Tool-Using in Primates and Other Vertebrates

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I. INTRODUCTION

Because tool-using has played a major role in the evolution of man, much attention has been directed to the use of objects as tools in lower animals. Anthropologists believe that a more detailed knowledge of tool use in primates, and of its origins, in ontogeny and phylogeny, will help to shed light on the development of tool use in early man. Behaviorists and psychologists have been primarily concerned with demonstrating either that tool-using behavior in nonhuman animals provides evidence of insight and "intelligence," or that it can be explained as purely "innate behavior." In fact, tool-using performances occur in species that are widely separated in the phylogenetic scale, and the evolutionary processes that have led to tool-using in, say, an insect on the one hand, and man on the other, are undoubtedly very different.

There is no general agreement in the literature as to what is, and what is not, tool-using in animals. In this chapter, a tool-using performance in an animal or bird is specified as the use of an external object as a functional extension of mouth or beak, hand or claw, in the attainment of an immediate goal. This goal may be related to the obtaining of food, care of the body, or repulsion of a predator, intruder, etc. If the object is used successfully, then the animal achieves a goal which, in a number

of instances, would not have been possible without the aid of the tool.

It may be helpful, at the outset, to make a clear distinction between a "tool" and "material." Tailor birds (*Orthotomus* spp.) have sometimes been considered to be tool-using birds (e.g., Thorpe, 1956). These birds make their nests within the fold of a large hanging leaf, the edges of which are "sewn" together with plant fiber. However, although this is undoubtedly a skillful manipulation of materials, it does not differ in any fundamental way from similar manipulations shown by other birds during nest-building. Some weavers (Ploceidae), for instance, may knot strands of grass around twigs with half-hitches (Crook, 1960).

It has actually been suggested (Lancaster, 1968) that we should perhaps consider the nest-making activities of all birds and mammals as examples of tool-using behavior. However, although one might argue, with Lancaster, that the finished product is a "tool" for sleeping or for the raising of young, it seems more logical to regard the beak and claws or mouth and paws of the bird or mammal as the tools in such cases, and the straws and leaves as the materials being manipulated. When someone is knitting, for instance, it is the knitting needles and not the wool or the finished jersey that are normally regarded as the tools.

Another category of behavior that is sometimes considered as tool or implement using is the string-pulling behavior of *Parus* spp. and some other passerines (e.g., Thorpe, 1956), monkeys (Klüver, 1933), and apes (e.g., Köhler, 1925). This again should perhaps be considered as skillful manipulation of objects rather than true tool use. The string and the food lure form a visual continuum and, in pulling on the string, the animal is merely pulling at a part of the food. A budgerigar will pull in a millet head if the end of the stem is put within its reach (personal observation): primates, in the wild, may pull lengths of vine hand-over-hand in order to reach shoots on the end (e.g., chimpanzees and baboons, personal observation; mangabeys, *Cercocebus albigena,* Chalmers, personal communication); and all monkeys and apes will break off or bend over branches in order to feed on fruit at their peripheries. Similar behavior is shown by elephants when they push over trees to feed on foliage otherwise out of reach.

It may put tool-using behavior, as such, in a better perspective if, before reviewing our present-day knowledge of the behavior in primates we briefly consider what is known of tool-using performances in non-primate mammals and in birds.[1] In doing so I shall include brief refer-

[1]There are a few examples of tool-using in invertebrates, and one fish "shoots" down insects by spitting water at them from the surface of the water. Some of these are mentioned by Hall (1963). But the evolutionary gap between an insect and a primate is too great to make it useful to review such performances in this chapter.

ences to types of behavior that seem to me to bear a close resemblance to tool-using, though not actually falling within my definition.

II. Tool-Using and Related Behavior in Birds

Several species of birds are known to use tools regularly, or fairly frequently, in order to obtain food, and one species shows this behavior during courtship. The other examples given below refer to instances of tool-use observed once or twice in a few individuals only, but in many cases further research may show that the behavior occurs more generally within the species. A variety of birds show behavior closely related to tool-using.

a. Use of Thorn or Twig as a "Skewer." Several species of shrikes *(Laniidae* spp.) impale or skewer their prey on thorns or other sharp projections on trees or bushes (e.g., Lorenz, 1950). The thorn is not manipulated by the bird in any way, and the behavior is not true tool-using. A pair of fiscal shrikes *(Lanius collaris)* in Tanzania used the same skewer throughout a two-year period, frequently flying 40 yards or more past other trees to the favored twig (personal observations). This use of a thorn skewer appears to be species-specific (Lorenz, 1950).

b. Use of Spine or Twig as a Probe. The only bird known to use tools as a normal part of its daily feeding pattern is the Galapagos woodpecker finch *(Cactospiza pallida),* which probes insects from crannies in the bark by means of a cactus spine or twig held in the beak (Fig. 1). When an insect emerges, the bird drops the spine and seizes the prey with its beak (Lack, 1947; Bowman, 1961; Eibl-Eibesfeldt and Sielmann, 1962; Eibl-Eibesfeldt, 1963, 1965). The bird has been seen to reject twigs that were too short. In addition, one bird tried (unsuccessfully) to break off the

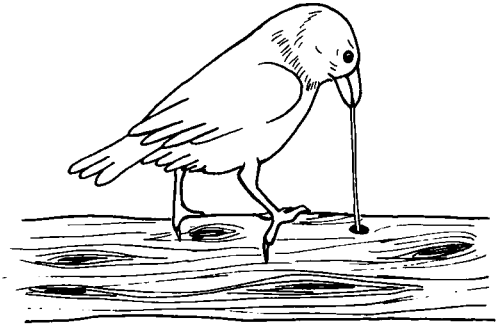


Fig. 1. Galapagos woodpecker finch using twig to probe insect from crevice in bark. (Drawing from photo by Eibl-Eibesfeldt.)

end of an excessively long probe, and another, having twice tried to insert the forked end of a twig into a cranny, broke it off at the fork and was thus able to use the implement successfully (Bowman, 1961). The bird may, therefore, be said to show the beginnings of object modification.

Eibl-Eibesfeldt (1963, 1965, 1967) obtained a young male Galapagos woodpecker finch which had been taken from the nest as a fledgling. He found that, although the bird showed manipulative interest in twigs and frequently poked about with them, when it was hungry and saw an insect in a hole it dropped the twig and tried to capture the prey with its beak, often without success. Eventually, however, during manipulative play, it learned the appropriate use of a twig as a probing tool.

c. Use of the Bark "Plug." During his courtship display, the male satin bowerbird *(Ptilonorhynchus violaceus)* uses a mixture of charcoal and saliva to "paint" the inside of his bower. While smearing the mixture onto the walls with the side of his beak he holds a small "plug" of bark fiber at the end of his beak and thus prevents the paint from dripping out. The behavior, which must be regarded as tool-using, is probably species-specific like the rest of the display (Bowman, 1961).

d. Use of Stones and Rocks. Birds make use of stones and rocks as "anvils" against which to break open food objects; and also as true tools, picking up stones to drop or throw on hard-shelled food.

i. Dropping or hitting food objects onto selected hard surfaces. This behavior is not, of course, true tool-using. There are a number of birds which drop food objects from the air to the ground below. Some gulls (Larinae) and crows *(Corvus)* often drop shellfish from a height, but usually it seems to be a matter of chance whether the prey falls on hard or soft ground (Hartley, 1964). However, the Pacific gull *L. pacificus* (Hartley, 1964), the lammergeier, *Gypaetus barbatus* (Huxley and Nicholson, 1963), the raven, *C. corax,* (Lorenz, personal communication), and the bald eagle, *Haliaeetus leucocephalus* (Bindner, personal communication) usually drop food objects onto rocky sites. The raven and the lammergeier drop bones in order to crack them and feed on the marrow. Favored dropping places of the lammergeier are littered with bone fragments (Huxley and Nicholson, 1963). Bald eagles have been observed flying into the air with tortoises or turtles, which they dropped from heights of several hundred feet over highways. The eagles then swooped down to feed on their prey. (Bindner, personal communication) On one occasion when the shell did not smash on impact, the eagle picked up the turtle in one foot and beat it time and again until, presumably, the shell was broken.

The song thrush *(Turdus philomelos)* and a bowerbird *(Scenepoeetes dentirostris)* have both evolved the habit of smashing snails against rock "anvils" (e.g., Hartley, 1964). In addition, two other species make use of anvils in order to crack egg shells. The Egyptian vulture *(Neophron percnopterus)* normally breaks any egg which it can pick up in its beak by throwing it at the ground or another egg. One individual, however, was tested with plaster eggs. After trying unsuccessfully to break them in the usual way, it carried them to an anvil stone several yards away and threw them forcefully against that (van Lawick-Goodall and van Lawick, 1968). Two crested seriemas *(Cariama cristata)* tested in captivity (Kooij and van Zon, 1964), broke hens' eggs by dropping them onto the ground. When presented with a lime egg, both birds first dropped it as usual and then carried it to an anvil and dropped it on that. When this was unsuccessful a definite throwing movement, similar to that shown by the Egyptian vulture, appeared for the first time.

ii. Dropping and throwing stones onto food objects, etc. The Australian black-breasted buzzard may drop rocks from the air onto the eggs of emus *(Dromaius novaehollandiae)*, the Australian bustard *(Ardeotis australis)*, or an Australian crane *(Grus* sp.) and then fly down to feed on the contents (Chisholm, 1954). A pair of African black kites *(Milvus migrans)* was also observed dropping stones. One bird picked up three stones in its talons, one after the other, flew some fifty yards with them, and dropped them at about 5-minute intervals: the second picked up and dropped two stones. All five stones were dropped from a height of about 60 feet. Unfortunately the observer, one of our assistants, did not immediately investigate: subsequently we found four of the five stones within an area of some five square yards at the bottom of a shallow grassy gully among some low bushes. We could find no indication as to why they had been dropped, but the behavior was probably connected with feeding, as the birds showed no aggressive diving or screaming during the performance.

