, 1964

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category										References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Catharacta skua	Great skua	N	N	N	N		F									Sladen, 1958
Ceryle rudis	Kingfisher	N	N	N	N		F		F							Cooper, 1981
Charadrius vociferous	Killdeer	N	N	N	N	F										Schardien & Jackson, 1982
Ciconia ciconia	White stork	N	N	N	Y										F[8]	Rékàsi, 1980
Colaptes auratus	Flicker	N	N	N	Y					F						Southern, 1963; Potter, 1970
Columba livia	Common pigeon	Y	Y	N	Y				C							Epstein & Medalie, 1983
Dacelo novaeguineae	Laughing kookaburra	Y	N	N	N		F									Roberts, 1961
Dendrocopos major	Great spotted woodpecker	Y	Y	N	N		C									Sielmann, 1958
Dendrocopos syriacus	Syrian woodpecker	Y	N	N	N		F									Gorman, 1998
Egretta gularis	Wester reef heron	Y	N	N	N				F							Davis Jr., 1993
Eulabeornis castraneoventris	Chestnut rail	N	N	N	N		F									Woinarski et al., 1998
Geococcyx californianus	Greater road runner	?	N	N	N		F									Meinzer, 1993
Grus canadensis	Sandhill crane	Y	Y	N	Y					C						Bartlett & Bartlett, 1973
Gypaëtus barbatus	Lämmergeier	Y	N	N	N		F									Fleming, 1955
Halcyon coromanda	Phillipine kingfisher	N	N	N	N		F									Rand, 1954
Halcyon smyrnensis	White-breasted kingfisher	Y	N	N	N	F										Tehsin, 1989
Haliaeetus leucocephalus	Bald eagle	N	Y	N	Y		C							C		Bindner, 1968

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Hamirostra melanosterna	Black-breasted buzzard	N	N	N	Y		C, F									Chisholm, 1954; Pepper-Edwards & Nottley, 1991
Jynx torquilla	Eurasian wryneck	Y	N	N	Y					F						Stone, 1954
Larus argentatus	Herring gull	N	N	N	N	C	F		F							Strong, 1914; Oldham, 1930; Ingolfsson & Estrella, 1978; Kent, 1981; Young, 1987; Connor, 1992; Henry & Aznar, 2006
Larus canus	Common gull	N	N	N	N		F									Oldham, 1930
Larus delawarensis	Ring-billed gull	N	N	N	N		F									Drennen, 1995
Larus dominicanus	Kelp/Southern black-backed gull	N	N	N	N		F									Moon, 1992; Siegfried, 1977; Ward, 1991
Larus fuscus	Lesser black-backed gull	Y	Y	N	N				C							Sinclair, 1984
Larus glaucescens	Glaucous-winged gull	N	N	N	N		F									Barash et al., 1975
Larus marinus	Great black-backed gull	Y	N	N	N	F										Harber & Johns, 1947
Larus melanocephalus	Mediterranean gull	Y	N	N	N		F									van Impe, 1978
Larus occidentalis	Western gull	N	N	N	N		F									Maron, 1982
Larus pacificus	Pacific gull	N	N	N	N		F									Wheeler, 1946; Teichert & Serventy, 1947
Leptoptilos crumeniferus	Marabou stork	N	N	N	Y	F	F									Seibt & Wickler, 1978; Marshall, 1982

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Leucophoyx thula	Snowy egret	N	N	N	N				F							Parks & Bressler, 1963; Kushlan, 1973
Limosa lapponica	Bar-tailed godwit	N	N	N	N	F										Vader, 1979
Limosa limosa	Black-tailed godwit	N	N	N	N	F										del Hoyo et al., 1996
Melanerpes carolinensis	Red-bellied woodpecker	Y	N	N	N		F									Erlwein, 1996
Melanerpes lewis	Lewis's woodpecker	Y	N	N	N		F									Law, 1929
Melanerpes/Centurus uropygialis	Gila woodpecker	Y	N	Y	Y		F	F								Antevs, 1948
Meleagris ocellata	Ocellated turkey	Y	N	N	Y					F						Sugihars & Heston, 1981
Milvus migrans	Kitehawk/Black kite	Y	N	N	N				F							Lockwood, 1962; Roberts, 1982
Neophron percnopterus	Egyptian vulture	N	N	N	Y	F	F									Alexander, 1838; An Old Sportsman from Uitkyk, 1867; Wood et al., 1875; Duerden, 1908; Lindblom, 1920; van Lawick-Goodall & van Lawick, 1966; Brown & Urban, 1969; Brooke, 1979; Ilany, 1982
Nestor notabilis	Kea	N	Y	N	Y										C[10]	Porter, 1936
Numenius tahitiensis	Curlew	N	N	N	Y		F									Marks & Hall, 1992
Nycticorax nycticorax	Black-crowned night heron	N	N	N	N				F							Drinkwater, 1958; Riehl, 2001; Davis Jr., 2004
Pandion haliaetus	Osprey	N	N	N	N		F									Leshem, 1985
Phalacrocorax auritus	Double-crested comorant	Y	N	N	Y										F[9]	Meyerriecks, 1972

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Picoides pubescens	Downy woodpecker	N	N	N	N		F									Davis Jr. 1995
Picoides villosus	Hairy woodpecker	Y	N	N	N		F									Erlwein, 1996
Picus viridis	Green woodpecker	Y	N	N	Y					F						Allsop, 1949
Pluvianus aegyptius	Egyptian plover	N	N	N	N					F						Howell, 1979
Podargus strigoides	Tawny frogmouth	Y	N	N	N	F										Wheeler, 1943
Porzana tabuensis	Spotless crake	Y	N	N	N	F										Johnson, 1976
Probosciger aterrimus	Black palm cockatoo	N	N	Y	Y		F				F				F[2]	Wallace, 1869; Wood, 1984; Bertagnolio, 1994
Psittacus erithacus	African grey parrot	N	Y	Y	Y					C					C[13]	Taylor, 1975; Janzen et al., 1976; Boswall, 1982
Pterocles burchelli	Spotted sandgrouse	N	N	N	N			F								Maclean, 1968
Pterocles namaqua	Namaqua sandgrouse	N	N	N	N			F								Maclean, 1968
Rallus aquaticus	Water-rail	Y	N	N	N	F										Caldwell, 1951
Rhinoptynx clamator	Striped owl	Y	Y	N	Y					C						Goodman & Fisk, 1973
Sphyrapicus varius	Yellow-bellied sapsucker	Y	N	N	N			F								Labedz, 1980
Threskiornis molucca	White ibis	N	N	N	N		F									Vestjens, 1973
Tringa melanoleuca/ flavipes	Greater yellowlegs	N	N	N	N	F										Jordheim, 1965
Tringa totanus	Common redshank	Y	N	N	N	F										Henry et al., 1998
Tyrannus dominicensis	Gray kingbird	Y	N	N	N	F										Reader et al., 2002
Phylum: Chordata, Class: Aves, Order: Passeriformes																
Acridotheres cristatellus	Crested jungle mynah	Y	Y	N	Y					C						Poulsen, 1956

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Acridotheres fuscus	Jungle mynah	N	N	N	N	F				C						Poulsen, 1956; Johnsingh, 1979
Acridotheres ginginianus	Bank mynah	N	Y	N	Y					C						Poulsen, 1956
Acridotheres tristis	Common mynah	N	N	N	Y					F						Pillai, 1941
Agelaius phoeniceus	Red-winged blackbird	N	N	N	Y	F				C, F						Nero, 1951; Poulsen, 1956; Luchtemeyer, 1969
Agelaius xanthomus	Yellow-shoulde-red blackbird	N	N	N	Y					F						Post & Browne, 1982
Ailuroedus crassirostris	Green catbird	Y	Y	N	Y					C						Poulsen, 1956
Ailuroedus dentirostris	Tooth-billed catbird	N	N	N	N		F									Marshall, 1954
Amblyospiza albifrons	Grosbeak weaver	N	N	N	N							F				Crook, 1960
Anthus petrosus	Rock pipit	Y	N	N	N		F									Tutt, 1990
Anthus trivialis	Tree pipit	Y	Y	N	Y					C						Poulsen, 1956
Basileuterus tristriatus	Three-striped warbler	Y	N	N	Y					F						Wenny, 1998
Bombycilla cedrorum	Cedar waxwing	?	Y	N	Y					C						Ivor, 1941
Bubalornis niger	Red-billed buffalo-weaver	Y	Y	N	Y					C						Poulsen, 1956
Cactospiza/ Geospiza pallida (*Camaryhynchus pallidus*)	Woodpecker finch	N	N	Y	Y		C, F		F					C		Bowman, 1961; Eibl-Eibesfeldt, 1961; Hundley, 1963; Millikan & Bowman, 1967; Greenhood & Norton, 1999; Tebbich et al., 2002, 2004

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category										References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Camarhynchus/ Cactospiza heliobates	Mangrove finch	N	N	Y	Y		F	F								Curio & Kramer, 1964
Cardinalis cardinalis	Northern cardinal	Y	Y	N	Y					C, F						Ivor, 1941, 1955
Catharus fuscescens	Veery	?	Y	N	Y					C						Ivor, 1941
Catharus guttatus	Hermit thrush	?	Y	N	Y					C						Ivor, 1941
Certhidea olivacea	Warbler finch	N	N	N	Y		F									Hundley, 1963
Chasiempis sandwichensis	Elepaio	N	N	N	Y					F						Vander Werf, 2005
Chlamydera guttata	Spotted bower-bird	Y	N	N	Y						F					Chaffer, 1945
Chloropsis aurifrons	Golden-fronted leafbird	Y	Y	N	Y					C						Poulsen, 1956
Cinclus cinclus	European dipper	N	N	N	Y					F					F[4]	Creutz, 1952; Johnston, 1985
Cinclus mexicanus	American dipper	N	N	N	Y	F				F						Goodge, 1959; Osborn, 1998
Cissa chinensis	Green magpie	N	Y	N	Y					C						Poulsen, 1956
Coccothraustes coccothraustes	Hawfinch	N	Y	N	Y					C						Poulsen, 1956
Coccothraustes vespertina	Evening grosbeak	?	Y	N	Y					C						Ivor, 1941
Coliuspasser macrourus	Yellow-backed whydah	N	N	N	N							F				Crook, 1960
Colluricincla harmonica	Grey shrike-thrush	N	N	N	Y	F										Mitchell, 1962; Tilt, 1962
Colluricincla megarhyncha	Little shrike-thrush	Y	N	N	Y					F						Sedgwick, 1946

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Copsychus malabaraicus	White-rumped shama	N	Y	N	Y					C						Poulsen, 1956
Copsychus saularis	Oriental magpie robin	Y	Y	N	Y					C						Poulsen, 1956
Corcorax melanorhamphus	White-winged chough	N	N	N	Y	F	F									McDonald, 1970; Hobbs, 1971
Corvus albicollis	Cape raven	Y	N	N	N		F									Uys, 1966
Corvus brachyrhynchos	American crow	N	N	Y	Y	F	F		F					F		Maple, 1974; Powell & Kelly, 1977; Grobecker & Pietsch, 1978; Montevecchi, 1978; Phillips, 1978; Cristol & Switzer, 1999; Caffrey, 2000, 2001; Balda, 2007
Corvus caurinus	Northwestern crow	N	N	N	Y		C, F									Jewett, 1924; Zach, 1978, 1979; Richardson & Verbeek, 1987
Corvus corax	Northern/ Common raven	N	N	Y	Y					F				F		Jacobsen, 1911; Janes, 1976; Heinrich, 1988
Corvus cornix	Hooded crow	N	N	N	N		F									Perry, 1972
Corvus corone	Hooded/carrion crow	N	N	Y	Y	C, F	F			F				F	F[7]	Goodwin, 1953a; Londei & Maffioli, 1978; Condor & Everett, 1979; Jones, 1979; Berrow et al., 1992; Rolando & Zunino, 1992; Mienis, 1993; Brampton, 1994; Nihei, 1995, 1998