In 1850, Africans in South-West Africa described how Egyptian vultures would fly above ostrich eggs, drop stones from their talons, and, having cracked the shells, feed on the contents of the eggs (Andersson, 1857). More recently we have observed Egyptian vultures throwing stones at ostrich eggs to crack the shells (van Lawick-Goodall and van Lawick, 1966, 1968). The vulture picks up a stone in its beak and throws it at an egg with a forceful downward movement of head and neck (Fig. 2). It continues throwing until the shell is cracked.

In view of the fact that the seriema breaks small eggs by throwing them down in the same way as the Egyptian vulture, some experiments were carried out at the Amsterdam zoo, on our behalf, by Dr. Dekker.

FIG. 2. Egyptian vulture about to throw stone at ostrich egg.

Two individuals were first presented with an ostrich egg: both birds, after pecking and clawing at the egg, picked up one stone each. These stones were dropped onto the ground quite far from the egg. During a second experiment some time later, one bird, after trying to pick up the egg (a rhea egg this time), picked up a stone and *threw* it at the ground. On the third testing neither bird picked up a stone, but on the fourth and last testing, when the birds were offered a goose egg, one seriema picked up a stone, carried it to a large "anvil" rock, and threw its stone at it. Further experiments are planned to try and ascertain whether these birds, in the wild, may in fact open rhea eggs in this manner.

iii. Use of stones as "weapons" and sticks for beating. Two captive bald eagles (one old bird of some 35 years and the other a 2- to 3-year-old taken as a fledgling from the nest) were observed using objects aggressively on a variety of occasions. Three times the old bird took a small rock in one foot and used this to smash crickets (twice) and one giant hairy scorpion. On a number of other occasions both birds, after first trying to use their feet but being prevented by the jesses with which they were secured, picked up stones in their beaks and threw them horizontally forward for distances of up to 24 inches at crickets (Fig. 3). Several times the crickets were killed by such throws. On no occasion was the victim eaten: once a cricket was picked up in the beak but immediately shaken violently to the ground as though it tasted unpleasant.

Both birds threw stones in the same manner at a tame Western gopher turtle—which was unharmed. Also each of the eagles once used a stick to "beat" this turtle. The stick was held in the beak, swung upward with a dorsolateral movement of head and neck, and brought down forcefully onto the objective. These movements were repeated until the turtle moved out of reach. In view of the fact that these eagles are known to feed on turtles in the wild (see Section d, i above), it is not clear exactly what these captive birds were trying to accomplish. Finally, the young eagle, when held "on the glove," frequently picked up the ring on its chain and threw it toward its owner. This continued until the bird hit him on the arm and thus obtained his attention, whereupon it immediately ceased the bombardment (Bindner, personal communication).

I have described these observations in detail because of the surprising number of different motor patterns adapted to the use of tools, and also because some of the incidents represent the only well-documented evidence of a bird apparently using an object as a weapon.

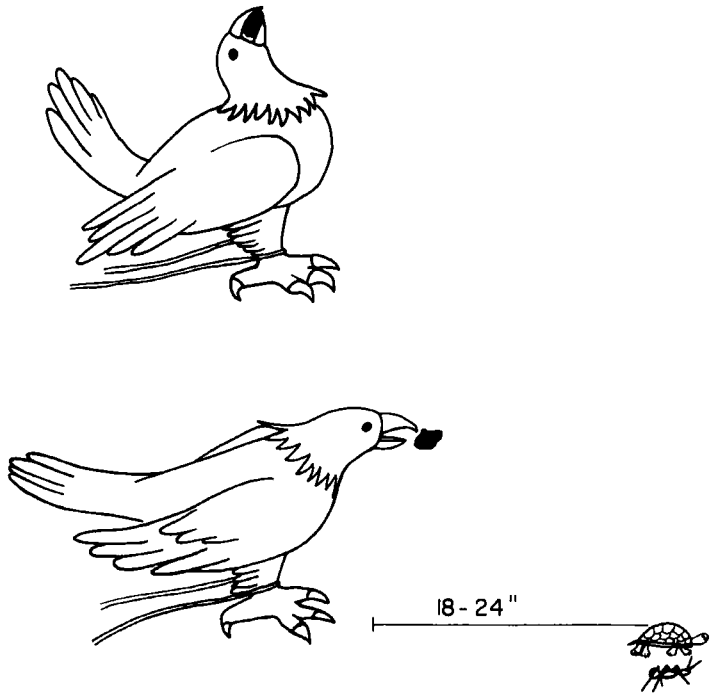


FIG. 3. Bald eagle throwing stone at turtle and cricket. (From original sketch by C. Bindner.)

e. Miscellaneous. Under this heading are two observations of tool-use in individual birds.

i. Use of bread as "bait." One green heron *(Butorides virescens)* repeatedly placed pieces of bread in the water where it was feeding and then caught and fed on the fish which came to nibble on the "bait." The heron did not eat the bread, and chased off other water birds which tried to do so (Lovell, 1957).

ii. Use of a "scoop." A captive cockatoo *(Kakatoeinae* sp.*),* when the water in its drinking container was low, regularly used a half walnut shell to scoop out the liquid. How the bird acquired this behavior was not known (Fyleman, 1936).

f. Discussion of Tool-Using Behavior in Birds. There has been little experimental work on tool-using behavior in birds, so that it is possible only to speculate on the ontogeny or evolution of a few of the patterns involved. The use of a skewer in the shrike, and probably of snail-smashing behavior in the song thrush, is species-specific. These be-

haviors almost certainly derive from the habit, shown by many birds, of hitting live prey against the substrate before eating it (Hartley, 1964).

The dropping of food objects from a height may have evolved from accidental release of the food while the birds tried to prize the shells open during flight—as has been suggested as an explanation of tortoise-dropping in the lammergeier (Hartley, 1964).

The Egyptian vulture throws stones at ostrich eggs using exactly the same movements as those seen when it throws a smaller egg at the ground, and it is from this pattern that the tool-using behavior undoubtedly derives. Moreover, when vultures were prevented from approaching an ostrich egg owing to fear of our car or the presence of higher-ranking birds, they invariably picked up stones and threw them repeatedly at the ground. This could perhaps be labeled as a displacement activity stimulated by the sight of the egg, as could also the stone dropping shown by the captive seriemas when they were presented with large eggs. If tool-using does *not* occur naturally in the seriema, it would be interesting to find out whether displacement stone dropping could lead to the use of a tool through trial-and-error learning.

Finally, while our present knowledge is too limited to suggest that object play may be important to the development of tool-use in some birds, it should nevertheless be mentioned that it is known to occur in several of the known bird tool-users. Eibl-Eibesfeldt (1967) describes how woodpecker finches frequently played with probes when satiated, poking insects out of holes only to push them back in to "hunt" again. Sometimes two birds stood one each side of a log and pushed a mealworm back and forth, one to the other, through a narrow tunnel. Eibl-Eibesfeldt does suggest, as we have seen, that it is during such manipulatory play that a young and inexperienced bird may learn to use twigs as tools in the feeding context. Lammergeiers (Huxley and Nicholson, 1963) have been observed to drop bones and then make lightening dives to seize them just before they hit the ground. Such activities might be repeated again and again before the birds finally smashed the food for eating. Finally it may be significant that for the bald eagle, the bird which shows the greatest variety of tool-using patterns to date, more varied object play has been recorded than is known to occur in other species. Thus it may play with turtles in the air in the same manner as the lammergeier with a bone. In addition, captive individuals frequently threw stones and other objects in the air and then pounced on them, and one was observed throwing a snake up with one foot, catching it as it fell to the ground, and throwing it up again. Moreover, in the wild, parent bald eagles take a variety of objects to their

nests, possibly for the young to play with. Rocks and turtles are thrown up and pounced on in the nest in play. Other objects found in nests range from spoons and balls to women's bras and panties (Bindner, personal communication). We shall return to the importance of object manipulation in play when discussing the development of tool use in the solving of problems in primates.

III. Tool-Using and Related Behavior in Mammals Other Than Primates

There are far fewer examples of tool-using behavior in this category of animal than among birds, and most of the examples to be given below refer to observations on individual mammals only.