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category										References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Corvus coronoides	Australian raven	Y	N	N	N	F										Reid & Reid, 1996
Corvus frugilegus	Rook	N	N	Y	Y		C, F		C	F						Priestley, 1947; Goodwin, 1953a; Reid, 1982; Bird & Emery, 2009
Corvus mellori	Little raven	N	N	N	N	F										Edmonds, 1991; McMillan, 1992; Slee, 1992
Corvus monedula	Jackdaw	N	N	N	N		F									Gibson, 1992
Corvus moneduloides	New Caledonian crow	N	N	Y	Y		C, F									Orenstein, 1972; Hunt, 1996; Chappell & Kacelnik, 2002; Hunt et al., 2002, 2006; Hunt & Gray, 2004
Corvus orru	Torresian crow	N	N	N	N	F										Mackay, 1997
Corvus ossifragus	Fish crow	Y	N	N	Y									F		Montevecchi, 1978
Corvus rhipidurus	Fan-tailed raven	Y	N	N	Y		F									Andersson, 1989
Corvus splendens	House crow	N	N	Y	Y	F	F									Fitzwater, 1967; Rajan & Balasubramanian, 1989
Cracticus spp.	Butcherbird	N	N	N	N	F										Gould, 1848
Cracticus tibicen	Australian magpie	Y	N	N	Y					F						Sedgwick, 1947a
Cracticus torquatus	Grey butcherbird	N	N	N	N		F									Sedgwick, 1947b
Cyanocitta cristata	Blue jay	N	N	Y	Y				C	C, F						Ivor, 1941, 1955; Potter, 1970; Jones & Kamil, 1973
Cyanocitta stelleri	Steller's jay	Y	N	N	Y									F		Balda, 2007
Cyanocorax beecheii	Purplish-backed jay	?	N	N	Y					F						Goodwin, 1953a

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Cyanocorax yncas	Green jay	N	N	N	Y		F									Gayou, 1982
Cyanopica cyana	Azure-winged magpie	?	N	N	Y					F						Goodwin, 1953a
Cyornis tickelliae	Tickell's blue flycatcher	N	Y	N	Y					C						Poulsen, 1956
Dacnis cayana	Blue dacnis	N	Y	N	Y					C						Poulsen, 1956
Daphoenositta chrysoptera	Varied sitella	N	N	N	Y	F										Noske, 1985
Dendrocitta bayleyi	Andaman treepie	Y	Y	N	Y					C						Osmaston, 1936
Dendrocolaptes certhia	Amazonian barred woodcreeper	Y	N	N	Y					F						Skutch, 1948
Dolichonyx oryzivorus	Bobolink	?	Y	N	Y					C, F						Ivor, 1943
Dumetella carolinensis	Grey catbird	N	N	N	Y					C, F						Ivor, 1941; Potter, 1970
Euphagus cyanocephalus	Brewer's blackbird	N	N	N	N	F										Koenig, 1985
Euplectes ardens	Red-collared widowbird	N	Y	N	Y					C						Poulsen, 1956
Euplectes franciscana	Orange bishop	N	Y	N	Y					C						Poulsen, 1956
Euplectes hordaeceus	Black-winged bishop	N	N	N	Y					C		F				Poulsen, 1956; Crook, 1960
Euplectes jacksoni	Jackson's widowbird	Y	Y	N	Y					C						Poulsen, 1956
Euplectes macroura	Yellow-shouldered widowbird	N	Y	N	Y					C						Poulsen, 1956
Euplectes progne	Long-tailed widowbird	Y	Y	N	Y					C						Poulsen, 1956
Euplectes taha	Taha bishop	Y	Y	N	Y					C						Aldersparre, 1936
Falcunculus frontatus	Crested shrike-tit	N	N	Y	Y	F	F									Richards, 1971; Noske, 1985

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Ficedula hypoleuca	Pied flycatcher	Y	N	N	N		F									Page, 1978
Fringilla coelebs	Chaffinch	N	Y	N	Y					C						Poulsen, 1956
Fringilla montifringilla	Brambling	N	Y	N	Y					C						Poulsen, 1956
Garrulax albogularis	White-throated laughingthrush	N	N	N	Y					F						Callegari, 1955
Garrulax/Dryonastes caerulatus	Gray-sided laughingthrush	Y	Y	N	Y					C						Osmaston, 1936
Garrulax chinensis	Black-throated laughingthrush	N	Y	N	Y					C						Poulsen, 1956
Garrulax/Trochalopteron erythrocephalus	Chestnut-crowned laughingthrush	Y	Y	N	Y					C						Osmaston, 1936
Garrulax leucolophus	White-crested laughingthrush	N	Y	N	Y					C						Poulsen, 1956
Garrulax/Dryonastes ruficollis	Rufous-necked laughingthrush	Y	Y	N	Y					C						Poulsen, 1956
Garrulus glandarius	Eurasian jay	Y	Y	N	Y					C						Poulsen, 1956
Garrulus lanceolatus	Lanceolated jay	N	Y	N	Y					C						Goodwin, 1953b
Geospiza conirostris	Large cactus finch	N	N	N	Y										F[3]	DeBenedictis, 1966
Geospiza difficilis	Sharp-beaked gound finch	N	N	N	N										F[6]	Köster & Köster, 1983
Gracula religiosa	Hill mynah	Y	Y	N	Y					C						Poulsen, 1956
Heterophasia capistrata	Rufous sibia	N	Y	N	Y					C						Poulsen, 1956
Hylocichla mustelina	Wood thrush	N	N	N	Y					C, F						Ivor, 1941; Terres, 1962
Icterus galbula	Baltimore oriole	N	Y	N	Y					C						Ivor, 1955
Icterus jamacaii	Campo troupial	N	Y	N	Y					C						Poulsen, 1956
Icterus spurius	Orchard oriole	Y	Y	N	Y					C						Whitaker, 1957

(Continued.)

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						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Junco hyemalis	Slate-colored junco	N	N	N	Y					C, F						Ivor, 1941; Potter, 1970
Lamprotornis caudatus	Long-tailed glossy starling	N	Y	N	Y					C						Poulsen, 1956
Lamprotornis chalybaeus	Greater blue-eared starling	N	N	N	Y					C, F						Poulsen, 1956; Whyte, 1981
Lamprotornis superbus	Superb starling	N	Y	N	Y					C						Poulsen, 1956
Lanius collaris	Fiscal shrike	Y	N	N	N	F										Gore, 1981
Lanius excubitor	Northern shrike	N	N	N	N	F										Cade, 1967
Leiothrix argentauris	Silver-eared mesia	N	Y	N	Y					C						Poulsen, 1956
Leiothrix lutea	Pekin robin	N	N	N	Y					C, F						Ivor, 1941; Poulsen, 1956
Malimbus nitens	Gray's malimbe	N	N	N	N							C, F				Crook, 1960
Malimbus rubricollis	Red-headed malimbe	N	N	N	N							F				Crook, 1960
Malimbus scutatus	Red-vented malimbe	N	N	N	N							F				Crook, 1960
Meliphaga lewini	Lewin's honeyeater	Y	N	N	Y					F						Bourke, 1941a
Melospiza melodia	Song sparrow	N	N	N	Y					C, F						Ivor, 1941; Mayr, 1948
Minla cyanouroptera	Blue-winged siva	N	Y	N	Y					C						Poulsen, 1956
Mionectes oleagineus	Ochre-bellied flycatcher	Y	N	N	Y					F						Skutch, 1948
Molothrus ater	Brown-headed cowbird	N	N	N	Y					F						Nice, 1945
Myophonus caeruleus	Blue whistling-thrush	N	N	N	N		F									Smythies, 1953
Neositta chrysoptera	Orange winged sittella	Y	N	N	Y		F									Green, 1972
Nesospingus speculiferus	Peurto Rican tanager	N	N	N	Y					F						King & Kepler, 1970
Niltava sundara	Rufous-bellied niltava	N	Y	N	Y					C						Poulsen, 1956

(Continued.)

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						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Oenanthe leucura	Black wheatear	N	N	N	Y	F					F					Moreno et al., 1994; Heselden et al., 1996
Oenanthe oenanthe	Northern wheatear	Y	N	N	N	F										King, 1978
Pachycephala rufiventris	Rufous whistler	N	N	N	Y					F						Bourke, 1941b
Paradoxornis gularis	Gray-headed parrotbill	Y	Y	N	Y					C						Poulsen, 1956
Paroaria capitata	Yellow-billed cardinal	N	Y	N	Y					C						Poulsen, 1956
Parus gambeli	Mountain chickadee	Y	N	Y	Y		F									Gaddis, 1981
Parus major	Great tit	Y	N	N	Y		F									Duyck & Duyck, 1984
Parus palustris	Marsh tit	N	Y	Y	Y	C		C								Clayton & Jollife, 1996
Passer domesticus	House sparrow	N	N	N	Y	F				F						Purser, 1959; Potter, 1970; Hammond, 1997
Passerella iliaca	Fox sparrow	?	Y	N	Y					C						Ivor, 1941
Passerina amoena	Lazuli bunting	N	Y	N	Y					C						Poulsen, 1956
Passerina cyanea	Indigo bunting	N	N	N	Y					C, F						Ivor, 1941; Shackleton & Shackleton, 1947
Passerina leclancherii	Orange-breasted bunting	Y	Y	N	Y					C						Poulsen, 1956
Pheucticus ludovicianus	Rose-breasted grosbeak	?	Y	N	Y					C						Ivor, 1941
Pheucticus melanocephalus	Black-headed grosbeak	?	Y	N	Y					C						Ivor, 1943
Pica pica	Magpie	N	N	N	Y		F			F						Goodwin, 1953a; Rolando & Zunino, 1992

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Pipilo erythrophthalmus	Eastern towhee	N	N	N	Y					F						McAtee, 1944; Potter, 1970
Piranga olivacea	Scarlet tanager	N	N	N	Y					F						Groskin, 1943
Piranga rubra	Summer tanager	Y	N	N	Y					F						Thomas, 1941
Pitta erythrogaster	Red-bellied pitta	N	N	N	N	F										McDonald, 1974
Pitta guajana	Banded pitta	?	N	N	N	F										Chasen, 1939
Pitta moluccensis	Blue-winged pitta	?	N	N	N	F										Robinson, 1927
Pitta sordida	Hooded pitta	?	N	N	N	F										Robinson, 1927
Pitta versicolor	Noisy pitta	N	N	N	N	F	F									Hindwood, 1966
Ploceus aurantius	Orange weaver	N	N	N	N							F				Crook, 1960
Ploceus brachypterus	Black-necked weaver	N	N	N	N							F				Crook, 1960
Ploceus castaneofuscus	Chestnut-and-black weaver	N	N	N	N							F				Crook, 1960
Ploceus cucullatus	Village weaver	N	N	N	N							F				Crook, 1960
Ploceus lutealus	Little weaver	N	N	N	N							F				Crook, 1960
Ploceus melanocephalus/ capitalis	Black-headed weaver	N	N	N	N							F				Crook, 1960
Ploceus monarchus	Monarch weaver	N	N	N	N							F				Crook, 1960
Ploceus nigerrimus	Vieillot's black weaver	N	N	N	N							F				Crook, 1960
Ploceus philippinus	Baya	N	N	N	N	F										George, 1973
Ploceus rubiginosus	Chestnut weaver	Y	Y	N	Y					C						Poulsen, 1956
Ploceus tricolor	Yellow-mantled weaver	N	N	N	N							F				Crook, 1960
Ploceus vitellinus	Vitelline masked weaver	N	N	N	N							F				Crook, 1960
Pomatorhinus erythrogenys	Rusty-cheeked scimitar-babbler	Y	Y	N	Y					C						Poulsen, 1956