1. Tool-Using and Related Behavior for Obtaining Food

a. Static Rocks Used as Anvils. A number of species of mongooses smash eggs by throwing or flinging them against hard surfaces. The dwarf mongoose, *Helogale undulata,* flings an egg between its hind leg at a rock or other hard surface: the marsh mongoose, *Atilax paludinosus* stands upright with an egg between its front paws and throws it at the ground (Dücker, 1957). The banded mongoose *Mungos mungo* may throw an egg (also glomerid millipedes) between its legs or down onto the ground (Dücker, 1957; Eisner and Davis, 1967). A tame white-tailed mongoose, *Ichneumia albicauda,* picked up an egg in its mouth, carried it to a rock, and dropped it. (J. Amet, personal communication).

b. Stones Used in Breaking Open Food Objects. The only non-primate mammal known to show true tool-using behavior as part of its everyday behavior is the sea otter, *Enhydra lutrus.* This animal dives to the sea bed and brings to the surface a shellfish together with an anvil stone. Lying on its back in the water it bangs the food against the rock, using both front paws, until the shell is broken (Fisher, 1939; Murie, 1940; Kenyon, 1959; Hall and Schaller, 1964). The latter investigators, working in California, in the southern part of the otters' range, found during a 3-week study that approximately 50% of the observed food intake of these otters was obtained by the use of anvils. It appears, however, that farther north the otters feed on different species of shellfish which the adults are able to open with their teeth: there are no reports of adults in the wild using anvils in this area, although a female was seen carrying a stone which she did not use. Youngsters, however, have been seen using anvils throughout the range—it appears that, in the north, their teeth are not strong enough to open the shellfish.

One experiment on two young wild-caught banded mongooses suggests that these mammals, too, may occasionally use objects as tools in their natural state. As we have seen, these mongooses typically crack eggs by hurling them through their legs at a rock anvil. When presented with an ostrich egg both mongooses first tried to push it between their legs, which was obviously impossible since the egg was larger than they were (Fig. 4), and then, with almost no hesitation, both took up stones

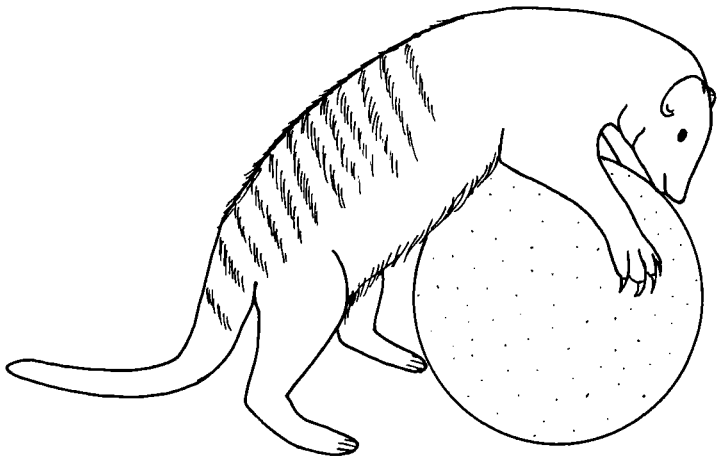


FIG. 4. Banded mongoose trying to hurl dummy ostrich egg between his legs. (Drawing from photo by P. McGinnis.)

in their front paws and hurled them back against the shell with good aim (Fig. 5). Whether or not they would have been successful is not certain, since the egg was a dummy (personal observation). Tests on wild mongooses of this species have not yet been successful because of their extreme wariness of strange objects.

2. Tools Used in Body Care

a. Sticks Used for Scratching. Three different nonprimate mammals have been observed to use sticks or straws for this purpose. Williams (1950) saw Burmese elephants pick up in their trunks long sticks with which to scratch their bodies. Huxley (cited in Thorpe, 1956) knew of a domestic goat which scratched itself with a straw held in its mouth, and Chapman (personal communication) has obtained evidence of a dock-tailed horse which frequently scratches itself with a stick (Fig. 6).

b. Stone Used in Grooming. Another tool-using individual is a Cocker Spaniel bitch which periodically uses a stone, marble, or other small

FIG. 5. Banded mongoose throwing stone between hind legs at plaster-filled ostrich egg.

hard object with which to "comb" the matted hair of her paws. She places the object against her upper incisors and draws the hair between the object and her tongue and/or lower incisors (Hart, personal communication; photos were sent as proof of this unusual behavior).

3. Objects Used as Missiles in an Aggressive Context

An Indian elephant in captivity, disturbed during the night by noises and lights in a neighboring cage, repeatedly hurled dung and straw over the dividing partition. This went on for several nights, the elephant gathering her "ammunition" into a pile in front of her before commencing the bombardment (Proske, 1957). To date the throwing of missiles has not been reported for wild elephants, although on two occasions African elephants *(Loxondonta africana)* tore off branches and waved them about in their trunks during mock charges or "intimidation displays" at the approach of a car (personal observation).

FIG. 6. Use of stick for scratching. (Photo by J. Chapman.)

4. Discussion of Tool-Use in Nonprimate Mammals

It appears, then, that so far as our present knowledge goes, only one nonprimate mammal, the sea otter, regularly uses objects as tools. So far as I am aware, no experimental work has been carried out on the development of the behavior. Hall and Schaller (1964) observed that young sea otters frequently manipulated objects, and sometimes pounded

objects together during play. Since these manipulatory patterns were in no way stereotyped, Hall and Schaller suggest that they might provide the basis for learning the use of tools in the feeding situation. These investigators also speculate that young otters may learn the actual tool-using technique from their mothers during the long period of dependency (Hall and Schaller, 1964). However, it would seem that youngsters in the northern part of the range, where adults probably seldom (if ever) use anvils, would have little opportunity for direct observational learning.

The throwing of stones by the two banded mongooses may have derived from the mongoose habit of throwing eggs or other food objects against hard surfaces. It is important to determine whether this was a spontaneous response of two individuals, or whether it is, in fact, common practice among wild mongooses of this species.

IV. Tool-Use in Primates

Tool-using behavior in primates falls into two distinct categories; the use of objects as weapons in aggressive contexts; and in nonagonistic contexts for obtaining food, for investigation, and for body care. While the use of objects as missiles is fairly common in a number of monkeys as well as in apes, examples of other types of tool-use have been only rarely reported in monkeys with the exception of *Cebus* species.

It has been suggested (Hall, 1963; Jay, 1968) that investigations into tool-using by animals, particularly by primates, should be limited to wild populations. Captive primates, it is argued, are living under abnormal conditions and their basic repertory of behavior may thus be affected. Individuals may show patterns that are not normal to the species as a whole. Although this may be so, it can be argued also that the potential ability to manipulate objects as tools in a given species is a fact as important to our understanding of the evolution of tool-use in primates, including man, as is the knowledge of whether or not an animal uses tools in its wild state. The fact that the abnormal conditions of captivity may induce a new behavior suggests that such behavior could occur in the wild too, given the right environmental stimulus. And, quite apart from this, our knowledge of primate behavior in the natural state is still extremely limited: if a primate shows behavior in captivity which has not been observed in the wild, this by no means implies that it does *not* occur in the wild.

Therefore, I shall briefly discuss tool-using performances known to occur in captive primates (other than those actually *taught* by demonstrations) as well as those known to occur in wild groups: in fact, as will

become apparent, tool-using is only infrequently recorded for captive individuals of species not known to use objects as tools in the wild.

A. Objects Wielded or Thrown in Aggressive Contexts

It is possible to trace a gradual increase in the effectiveness of objects used by primates as "weapons" during aggressive interactions with predators, intruders, or conspecifics. At one end of the scale is the shower of twigs, fruits, and so forth that may be dropped by monkeys onto an intruder below: when a group of coati *(Nasua narica)* were treated to such a bombardment by a group of *Cebus* monkeys *(C. capucinus)*, the "victims" merely waited under the tree to eat the ripe fruits included among the other "missiles" (Kaufmann, 1962). At the other end of the scale is the two-pound rock that may be hurled with deliberate aim by a chimpanzee: a research student at the Gombe Stream Research Centre, hit by such a missile, was limping for several hours and bruised for days.

Within the category of objects used during aggressive contexts, it is difficult to draw the line between true weapons, objects apparently purposefully used to intimidate predators or conspecifics, and objects used randomly during aggressive displays. Thus although a male chimpanzee who grabs a branch and waves and hurls it randomly during a charging display through his group cannot be said to be "using a weapon," his branch is, nevertheless, a more *effective* weapon than, for example, the handful of leaves that he may throw, with deliberate aim, toward a baboon. Nor is it always possible accurately to determine whether an object has been thrown or wielded randomly or purposefully. And so, particularly since the random use of objects may, as we shall see, lead directly to a more deliberate use of weapons, it is appropriate to discuss all aspects of object use that may occur in aggressive contexts rather than limit the field to weapon use as such.