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon Other	
Pomatorhinus schisticeps	White-browed scimitar-babbler	Y	Y	N	Y					C					Poulsen, 1956
Protonotaria citrea	Prothonotary warbler	Y	N	N	Y					F					Tedards, 1967
Ptilonorhynchus violaceus	Satin bowerbird	N	N	Y	Y						F				Chaffer, 1945; Gannon, 1930; Marshall, 1960
Pycnonotus cafer	Red-vented bulbul	Y	N	N	N	F									Bharos, 1999
Quelea quelea	Red-billed quelea	N	N	N	N							F			Crook, 1960
Quiscalus lugubris	Carib grackle	N	N	N	N	F									Morand-Ferron et al., 2004
Quiscalus major	Boat-tailed grackle	N	N	N	N	F									Jackson, 1985; Wible, 1975
Quiscalus mexicanus	Great-tailed grackle	N	N	N	N	F									Pulich, 1969
Quiscalus quiscula	Common grackle	N	N	N	N	F				C, F					Ivor, 1941; Hill, 1946; Laskey, 1948; Rand, 1967; Nicklas, 1974; Wible, 1975; Jackson, 1985; Pitochelli, 1985; Clark et al., 1999
Regulus satrapa	Golden-crowned kinglet	Y	N	N	Y					F					Davis, 1939
Saltator maximus	Buff-throated saltator	Y	N	N	Y					F					Skutch, 1948
Saxicola rubetra	Whinchat	N	N	N	N	F									King, 1978
Saxicola torquatus	Stonechat	N	N	N	N	F	F								King, 1978; Fisher, 1979
Saxicoloides fulicata	Indian robin	N	N	N	N	F									Sivasubramanian, 1991
Scenopoeetes dentirostris	Stagemaker bowerbird	N	N	N	N		F								Marshall, 1954

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Sericulus chrysocephalus	Regent bowerbird	N	N	N	N						F					Marshall, 1960
Sitta canadensis	Red-breasted nuthatch	N	N	N	Y										F[5]	Kilham, 1968
Sitta carolinensis	White-breasted nuthatch	N	N	Y	Y		F						F		F[5]	Kilham, 1968, 1974; Mitchell, 1993
Sitta pusilla	Brown-headed nuthatch	N	N	Y	Y		F									Morse, 1968; Pranty, 1995
Sporophila aurita	Variable seedeater	Y	N	N	Y					F						Skutch, 1948
Sturnus contra	Asian pied starling	N	Y	N	Y					C						Poulsen, 1956
Sturnus roseus	Rosy starling	N	Y	N	Y					C						Poulsen, 1956
Sturnus vulgaris	Common starling	N	N	N	Y					C, F					F[12]	Ivor, 1955; Southern, 1963; Potter, 1970; Radford, 1979; Clark et al., 1990; Judson & Bennett, 1992
Tangara cyanicollis	Blue-necked tanager	Y	N	N	Y					F						Sick, 1957
Tangara cyanoventris	Gilt-edged tanager	N	N	N	Y					F						Sick, 1957
Tangara fastuosa	Seven-colored tanager	Y	Y	N	Y					C						Poulsen, 1956
Thryothorus ludovicianus	Carolina wren	Y	N	N	N		F									Haney, 1982
Toxostoma rufum	Brown thrasher	Y	N	N	Y					F						Chamberlain, 1954
Turdus ericetorum/ philomelos	Song thrush	N	N	N	Y		C, F			C						Morris, 1954; Poulsen, 1956; Henty, 1986

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category										References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Turdus iliacus	Redwing thrush	N	N	N	Y		F			C						Poulsen, 1956; Richards, 1977
Turdus merula	Common blackbird	N	N	N	Y	F				F					F[11]	Williams, 1947; Watkin, 1950; Priddey, 1977
Turdus migratorius	Robin	N	N	N	Y				F	C, F						Ivor, 1955; Southern, 1963; Potter, 1970
Turdus pelios	African thrush	N	N	N	N		F									Walsh & Walsh, 1983
Turdus pilaris	Fieldfare	N	N	N	N									F		Löhrl, 1983
Turdus torquatus	Ring ouzel	N	N	N	Y					F						Reymond, 1948
Turdus viscivorus	Mistle thrush	Y	N	N	Y					F						Abma, 1951
Urocissa erythrorhyncha	Red-billed blue magpie	N	Y	N	Y					C						Poulsen, 1956
Vermivora pinus	Blue-winged warbler	Y	N	N	Y					F						Dater, 1953
Xenicus gilviventris	Black wren	Y	N	N	N	F										Sibson, 1974
Yuhina nigrimentum	Black-chinned yuhina	Y	Y	N	Y					C						Osmaston, 1936
Zonotrichia albicollis	White-throated sparrow	?	Y	N	Y					C						Ivor, 1941
Zonotrichia leucophrys	White-crowned sparrow	N	N	N	Y					C, F						Ivor, 1941; Paroni, 1954
Zonotrichia querula	Harris sparrow	?	Y	N	Y					C						Ivor, 1943
Zosterops pallidus	Cape white-eye	N	Y	N	Y					C						Lunt et al., 2004
Zosterops palpebrosa	Oriental white-eye	N	Y	N	Y					C						Poulsen, 1956

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Phylum: Chordata, Class: Mammalia (except Order Primates)																
Ailuropoda melanoleuca	Giant panda	N	Y	N	Y					C						Eisenberg & Kleiman, 1977
Bubalus bubalis	Water buffalo	Y	Y	Y	Y					C						Grummt, 1963
Castor canadensis	Beaver	Y	N	Y	Y							F				Barnes, 2005
Castor fiber	Eurasian beaver	N	N	N	Y									F		Thomsen et al., 2007
Elephas maximus	Asian elephant	N	N	N	Y					F						McKay, 1973; Chevalier-Skolnikoff & Liska, 1993; Hart & Hart, 1994; Hart et al., 2001
Enhydra lutris	Sea otter	N	N	N	Y		F			F						Fisher, 1939; Murie, 1940; Kenyon, 1958; Hall & Schaller, 1964; Ebert, 1968; Houk & Geibel, 1974; Wade, 1975
Galidia elegans	Ring-tailed mongoose	N	N	N	N		F									Albignac, 1969
Helogale undulata	African dwarf mongoose	N	Y	N	N		C									Rasa, 1973
Herpestes urva	Crabeating mongoose	N	Y	N	N		C									Acharjyo & Misra, 1972
Heterocephalus glaber	Naked mole rat	N	Y	N	Y							C				Shuster & Sherman, 1998
Loxodonta africana	African elephant	N	N	Y	Y					F				F		Chevalier-Skolnikoff & Liska, 1993; Wickler & Seibt, 1997

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category										References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Martes flavigula	Yellow-throated marten	Y	Y	N	N		C									Wemmer & Johnson, 1976
Mungos mungo	African banded mongoose	Y	Y	N	N		C									Eisner & Davis, 1967
Octodon degus	Common degu	N	Y	N	Y				C							Okanoya et al., 2008
Panthera leo	African lion	Y	N	N	Y					F						Bauer, 2001
Sousa chinensis	Indo-Pacific humpback dolphin	Y	N	N	Y				F							Parra, 2007
Taxidea taxus	North American badger	N	N	N	Y				F							Michener, 2004
Thomomys bottae	Pocket gopher	Y	Y	N	Y							C				Katz, 1980
Tursiops spp.	Bottlenose dolphin	N	N	Y	Y				F							Smolker et al., 1997; Krützen et al., 2005; Mann et al., 2008
Ursus arctos	Alaskan brown bear	Y	Y	N	N		C									Hornaday, 1934
Ursus maritimus	Polar bear	N	N	Y	Y				F						F[15]	Kiliaan, 1972; Stirling, 1974
Ursus ornatus	Spectacled bear	N	Y	N	Y		C									Lang, 1974
Phylum: Chordata, Class: Mammalia, Order: Primates																
Alouatta seniculus	Red howler	Y	N	Y	Y									F		Richard-Hansen et al., 1998
Ateles geoffroyi	Spider monkey	N	N	N	Y					F						Campbell, 2000; Rodrigues & Lindshield, 2007
Bunopithecus hoolock	Hoolock gibbon	N	Y	N	Y				C							Cunningham et al., 2006

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Cebus albifrons	White-fronted capuchin	N	N	Y	Y			F								Phillips, 1998
Cebus apella	Black-capped/ Brown/Tufted capuchin	N	N	Y	Y		C, F, S	C	F					C		Cooper & Harlow, 1961; Izawa & Mizuno, 1977; Strusaker & Leland, 1977; Antinucci & Visalberghi, 1986; Visalberghi, 1990, 1993; Fernandes, 1991; Anderson & Henneman, 1994; Westergaard & Suomi, 1994, 1995; Westergaard et al., 1995; Lavallee, 1999; Boinski et al., 2000; Cleveland et al., 2004; de A. Moura & Lee, 2004; Ottoni & Mannu, 2001; Ottoni et al., 2005; Schrauf et al., 2008
Cebus capucinus	White-faced capuchin	N	N	Y	Y		F			F			F	F		Bierens de Haan, 1931; Boinski, 1988; Chevalier-Skolnikoff, 1990; Baker, 1996
Cebus libidinosus	Bearded capuchin	N	N	Y	Y	F	F			F						Fragaszy et al., 2004; Waga et al., 2006; Visalberghi et al., 2007; Mannu & Ottoni, 2009
Cebus olivaceus	Wedge-capped capuchin	N	N	N	Y					F						Valderrama et al., 2000
Cebus xanthosternos	Yellow-breasted capuchin	N	N	N	Y		F									Canale et al., 2009
Cercocebus atys	Sooty mangabey	N	Y	N	Y					C						Galat-Luong, 1984; Kyes, 1988
Cercocebus galeritus	Agile mangabey	Y	Y	N	Y				C							Guillaume & Meyerson, 1934

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Cercopithecus ascanius	Red-tailed monkey	Y	N	N	Y					F						Worch, 2001
Cercopithecus aethiops	Vervet monkey	N	Y	N	Y				C	C						Galat-Luong, 1984; Pollack, 1998; Santos et al., 2006
Cercopithecus campbelli	Lowe's mona monkey	Y	Y	N	Y					C						Galat-Luong, 1984
Colobus badius	Red colobus	N	N	Y	Y									F		Struhsaker, 1975; Starin, 1990
Erythrocebus patas	Patas monkey	Y	Y	N	Y				C							Gatinot, 1974
Eulemur fulvus	Brown lemur	N	Y	N	Y				C							Santos et al., 2005
Galago senegalensis	Lesser bushbaby	Y	N	N	N										F[18]	Harcourt, 1981
Gorilla gorilla	Gorilla	N	N	Y	Y		C		C	C				C, F	F[16]	Kortlandt & Kooij, 1963; Redshaw, 1975; Fontaine et al., 1995; Nakamichi, 1999; Breuer et al., 2005; Pouydebat et al., 2005; Wittiger & Sunderland-Groves, 2007
Hylobates lar	White-handed gibbon	N	N	Y	Y		F	F						F	C[22]	Carpenter, 1940; Rumbaugh, 1970
Leontopithicus rosalia	Golden lion tamarin	N	Y	N	Y		C			C						Stoinski & Beck, 2001
Lemur catta	Ring-tailed lemur	N	Y	N	Y				C							Santos et al., 2005