1. Object-Use that Enhances Displays

A number of species of monkeys, gibbons, gorillas, and chimpanzees show characteristic displays, usually performed during intergroup encounters, but sometimes also as a response to intruders or during intragroup interactions. These displays are most frequently performed by adult males of the group. Vervets, *Cercopithecus aethiops* (Hall and Gartlan, 1965), patas monkeys, *Erythricebus patas* (Hall, 1965), colobus monkeys, *Colobus guereza* (Marler, 1968), and langurs, *Presbytis entellus* (Jay, 1968; Yoshiba, 1968) bounce and jump vigorously through the branches. During such displays quite large branches may be knocked off: in patas

(Hall, 1965) and langurs (Yoshiba, 1968) at any rate this often appears to be deliberate. Gibbons, *Hylobates lar* (Ellefson, 1968), swing through the trees and knock large dead branches down with their feet, also in a seemingly deliberate manner. The gorilla, *Gorilla gorilla beringei,* may perform a characteristic display that includes tearing off handfuls of vegetation and branches which may be hurled (usually randomly) as the animal charges (Emlen, 1962; Schaller, 1963). And the chimpanzee, *Pan trogolodytes* spp., during his branch waving or charging display may brandish and hurl large branches (Fig. 7) and throw or roll stones or large rocks (Reynolds and Reynolds, 1965; van Lawick-Goodall, 1968). In none of these displays are the branches or rocks typically directed toward other individuals; yet the crashing of branches through the leaves or the hurling of objects through the air undoubtedly serves to enhance the displays.

In the chimpanzee, such displays may sometimes function to maintain or enhance the social status of the individual performing it. One male chimpanzee at the Gombe National Park appeared to make deliberate use of abnormal objects to better his charging displays: this, in turn, probably led to his becoming the dominant male of the group. In 1964 he held a very low social status. In December that year he began to use empty 4-gallon parafin cans during his charging displays. Initially he used one can only, hitting it ahead of him with alternate hands or occasionally kicking it as he ran. After a while he was able to keep three cans on the move at once without noticeably diminishing his speed. The effect of such performances on his conspecifics was dramatic; the noise of the cans was tremendous and, as he approached, the other chimpanzees hurried out of his way, including those who held a much higher status. Often he repeated the display three or four times, running straight toward one or more of the other chimpanzees present. When he finally stopeed, the others usually approached and directed submissive gestures toward him. After 4 months we removed all cans, but by then he had acquired the number one position—which he still holds five years later. That his use of these cans was deliberate is suggested by the fact that, once the pattern was established, he would often walk calmly to the tent and select his cans. He dragged these quietly to a place from where he could, for instance, watch a group of conspecifics resting and then sat quite still for 5 minutes. Then he gradually started to rock, his hair slowly erected, he began a series of calls and then finally charged straight toward the peaceful group.

Chimpanzees and gorillas in captivity, deprived of natural display objects, may spit saliva or water, or throw feces at spectators, often after

FIG. 7. Mature male chimpanzee at the Gombe National Park brandishing a stick during a charging display.

rushing around the cage banging on the walls (Hewes, 1963; Riopelle, 1963; Wilson and Wilson, 1968; van Lawick-Goodall, personal observation).

2. Objects Shaken or Dropped from Above

This behavior occurs both in monkeys and apes.

a. In Monkeys. Some species of monkeys include in their threat repertory the vigorous shaking or hitting of branches (e.g., howler monkeys *Alouatta palliata,* Carpenter, 1934; red spider monkeys *Ateles geoffroyi,* Carpenter, 1935; rhesus monkeys *Macaca mulatta,* Hinde and Rowell, 1962; baboons *Papio* spp., Hall, 1962; DeVore and Hall, 1965; Hall and DeVore, 1965; van Lawick-Goodall, personal observation). This behavior may dislodge fruits and leaves and result in a shower of debris falling close to or onto the predator or other creature which has incited the monkey's aggression. In addition, in some of these species individuals may purposefully break off branches, for example, and drop them with definite relation to the predator or intruder below. Howlers and red spider monkeys may react in this way to the presence of human observers (Carpenter, 1934, 1935) and, as we have seen, capuchins picked and dropped objects onto a group of coati (Kaufmann, 1962). No deliberate throwing movements were observed in any of these monkeys although the spider monkey "may cause the object to fall away from the perpendicular by a sharp twist of its body or a swinging circular movement of its powerful tail." Also these monkeys may pick branches and then retain them for a few moments until the intruder is more directly below (Carpenter, 1935).

Reliable reports of similar behavior in Old World monkeys made by trained observers are lacking, although Boulenger (1937) describes behavior that may be analogous in Patas monkeys *(Erythrocebus patas)* in West Africa, and Kortlandt and Kooij (1963) present undocumented instances of the dropping of objects by macaques, guenons, and colobus.

b. In the Apes. Gibbons (Carpenter, 1940), gorillas (Schaller, 1963), orangutans (Wallace, 1869; Schaller, 1961; Harrisson, 1962, 1963), and chimpanzees (personal observation) have all been observed to shake branches and break off and drop them in a similar way onto intruders below. The behavior seems to be particularly characteristic of the orangutan, presumably because both chimpanzees and gorillas usually move away on the ground when disturbed, whereas orangutans frequently climb even higher in a tree and then drop or throw branches.

3. Random and Aimed Throwing

Throwing differs from the behavior described above in that a forceful movement of the arm is involved: it may be apparently unaimed and random, or deliberately directed toward an objective.

a. In Monkeys. A captive *Cebus* monkey *(C. apella)* frequently threw objects at persons it "disliked." Initially it threw from the ground and was thus usually able to hit only people's legs. Eventually, however, it would climb quickly onto a chair or table with its missile, which it then threw at its victim's head (Romanes, 1882). Kortlandt and Kooij (1963) also cite reports of throwing in nine zoo *Cebus* monkeys.

Bolwig (1961) has recorded purposeful aimed throwing in a captive baboon, *Papio ursinus.* In addition Kortlandt and Kooij (1963) obtained reports on throwing in thirty-one baboons in zoos as compared with twelve for all other monkey species (excluding *Cebus*). As these authors themselves pointed out, the numbers of the different species in these zoos was not known and the figures, therefore, are of interest mainly because of the relatively large number of throwings recorded for baboons.

There is little evidence of true throwing in wild monkeys. Kortlandt and Kooij (1963) collected twelve reports of throwing in baboons, but no details of the motor patterns or behavioral contexts are given. It seems unlikely that the behavior is a common pattern among baboons in the wild: neither Hall nor DeVore (Hall, 1962; Hall and DeVore, 1965) observed throwing in the baboon groups they studied, nor has the behavior been seen in the baboons *(P. anubis)* at the Gombe National Park despite the fact that for five years they have been frequently aimed at and sometimes hit by stones thrown at them by chimpanzees (see below).

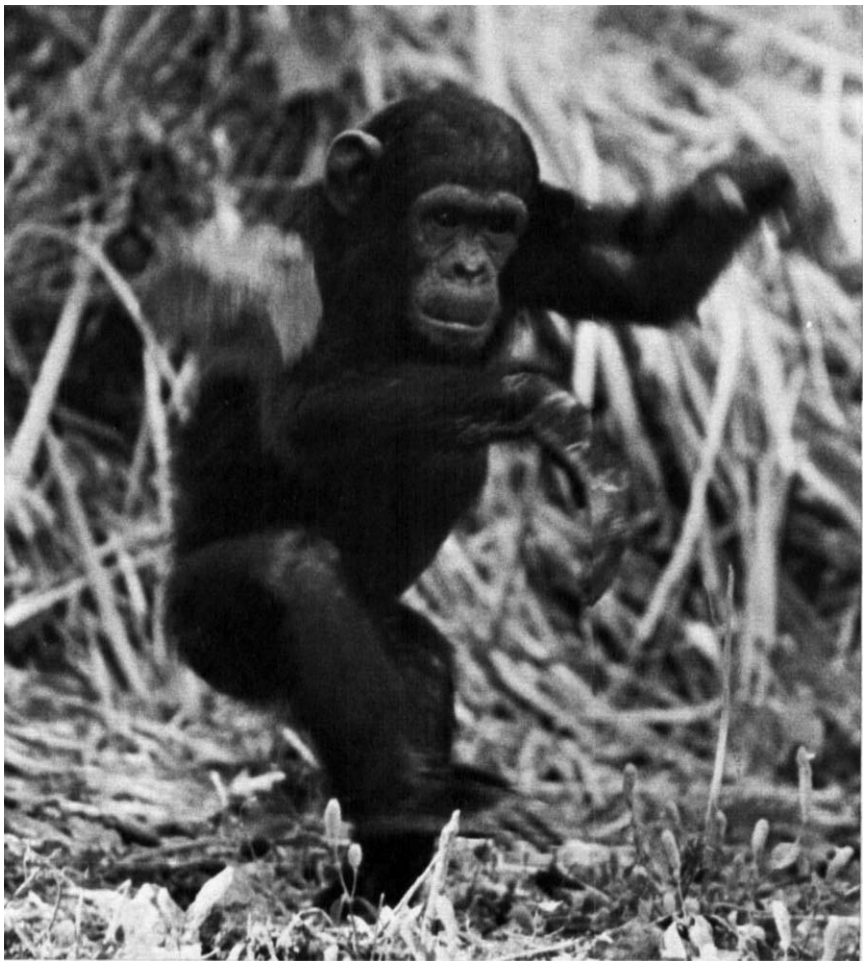
b. Throwing in Captive Apes. All three species of the great apes have been observed to throw objects in aggressive contexts in captivity (e.g., Köhler, 1925; Yerkes and Yerkes, 1929; Kortlandt and Kooij, 1963). Young chimpanzees, when first they arrive in captivity, usually show poor aim; the aim, however, improves with practice (Köhler, 1925; Kortlandt and Kooij, 1963). When young chimpanzees are taught to aim and throw experimentally, they may succeed in obtaining good scores (Morris, 1959; Kortlandt and Kooij, 1963).

c. Throwing in Wild Apes. As we have seen, gorillas and chimpanzees may throw branches, rocks, etc., at random during their chest-beating and charging displays. Orangutans *(Pongo pygmaeus)* also may hurl branches and so forth down toward intruders in a seemingly random manner (Schaller, 1961).

In addition to this random hurling, true aimed throwing has been observed in orangutans and chimpanzees in the wild. Orangutans may throw large fruits and branches in the direction of humans below (Schaller, 1961; Harrisson, 1962). Chimpanzee groups in the Congo and in

Guinea, when confronted with a stuffed leopard, were observed on a number of occasions to throw sticks toward the dummy: the groups living in thick rain forest showed poor aim whereas chimpanzees in the more open habitat in Guinea achieved a greater number of direct hits (Kortlandt, 1962, 1965, 1967; Kortlandt and Kooij, 1963).

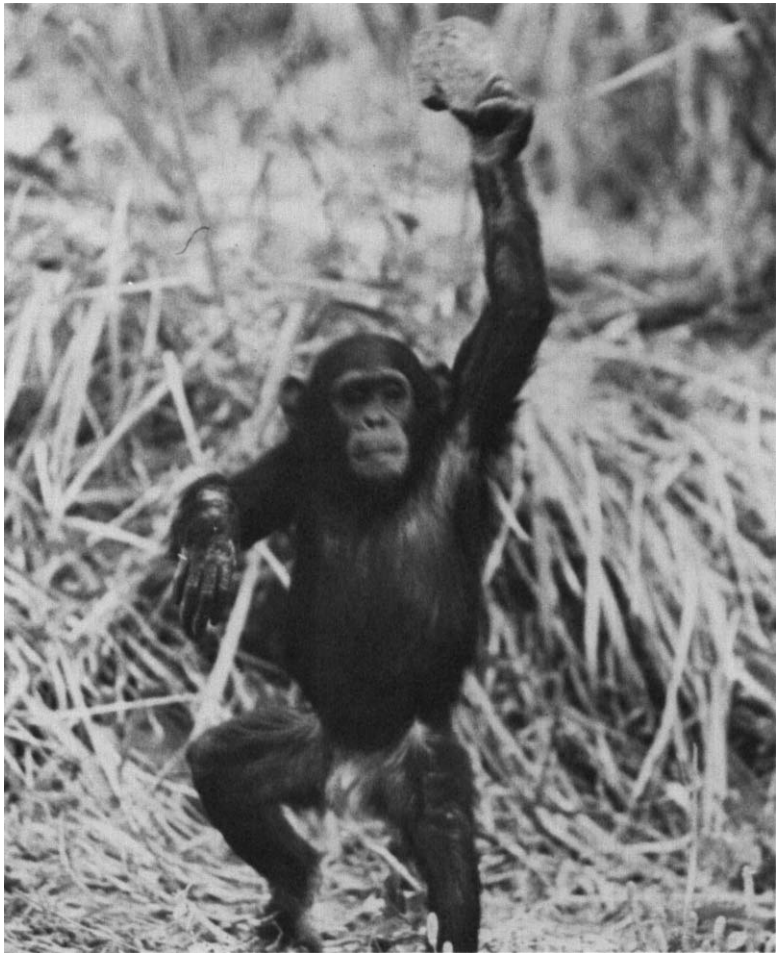
In the Gombe Stream area, chimpanzees, on numerous occasions, aimed and threw sticks, stones, or other objects at baboons, humans, and occasionally conspecifics. Such behavior almost always occurred



FIGS. 8 and 9. Three and a half-year-old male chimpanzee throwing large stone at photographer.

when the context suggested that the throwing was aggressive. The chimpanzees threw either underhand or overarm (Figs. 8 and 9)—in either case the movements were similar to those made by a man performing similar actions. Kortlandt (1967) wrongly states that "the overhand throwing technique [does not] belong to the natural behavior inventory of the African apes." Throwing was more common in males than females (see also Kortlandt and Kooij, 1963), but one female at the Gombe became an expert thrower.

Although the data have not yet been fully analyzed, it is certain that, subsequent to the setting up of a feeding area for the chimpanzees (where they engage in frequent competition with baboons for bananas),



aimed throwing has increased both in frequency and efficiency.[2] Thus during the first year of the feeding station, five of sixteen male chimpanzees were observed to take aim and throw in aggressive contexts, and of the nine objects thrown only three were large enough to be potentially effective. By the end of the following year, aimed throwing had been recorded in three additional males and just over half of the thirty-two objects thrown that year were large rocks. The frequency of actual hits, however, showed no improvement (one the first year, four the second). The chimpanzees aim was good, but the missiles usually fell short of their objectives (Goodall, 1964; van Lawick-Goodall, 1968). Since then the frequency of throwing has continued to increase and is a fairly common aggressive pattern in some juveniles and one female. In addition a greater percentage of direct hits has been recorded.

4. Swaying Branches and "Whipping"

During an aggressive interaction, a chimpanzee may seize a growing branch or sapling and sway it very vigorously to and fro or up and down (van Lawick-Goodall, 1968). Frequently the "victim" is hit or whipped by the distal ends, sometimes very hard indeed. Kortlandt (1962, 1965, 1967; Kortlandt and Kooij, 1963) observed individuals in a number of different groups using saplings as whips in response to a stuffed leopard. At the Gombe Stream, the behavior was directed toward humans, baboons and, quite frequently, conspecifics, particularly during "dominance fights" between adult males (van Lawick-Goodall, 1968).

5. Branches Used for Brandishing, Hitting, and "Clubbing"

This type of behavior, although it has been observed in a monkey and occasionally in gorillas and orangutans, appears to be most common in captive and wild chimpanzees.

a. In a Monkey. There is only one well-documented observation of a monkey using a stick for hitting a victim. A *Cebus (Cebus fatuellus),* after waving a stick around, used it to beat another monkey with which it was sharing a cage (Cooper and Harlow, 1961). Kortlandt and Kooij (1963) list a few records of "Agonistic (incipient) clubbing/stabbing" behavior in captive capuchins, and one for a baboon, but again they give no details of context, nor are the motor patterns described.

[2]A very similar increase in the frequency and efficiency of aimed throwing was reported by Köhler (1925) for his group of captive chimpanzees at Teneriffe.

b. In Captive Apes. Köhler (1925) briefly mentions one young female orangutan, who demonstrated "all shades of explosive actions with various implements up to complete armed attack on an enemy," and Harrisson (1963) describes how a young tame orangutan picked a twig, ran after a snake, and hit it. The other reports on the use of sticks as weapons in captive apes nearly all refer to chimpanzees. In a large group of chimpanzees in New Mexico several instances of one individual hitting another with a stick have been recorded. On one occasion the victim of a "gang fight" was beaten with a 2-foot long stick and received many cuts on his back (Wilson and Wilson, 1968). Kortlandt observed adult chimpanzees in an enclosure rush about brandishing large sticks when a live leopard was led to the top of the surrounding wall. Two adults rushed right up to the wall, dropping or flinging their sticks aside as they jumped up toward the leopard. On a later occasion, one of the adults, a mother, forcefully hit with a very large "club" the stuffed leopard which had been placed in the enclosure (Plate 8 in Kortlandt, 1967).

Kortlandt and Kooij (1963) also cite other examples of "clubbing" in captive chimpanzees. Again, however, the motor patterns are not described in detail, and it appears that these authors do not always differentiate between investigatory tapping or poking and aggressive hitting or stabbing. Thus they cite one instance of a chimpanzee which "alternated his striking at a pangolin by a few stabbing movements." This observation, in fact, concerned a chimpanzee that was merely investigating—tapping with his stick and occasionally poking at the strange animal (H. van Lawick, personal communication).

Köhler (1925) comments that the chimpanzees of his group at Teneriffe nearly always used sticks to investigate small creatures such as lizards or mice. But when the creature made a rapid movement in the direction of the chimpanzee concerned, the stick "became a weapon" and the victim was hit hard. If the creature did not manage to escape, it was killed anyway—not "deliberately" but "in the sheer excitement of the pursuit and capture." Kortlandt and Kooij (1963) also describe chimpanzees in captivity beating small creatures to death with sticks.

c. In Wild Apes. Gorillas may brandish branches during the chest beating display (Emlen, 1962; Schaller, 1963). One young male gorilla, holding a long stick in his hand, charged at a trapper. Before reaching his objective, however, he stopped, dropped the stick, and retreated (Kortlandt and Kooij, 1963).

Wild chimpanzees, as we have seen, frequently drag or wave branches during their charging displays. These may be picked up from the ground

or torn from a tree (van Lawick-Goodall, 1968). In addition, while charging directly toward or past predators or other creatures which have aroused their hostility, chimpanzees have been observed to seize and brandish large sticks and branches. Thus many of the wild chimpanzees which encountered Kortlandt's stuffed leopard responded by waving and brandishing branches as they charged toward or around the model (e.g., Kortlandt, 1967).