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category									References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Macaca fascicularis	Long-tailed macaque	N	N	Y	Y	S, F	F	C	C	C, F					C[25]	Carpenter, 1887; Chiang, 1967; Karrer, 1970; Artaud & Bertrand, 1984; Zuberbühler et al., 1996; Malaivijitnond et al., 2007; Watanabe et al., 2007; Masataka et al., 2009; Gumert et al., 2009
Macaca fuscata	Japanese macaque	N	N	N	Y	F	F		C							Kawai, 1965; Tokida et al., 1994; Hihara et al., 2003
Macaca mulatta	Rhesus macaque	N	Y	N	Y	C		C	C							Shepherd, 1910; Hobhouse, 1926; Parks & Novak, 1993; Erwin, 1974
Macaca nemestrina	Pigtailed macaque	N	Y	N	Y				C							Beck, 1976
Macaca nigra	Sulawesi macaque	Y	Y	Y	Y		C									Babitz, 2000
Macaca radiata	Bonnet macaque	Y	N	Y	Y					F						Sinha, 1997
Macaca silenus	Liontailed macaque	N	N	Y	Y	F	C	C, S								Hohmann, 1988; Westergaard, 1988; Fitch-Snyder & Carter, 1993; Kumar et al., 2008
Macaca tonkeana	Tonkean macaque	N	N	N	Y		C		S	C						Bayart, 1982; Anderson, 1985; Ueno & Fujita, 1998; Ducoing & Thierry, 2005
Mandrillus leucophaeus	Drill	N	Y	N	Y					C				C		Armbruster, 1921; Galat-Luong, 1984
Mandrillus sphinx	Mandrill	Y	Y	N	Y									C		Schultz, 1961
Pan paniscus	Bonobo	N	Y	N	Y		C	C	C	C				S	S[24]	Jordan, 1982; Gold, 2002; Mulcahy & Call, 2006

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category										References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Pan troglodytes	Chimpanzee	N	N	Y	Y	F	C, F	F	C, F	C, F	F		C, F	F	F[19], C[20]	Jackson, 1942; Beatty, 1951; Goodall, 1964; Suzuki, 1966; Kortlandt, 1967, 1986; Jones & Pi, 1969; Strusaker & Hunkeler, 1971; Menzel, 1972; McGrew & Tutin, 1973; Teleki, 1973; Pi, 1974; McGrew et al., 1975, 1999; Plooij, 1978; Nishida, 1980; Nishida & Uehara, 1980; Sugiyama, 1981, 1985, 1995a, 1995b, 1997; McBeath & McGrew, 1982; Uehara, 1982; Anderson et al., 1983; McGrew & Rogers, 1983; McGrew & Collins, 1985; Sumita et al., 1985; Whitesides, 1985; Hannah & McGrew, 1987; Kitahara-Frisch et al., 1987; Kortlandt & Holzhaus, 1987; Yamagiwa et al., 1988; Bermejo et al., 1989; Boesch & Boesch, 1990; Brewer & McGrew, 1990; Gonzalez-Kirchner & Sainz de la Maza, 1992; Tutin & Fernandez, 1992; Alp, 1993, 1997; Huffman & Kalunde, 1993; Nishida & Nakamura, 1993; Boesch et al., 1994, 2009; Fay & Carroll, 1994; Suzuki et al., 1995; Tutin et al., 1995; Yamakoshi & Sugiyama, 1995; Inoue-Nakamura & Matsuzawa, 1997; Arcadi et al., 1998; Hirata et al., 1998; Yamakoshi, 1998; Bermejo & Illera, 1999; Whiten et al., 1999; Stanford et al., 2000; Tonooka, 2001; Humle & Matsuzawa, 2002, 2004; Mercader et al., 2002; Biro et al., 2003; Nishimura et al., 2003; Sanz et al., 2004; Hicks et al., 2005; Lonsdorf, 2005; Sherrow, 2005; Deblauwe et al., 2006; Matsusaka et al., 2006; O'Hara & Lee, 2006; Hernandez-Aguilar et al., 2007; Pruetz & Bertolani, 2007; Sanz & Morgan, 2007; Schöning et al., 2007; Furlong et al., 2008; Watts, 2008; Yamamoto et al., 2008

(Continued.)

Genus species	Common name	$N = 1$?	Captive only?	Tool manufact.?	True tool use?	Tool use category								References
						Food Prep	Food Extrac	Food Trans	Food Cap	Phys Main	Mate Attrac	Nest Const	Pred. Defen	Agon	Other	
Papio anubis	Olive baboon	N	N	N	Y	F	F		C	F				F	F[21]	van Lawick-Goodall et al., 1973; Pettet, 1975; Pickford, 1975; Benhar & Samuel, 1978; Oyen, 1979; Westergaard, 1992, 1993
Papio cynocephalus	Yellow baboon	Y	Y	N	Y				C							Nellman & Trendelenburg, 1926
Papio hamadryas	Hamadryas baboon	N	Y	N	Y				C							Beck, 1972, 1973a
Papio papio	Guinea baboon	N	Y	N	Y				C						C[23]	Beck, 1973b; Petit & Thierry, 1993
Papio ursinus	Chacma baboon	N	N	Y	Y		F		C					F		Bolwig, 1961; Marais, 1969; Hamilton III et al., 1975
Pongo pygmaeus	Orangutan	N	N	Y	Y	F	C, F	C, F	C, F	F				C, F	F[17]	Schaller, 1961; Ellis, 1975; Galdikas, 1982, 1989; Miller & Quiatt, 1983; Call & Tomasello, 1994; Rogers & Kaplan, 1994; O'Malley & McGrew, 2000; Peters, 2001; van Schaik & Knott, 2001; Fox & bin'Muhammad, 2002; van Schaik et al., 2003a, b; Fox et al., 2004; Nakamichi, 2004; Mulcahy & Call, 2006
Presbytis cristatus	Silvered leaf monkey	N	N	Y	Y									F		Lydekker, 1910
Saguinus mystax	Moustached tamarin	N	N	N	N										F[18]	Heymann, 1995
Saguinus oedipus	Cottontop tamarin	N	Y	N	Y		C		C							Hauser et al., 2002; Santos et al., 2006

[1] Dropped grains of sand directly on social halictine bee (*Lasioglossum zephyrum*) that was guarding an underground nest. Sand was used as weapon by the ants against the bees guarding the nest (elimination of foraging competition).