At the Gombe National Park the chimpanzees sometimes brandished sticks in this manner during aggressive interactions with baboons (Fig. 10) and conspecifics. In addition these chimpanzees occasionally made purposeful hitting movements toward animals or other objects—such as their own reflections in a mirror (Fig. 11) and, once, some sort of insect (Fig. 12). The chimpanzee grasps the stick firmly in one hand and brings it down toward the objective. Sometimes these "clubbing" movements were very forceful, but quite often the weapon was released

FIG. 10.—Three and a half-year-old male brandishing a stick as he approaches baboons at the feeding area.

FIG. 11. Male chimpanzee just about to hit toward his mirror image.

before the moment of contact. Nevertheless, the behavior differed markedly from the random brandishing of branches described above. Once an old female received a very hard blow across her back, and I saw one baboon hit very hard with a dead palm frond. When chimpanzees used sticks as true weapons, they nearly always adopted a bipedal position (see also Kortlandt and Kooij, 1963; Wilson and Wilson, 1968).

FIG. 12. Infant "clubbing" an insect. The type of grip, at the moment of impact, is typical for these chimpanzees.

6. *Use of Potential Weapons during Social Play*

Just as aggressive patterns such as biting and hitting are incorporated by primates into their social play, so, in chimpanzees at any rate, we find examples of the playful use of "weapons." Köhler (1925) describes how the chimpanzees of his captive group frequently approached humans or conspecifics while brandishing sticks, and sometimes two would wave sticks at each other. Occasionally these chimpanzees hit each other quite hard during play, without causing an aggressive response from the playmate. It is significant that, if a quarrel did arise

between two chimpanzees playing with sticks, then the "weapons" were flung aside and the animals attacked each other with hands and teeth. Köhler also observed the throwing of objects during play; and the use of pointed sticks for jabbing unsuspecting humans, dogs, or domestic hens also appeared to be a type of "game."

A similar use of potential weapons was also observed at the Gombe Stream. Occasionally large sticks were waved or dragged about during social play; the wild chimpanzees were not, however, observed to hit each other during play with sticks. Playful throwing was observed twice, both times during play bouts between juveniles: dead sticks were broken from a tree and thrown, overarm, with deliberate aim. Once an infant picked up a hard clod of earth to which was attached a few long dry grasses. Holding the ends of the grasses in one hand he swung the clod beating his playmate with it time and again.

7. *Development and Evolution of Weapon-Use in Primates*

As we have seen, many species of monkeys and all the apes may hit at or shake branches during aggressive displays directed toward enemies. As Hall (1963) has pointed out, it seems logical to suppose that if a branch shaken down by a monkey actually hits the intruder below, this will be more rewarding to the monkey concerned than if this did not happen. In the same way, a large branch which hits the enemy will probably produce a more rewarding response than would a small twig. It seems probable, therefore, that in species known for their learning ability, repeated experiences rewarded in this way might cause the slight modification of the threat-gesture repertory which is necessary in order for them to break off objects and drop them purposefully.

Tree-dwelling monkeys and the more arboreal apes have little incentive to develop true throwing behavior—it is often more practical to drop something through an observed gap in a tangle of branches than to try to throw. However, the fact that capuchin monkeys as well as orangutans are able to throw in captivity shows that arboreal species may indeed develop true throwing behavior.

That throwing behavior has been recorded in baboons is not surprising. As Hall (1963) pointed out, not only do baboons hold and shake branches in threat directed at an enemy, but they also manipulate stones as they turn them over during feeding and, when suddenly startled by a small noxious insect, these primates may make a swift, underarm hitting away movement. Thus the baboon has available the motor patterns necessary to direct objects as well as gestures toward predators or intruders.

The apes are anatomically better adapted to make throwing movements than are the monkeys: the ape shoulder girdle, like that of man, enables him to throw with power (Washburn and Jay, 1967), and he is also anatomically adapted for standing upright, a good posture for forceful throwing. In addition the chimpanzee, when threatening a conspecific, baboon, or human, may make arm movements very similar, or exactly similar, to those seen during aimed throwing (Fig. 13). On some occasions at the Gombe Stream, a chimpanzee let fly (almost by accident it seemed) some object that it happened to be holding—such as a banana—during an aggressive encounter with a baboon. Because the threat gesture was directed toward the baboon, the object also traveled in that direction.

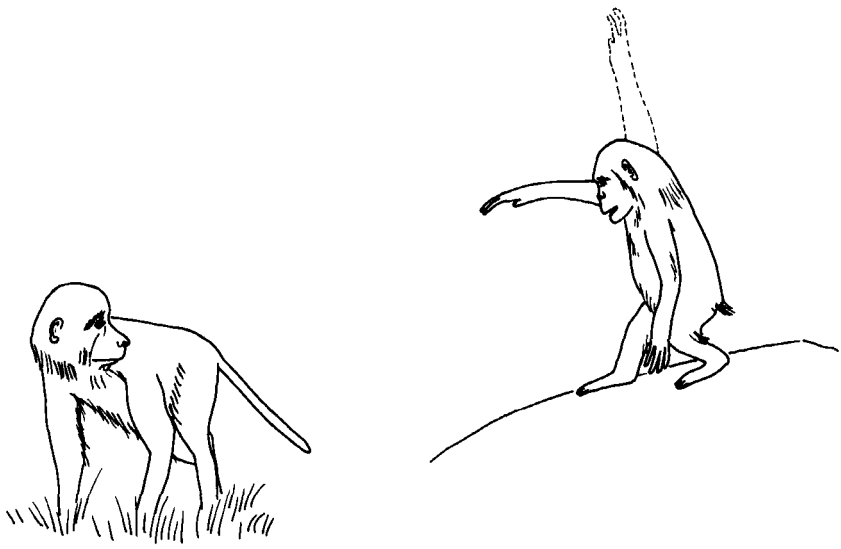


FIG. 13. Juvenile chimpanzee directing threat gesture toward baboon. Compare Figs. 8 and 9. (Drawing from photos by H. van Lawick.)

Some chimpanzees at the Gombe Stream threw far more frequently than others: there are a few adult males who have never been observed to throw in aggressive encounters. Possibly, therefore, an important factor in the development of aimed throwing lies in the experience of the individual: the success of an "accidental" throw might well reinforce the behavior so that it is repeated in a similar aggressive context. Observational learning, which will be discussed in a subsequent section, might also play a role in the development of aggressive throwing.

In addition, throwing, as we have seen, occurs during the lone play of infants in the wild. This is not directed, but it provides an opportunity for the youngster to become familiar with stones and probably also aids in the development of the motor patterns involved. Throwing during social play in young chimpanzees, although it was rarely observed at the Gombe Stream, might also play a role in the development of aggressive aimed throwing.

A similar hypothesis may be put forward regarding the development of the use of sticks as weapons in chimpanzees. It is but a short step from the violent shaking of a branch to the deliberate swaying of a branch which causes the ends to touch or whip the object which has aroused the individual's hostility. Similarly, the random waving of branches during charging displays frequently causes other chimpanzees or baboons to rush out of the way—sometimes they may actually be hit. The screaming, running away, or cringing responses induced by such random branch-waving might well be sufficient "reward" to reinforce the branch-waving pattern. Moreover, some movements shown by a chimpanzee during normal threat or attack are very similar to the hitting movements when a stick is wielded.

Kortlandt's investigations with captive and wild apes have demonstrated convincingly the readiness with which chimpanzees will throw objects and brandish sticks in aggressive contexts. This has led Kortlandt to put forward a hypothesis which postulates that these behaviors must have had their origins in savanna-dwelling populations of chimpanzees and gorillas. When early man invented the spear, so Kortlandt argues, the apes, with only their primitive stick clubs and ability to throw, were driven back into the forests. In the more open forests, the chimpanzees retained their throwing and clubbing abilities to a considerable degree of proficiency: in the thick rain forests such activities were impractical and survived only as vestigial patterns. (e.g., Kortlandt, 1967).

An alternative theory to Kortlandt's "dehumanization" theory is that the anatomical structure of the chimpanzee, its inherent threat-gesture repertory, its innate tendency to manipulate objects (Schiller, 1949), and its marked ability to learn from past experience (e.g., Köhler, 1925; Yerkes, 1943) enables throwing and hitting to develop independently in different individuals.

That chimpanzees in more open habitats show a greater proficiency in throwing is not surprising, for they have a better chance to "exercise" and develop the behaviors. It is true that even in the thickest rain forest a chimpanzee could throw branches or brandish them as he displayed along an animal trail, but he certainly has less opportunity to acquire

weapon use. It is equally plausible to regard weapon use as a latent behavior in forest populations of chimpanzees as to regard it as a vestigial pattern. Many people cannot play tennis, but everyone (if he is physically fit) has the capacity to learn how to.

Over and above these arguments is the fact that at least two forest-living primates, the capuchin and the orangutan, show true aimed throwing in captivity (Yerkes and Yerkes, 1929; Harrisson, 1963; Kortlandt and Kooij, 1963). Kortlandt argues that the zoo orangutan seldom throws as compared with the zoo chimpanzee (Kortlandt and Kooij, 1963). This, however, is possibly an artifact of zoo conditions, which are far more alien to the strictly arboreal orang than to the more terrestrial chimpanzee. Thus orangs usually become morose and lethargic very quickly: indeed, Harrisson (1963) writes that their development may be "arrested by lack of incentive to exercise." That such conditions are adverse to such behavior as spontaneous throwing is suggested by the fact that a young orangutan being reintroduced to the wild frequently threw, usually as a form of play but often with good aim (Harrisson, 1963).

Kortlandt (e.g., 1967) also postulates that chimpanzees use sticks as clubs during encounters with leopards in the wild. While it seems reasonable to suppose that chimpanzees might, in fact, use stones or sticks as missiles to *throw* at a predator, such as a leopard, it seems unlikely that, under normal circumstances, a chimpanzee would approach a healthy adult leopard close enough to hit it with a stick. Also, as Washburn (1963) has commented, "unless a stick is well selected and skillfully used an ape's teeth are far more effective." In Kortlandt's 1967 report he includes an excellent photograph of an adult female chimpanzee in a large enclosure hitting the stuffed leopard. She is using a very long stick which she is holding by its thinnest end. If the leopard were alive, this would scarcely be an effective weapon.

Kortlandt's hypothesis is, of course, based on the behavior he observed when he presented chimpanzees, in captivity with a chained, caged, or stuffed leopard; and in the wild, with the stuffed one. But it is not sensible to assume that an animal as "intelligent" as a chimpanzee is likely to be "duped" into believing that a stuffed leopard (even if it does wag its head) is normal, or that a chained or caged leopard is dangerous. Gnadeberg (1962) describes the behavior of a dog which, upon seeing that his stronger rival was tied up, calmly strolled into the other's territory, quite ignoring the vain struggles of the superior dog to pull free. "Evidently he recognized the lack of danger" comments the author. If a dog can take advantage of such a situation, then a chim-

panzee most certainly can: one cannot, therefore, assume that the reactions of chimpanzees to live wild leopards will be the same as those elicited by a stuffed model or a securely tied captive.

Unfortunately the only two encounters between chimpanzees and wild leopards which have been recorded did not involve mature male chimpanzees (Izawa and Itani, 1966; van Lawick-Goodall, 1968). In neither case did the chimpanzees involved use weapons of any type. It is necessary to await further evidence from the field before either rejecting or accepting Kortlandt's suggestion that "groups of savanna-dwelling chimpanzees do indeed fiercely attack living leopards in the wild" (Kortlandt, 1967).

B. Tool-Using by Primates in Nonagonistic Contexts

The use of objects as tools in nonagonistic contexts has rarely been reported in free-living or captive primates with the exception of *Cebus* monkeys and the apes: only the chimpanzee is known to use tools frequently and in a wide variety of situations. In this section I shall discuss tool-using performances directed toward food-getting, investigation, and body care which occur in wild primates and in those living under normal captive conditions, together with a brief summary of performances which appear in experimental situations designed to test the ability of the subjects to use objects as tools in the solving of problems.

1. Tool-Using for Obtaining or Preparing Food (Other Than in Experimental Laboratory Situations

a. In Monkeys. Wild *Cebus* monkeys have been observed to peel the bark from twigs and then use them as probes to prize insects from under bark (Thorington, cited in Jay, 1968). In captivity *Cebus* monkeys (e.g., *C. apella, C. capuscinus)* have been observed on a number of occasions to use rocks or other hard objects to crack open nuts (Romanes, 1882; Vevers and Weiner, 1963; Tobias, 1965) and eggs (Kooij and Zon, 1964). Interestingly, these monkeys also open nuts by hitting them directly onto the ground, and an egg was opened in the same way. (Hill, 1960; Kooij and van Zon, 1964).

Rhesus macaques in Singapore have been observed using leaves to rub dirt from food—and from other objects such as an elastic band (Chiang, 1967). Possibly nonfood items are rubbed as a form of playful manipulative behavior.

The use of water by the Japanese macaque *(M. fuscata)* to wash sweet potatoes and wheat (Kawamura, 1959; Frisch, 1968) is not usually considered tool-using, but it seems somewhat arbitrary to draw a line be-

tween the plucking of a leaf, which is invariably close to hand, and the deliberate immersion of a food object in water. Sometimes the monkeys travel a good many yards in order to wash their food: also, of course, the water cleans off the dirt far better than rubbing with leaves. A captive vervet monkey also developed the habit of washing food in her drinking bowl (Gartlan and Brain, 1968).[3]

In addition to the above, Kortlandt and Kooij (1963) mentioned a baboon squashing a scorpion with a stone and then eating it, and another using a stick to prod about in a termite nest. A *Colobus* monkey and a mangabey were also reported to use sticks while feeding on termites. It would not be surprising if these monkeys used tools in the wild: however, since no details of the behaviors, nor the conditions under which they were observed, are given, we should perhaps await further evidence before fully accepting these performances.

b. In the Great Apes. i. Use of rocks. The use of a stone as a hammer has been recorded only twice. Savage and Wyman (1843–1844) quoted an example of a chimpanzee using a rock to open a small hard-shelled fruit, and Beatty (1951) observed a chimpanzee in Liberia pound open the kernals of palm nuts in this way. One infant chimpanzee at the Gombe Stream pounded on the ground several times with a stone, but we were not able to find out what his objective had been—possibly the action was simply nondirected play.

ii. Use of sticks to reach food out of reach. While this is one of the most commonly discussed tool-using patterns of captive great apes, there are only two isolated observations of the behavior in the wild: one gorilla and one orangutan drew food toward them with sticks (Pitman, 1931; Kortlandt and Kooij, 1963).

iii. Use of sticks for digging. Köhler (1925) describes how the chimpanzees of his captive group ate roots by digging with their hands. The use of sticks for digging started independently of this behavior, as a form of play, but was quickly adapted to the digging for roots. The chimpanzees not only held the sticks in their hands: sometimes they placed the soles of their feet on the uppermost ends and pushed, and sometimes they gripped one end between their teeth and pushed with the head and neck. It is of interest that a young tame orangutan, when pushing a stick into an insect nest, also occasionally gripped the tool with his teeth (Harrisson, 1963).

[3]It may be of interest to note here that the so-called food "washing" behavior of the raccoon *(Procyon lotor)* does not appear to be motivated by a need to clean the food. The behavior may serve to create, in captivity, a natural situation and function "to allow the expression of a thwarted independent feeding mechanism" (i.e., the feeling for food objects in rivers) (Lyall-Watson, 1963).

iv. Use of sticks as levers. Captive chimpanzees and orangutans frequently use sticks, iron bars, or similar objects to try to force apart the bars or mesh of their cages (e.g., Boulenger, 1937; Harrison, 1962). One group spent long hours trying to lever up the lid of a water tank (Köhler, 1925). In a similar manner the chimpanzees at the Gombe Stream began to use sticks to try to prize open the lids of boxes containing bananas (Fig. 14). Usually the chimpanzee, after breaking off a suitable stick, stripped off the leaves (see also Köhler, 1925) and often

FIG. 14. Mature female trying to pry open lid of box that contains bananas. Her infant (on the box) and a juvenile watch intently.

bit splinters off one end so that they formed a chisel-shaped edge. The chimpanzees were very persistent in their attempts—presumably because we occasionally opened a box at which one was working and thus reinforced the behavior.

Another use of sticks as levers at the Gombe Stream was observed when two individuals made repeated attempts to force an opening into the large nest of a species of arboreal ant [*Crematogaster (Atopogyne)* sp.]. The chimpanzees tried to push their sticks between the nest and the branch to which it was attached. The walls of these nests are extremely hard and after some 5 minutes the chimpanzees abandoned their attempt.

v. Use of sticks, twigs, and grasses when feeding on honey and insects. Wild chimpanzees have been observed poking sticks into the nests of bees and licking off the honey (Merfield and Miller, 1956; Izawa and Itani, 1966). At the Gombe Stream, chimpanzees were observed using large sticks to enlarge the entrance of bees' nests: holding the sticks in both hands they pushed them backward and forward. They then reached for the honey with their hands.

At the Gombe Stream the chimpanzees also used sticks when feeding on two species of ant, the arboreal *Crematogaster,* as described above,[4] and *Anomma* sp. (safari ant). In both cases the sticks were pushed into the nests, left for a few seconds, and then withdrawn covered in ants which were then eaten either directly from the stick or after being gathered together as the chimpanzee swept the stick through his free hand. Occasionally, when a chimpanzee came across a line of *Anomma* traveling across its path, it held a grass stem or twig among the insects and picked off those that climbed onto the tool. This is exactly similar to ant-eating behavior observed by Köhler (1925) in all the individuals of his captive group.

The most frequently observed tool-using behavior in the Gombe Stream area is the use of stems and small twigs during termite *(Macrotermes bellicosus)* feeding. After opening up a passage in a termite mound, a chimpanzee picks a grass stem or small twig and pushes it carefully down the hole. After a slight pause he withdraws the tool and picks off with his lips and teeth the insects clinging to it. The tool is held between the thumb and the side of the index finger (Fig. 15) with a precision grip (Napier, 1960).