[2] Peel bark from branches that is then inserted into the nest as a perch.

[3] Placed the base of the upper mandible against a large rock, and kick gravel from beneath itself with its feet, moving the legs in rapid succession as if it were running, the bill being used as a brace.

[4] Caught small trout (*Salmo trutta*) rubbed it wings with the fish, with a second fish preened neck and breast feathers, upper wing coverts and carpal areas.

[5] Covered stores of food with lichens and bits of bark.

[6] Used 'bill-bracing technique' for stealing a masked booby (*Sula dactylatra*) egg. One individual used its bill as a lever shoving it under the egg and lifting, while another individual anchored its bill in the soft ground and then against a nearly stone and kicked the egg forcefully with both feet at the same time. Succeeded in moving an egg away from nest.

[7] Took food that had been placed out for stray cats and hid it under roof tiles for later consumption.

[8] Wring moss in beak to give chicks water.

[9] Used a feather loosened in the moulting process to apply secretion from uropygial gland to extended wing using sweeping motions.

[10] Used cup to bail water.

[11] Used 8 cm forked twig to remove snow from ground in order to search for insects.

[12] Carried a 6–7 inch feather to bird bath, immersed the feather, then swallowed it.

[13] Used pipe to bail water.

[14] Used small stones to right itself. Small stones were transferred to the posterior portion of the foot where they accumulated and allowed snail to right itself.

[15] 2.5 year old deserted by mother attempted to cover the remains of a kill with bits of snow and ice.

[16] Used branch as walking stick to test water depth while crossing a pool. Also used detached branch as bridge to cross swamp. Threw grass/branch towards observers. Used logs as ladders.

[17] Used a branch as a hook to pull a distant branch closer. Made a protective pad of leaves to protect hands and feet from thorns of *Erythrina* sp. Used leaves to amplify vocalizations. Used tools for sexual stimulation.

[18] Wet hands and feet with urine. Concluded that urine washing was a means of improving grip.

[19] Used leaves of parasol tree (*Musanga cecropioides*) as a leaf cushion, as well as leaves of the carapa tree (*Carapa procera*).

[20] Used poles as ladders to escape from outdoor enclosure. Manufactured pitons from saplings to aid in escape from enclosure.

[21] Adult male used a twig (5 mm in diameter and 10 cm long) to extract and separate 'bite sized' stone fragments from a rock and clay matrix.

[22] Created swings in cage by hanging rope and hose on mesh and bars.

[23] Stones used as hammers to break cement.

[24] Used branch as ladder and another as a club.

[25] Used a piece of cloth to transport other objects.

Appendix B: Databases consulted in compiling catalog

Database	Web address
Biological Sciences	http://csaweb103v.csa.com/factsheets/biolclust-set-c.php
Biosis Previews	http://library.dialog.com/bluesheets/html/bl0005.html
EBSCO Host/Academic Search Premier	http://support.ebsco.com/help/index.php?help_id=DB: 687
Environmental Sciences	http://csaweb105v.csa.com/factsheets/envclust-set-c.php?
JSTOR	http://www.jstor.org
Medline	http://www.oclc.org/us/en/support/documentation/firstsearch/databases/dbdetails/details/MEDLINE.htm
Primate Lit	http://primatelit.library.wisc.edu/
PsycInfo	http://csaweb105v.csa.com/factsheets/psycinfo-set-c.php?
Science Direct	http://www.sciencedirect.com/science/
Searchable Ornithological Research Archive (SORA)	http://elibrary.unm.edu/sora/
Web of Science	http://thomsonreuters.com/products_services/scientific/Web_of_Science
Zoological Record Online	http://library.dialog.com/bluesheets/html/bl0185.html

Appendix C: Reviews consulted in compiling catalog

Author (year)	Citation
Alcock, J. (1972)	The evolution of the use of tools by feeding animals. — Evolution 26: 464-473.
Anderson, J.R. (2002)	Gone fishing: Tool use in animals. — Biologist 49: 15-18.
Beck, B. (1980)	Animal tool behaviour: The use and manufacture of tools by animals. — Garland STPM Publishing, NY.
Boswall, J. (1977b)	Tool-using by birds and related behaviour I — Avic. Mag. 83: 88-97.
Boswall, J. (1977c)	Tool-using by birds and related behaviour II — Avic. Mag. 83: 146-159.
Boswall, J. (1977d)	Tool-using by birds and related behaviour III — Avic. Mag. 83: 220-228.
Boswall, J. (1978)	Further notes on tool-using by birds and related behaviour. — Avic. Mag. 84: 162-166.
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Chisholm, A.H. (1954)	The use by birds of "tools" or "instruments". — Ibis 96: 380-383.
Hall, K.R.L. (1963)	Tool-using performances as indicators of behavioural adaptability. — Curr. Anthropol. 4: 479-494.
Lefebvre, L., Nicolakakis, N. & Boire, D. (2002)	Tools and brains in birds. — Behaviour 139: 939-973.
Marler, P. (1996)	Are primates smarter than birds? — In: Current ornithology, Vol. 13 (Nolan Jr., V. & Ketterson, E.D., eds). Plenum, New York, NY, p. 1-32.
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Panger, M.A. (2007)	Tool use and cognition in primates. — In: Primates in perspective (Campbell, C., Fuentes, A., MacKinnon, K., Panger, M. & Bearder, S., eds). Oxford University Press, New York, NY, p. 655-677.
Pierce, J.D. (1986)	A review of tool use in insects. — Fla. Entomol. 69: 95-104.
Potter, E.F. (1970)	Anting by wild birds, its frequency and probable purpose. — Auk 87: 692-713.
van Lawick-Goodall, J. (1970)	Tool-using in primates and other vertebrates. — In: Advances in the study of behaviour, Vol. 3 (Lehrman, D.S., Hinde, R.A. & Shaw, E., eds). Academic Press, New York, NY, p. 195-249.
Whitaker, L.M. (1957)	A résumé of anting, with particular reference to a captive orchard oriole. — Wilson Bull. 69: 195-262.