Some individuals use as a tool any material that is at hand; others carefully inspect various clumps of grass before selecting a tool. Often several tools are picked at a time for immediate and subsequent use. Tools are frequently prepared carefully: leaves may be stripped from twigs, strips pulled from blades of grass, thin strips of fiber detached from bark. When the end of a tool gets bent, the end may be bitten off

[4]I never found out whether the chimpanzees opened the nests themselves or took advantage of openings made by the ants during swarming.

FIG. 15. Old female "fishing" for termites.

(cf. Köhler, 1925 p. 94), the other end used, or a new tool selected. Sometimes when only a few termites, or none at all, are biting onto his tool, a chimpanzee may use one after another in quick succession, poking in two or three times with one tool and then discarding it for another—as though it is the tool that is at fault. No chimpanzee was observed to move out of sight of the nest at which it was working to collect a new tool, but often tools were selected for subsequent use when a nest might be as much as 100 yards away and out of sight (Fig. 16). One male traveled for half a mile with the same tool in his mouth, inspecting one termite nest after another, none of which was ready for working.

The use of tools for termiting was not observed in infants under two years, although from about 9 months of age youngsters sometimes watched their mothers intently (see also Fig. 14). Older infants, between one and two years old, often manipulated and prepared "tools" as a form of play activity during the termite season (three or four months a year). A one and a half-year-old once jabbed a short twig at the surface of a nest (there was no hole there) using the power grip (Napier, 1960)—rather as a small human infant holds a spoon or pencil (Gesell,

FIG. 16. Chimpanzee mother, after picking a grass tool for use at a termite nest approximately 60 yards away and out of sight, pulls her infant from a play session prior to leaving.

1940). Infants between two and three years of age used tools in the correct contexts, but the behavior was characterized by the use of inappropriate material (too short, too thick, etc.) and clumsy technique (the tool was often pulled from a hole with a jerking movement which would have dislodged any insect that had bitten on). Thus during twenty-two bouts observed in these infants (varying from a few seconds to 5 minutes in length), I saw only two termites caught. Three- to four-year-old infants still used tools inefficiently. The tools were sometimes longer, but they were often too flexible (see also Fig. 17, which shows a very flexible stem selected by an infant for pushing into an artificial "honey bowl"). In addition, during termiting, infants of this age often pushed only one or two inches of their tools into the hole—as compared with the five to eight inches often inserted by adults. Four-year-old infants showed a more adult technique, although their tools were usually shorter

FIG. 17. Three-year-old male infant using inappropriate tool (too long, too flexible) while sampling honey from an artificial underground "honey bowl" at the feeding area. The two adults who tried the honey selected long but very firm stems.

than those of adults; they often persisted for as long as 15 minutes as compared with the usual bouts of less than 5 minutes of the 3-year-olds.

vi. Use of stick to knock food object to the ground. This occurred once at the Gombe Stream when a mature male was afraid to take a banana held out to him by hand. After staring at the fruit he shook a clump of grasses in mild threat. He then shook them more violently and one of the stems touched the banana. He stopped shaking, let go of the grasses, plucked

a thin plant from the ground, dropped it immediately and broke off a thicker stick. He then hit the banana to the ground, picked it up and ate it. When a second banana was held out he used the tool immediately. This observation is of interest since it was the only time when it was possible to observe what was probably an original solution to a completely new problem involving tool use in the wild.

c. Use of Sticks, Twigs, and Grasses as "Olfactory Aids" during Feeding. During termite feeding behavior, a chimpanzee frequently pokes a stem into a hole which he has just opened and then, on pulling it out, sniffs intently at the end. Seemingly as a result of this behavior, he then either works at the hole or tries elsewhere. On four occasions young chimpanzees poked twigs into holes in rotten branches. After withdrawing their tools and sniffing the ends, three of them then broke open their branches. Twice this revealed grubs (probably wasp larvae) which were eaten. Once an adult wasp flew out. The fourth individual was only 3 years old: her "probe" was too thick and the end broke off in the hole. She tried to poke it out and then gave up. Another chimpanzee pushed a stick into a larger hole in a tree trunk and, after intently sniffing the end, dropped it and moved away.

Three times, when I prevented a juvenile from reaching into my pocket to feel if there was a banana there, she poked long grasses in and then sniffed their ends. Each time there was, in fact, a fruit there and she followed me whimpering until I gave it to her.

Other examples of sticks used to investigate occurred out of the feeding context and will be described under Section B,2 below.

d. Use of Straws and Leaves for Drinking. In captivity chimpanzees have been observed dipping straws into water through cracks in a tank lid and licking them, and also drinking in this manner when water was fully accessible (Köhler, 1925). A chimpanzee at London Zoo dipped a straw into melted ice cream in a carton and licked it (personal observation). In the same zoo a gorilla selected an unbroken rye straw which he pushed through the bars until the crushed end reached a pool of his own urine outside. After soaking the absorbent end, the gorilla withdrew the stalk and put the liquid to his lips. This was repeated many times (R. Teleki, personal communication, 1968).

The normal practice among chimpanzees at the Gombe Stream, when they were unable to reach water with their lips (e.g., when rainwater had collected in a natural water bowl in a tree trunk), was to use leaves as "sponges" to sop up the liquid. I saw individuals drinking in this way from natural hollows and also from bowls artifically scooped out at the

feeding area. The chimpanzee usually strips leaves from a nearby twig and briefly crumples them by chewing, thus increasing their absorbancy. The leaf mass, held between the index and second finger, is then pushed into the bowl, withdrawn, and the water is sucked out.

A 2-year-old infant used leaves in the adult manner, but twice chose very tiny ones. A three and a half-year-old infant, however, after first dipping his hand into the water then poked in a piece of dry grass, using movements similar to those observed during termite feeding. Each time he put it to his mouth, he chewed the end: eventually, therefore, the stem was a tiny crumpled mass—a minute "sponge" (Fig. 18). Soon he abandoned this and poked in, again with termiting movements, a long narrow dead leaf. When he withdrew this, he immediately crumpled it in his mouth to make a sponge. On subsequent occasions he once used a similar leaf, but abandoned it after 2 minutes; once he used a leaf mass left by another individual; and once the back of his fingers again. Three other infants were observed using sponges in apparently playful contexts: the same may be true for the infant just described.

2. Sticks and Twigs Used to Investigate Unfamiliar Objects

In captivity chimpanzees readily use sticks to poke and prod at small creatures of which they are afraid or at fire (Köhler, 1925; Kortlandt and Kooij, 1963; Butler, 1965).

Among wild chimpanzees, I have not observed exactly this type of poking and prodding, but sticks are used to *smell* unfamiliar objects. When a dead python was placed at the feeding area one 8-year-old female, who had been staring at it for some time, first sniffed the end of a long palm frond on which the snake had lain, and then pushed it, hand over hand, until its tip touched the python's head (which was bloody). She then withdrew the implement and sniffed the end intently. (Pythons, although they occur in the area, are rarely seen.) On another occasion a juvenile, when he was prevented by his mother from touching his newborn sibling, repeatedly touched her gently with a stick and then sniffed the end (Fig. 19).

3. Objects Used in Body Care

Köhler (1925) comments on the fact that although the chimpanzees of his group often indulged in coprophagy, if they accidentally trod in feces they would limp away to find something with which to wipe themselves clean. Blood was dabbed with leaves or straw, often moistened with saliva, and one female constantly wiped her genital area with leaves during her menstrual periods.

FIG. 18. Three and a half-year-old male after crumpling a "grass stem tool" into a "sponge tool" while drinking at an artificial water bowl.

At the Gombe Stream the wild chimpanzees use leaves to wipe feces, mud, sticky fruit juice, urine, and blood from their bodies in precisely the same way (Fig. 20). I never observed menstrual blood being wiped away with leaves, but when a chimpanzee had diarrhea it often wiped

FIG. 19. Five-year-old "investigates" his newborn sibling.

itself clean with a very large handful of leaves. As Köhler also observed wounds were dabbed rather than wiped, and the leaves were then licked and reapplied to the wound. Several times chimpanzees pulled sprays of leaves toward them and rubbed vigorously after heavy rain. Once a juvenile wiped sticky banana from the head of her infant sibling with leaves. This was the only occasion when a chimpanzee was seen to wipe another individual; one infant, 9 months old, ran to his mother whimpering after falling into a heap of diarrhea, but she ignored the mess. No infant under 10 months of age was seen to wipe itself.

In addition to the above use of leaves, a female chimpanzee once used a twig apparently to pick her teeth, after first using her finger nail, and an infant briefly used a twig to pick his nose. No chimpanzee in the wild has, so far, been observed to use an object to scratch itself, as was observed in captive chimpanzees (Köhler, 1925).

4. Some Unusual Tool-Using Patterns That May Appear in Captive Primates

One common behavior in captive chimpanzees (Köhler, 1925; Yerkes, 1943) and orangutans (Harrisson, 1962, 1963) is the use of straw, cloth, or comparable materials as covering for the body at night, or during cold weather. One adult female chimpanzee, shut out in her open enclosure late in the evening, first started to make a nest but eventually collected a mass of leaves and straw and piled it all on her back (Köhler, 1925). Only one observation in the wild which may relate to this behavior con-

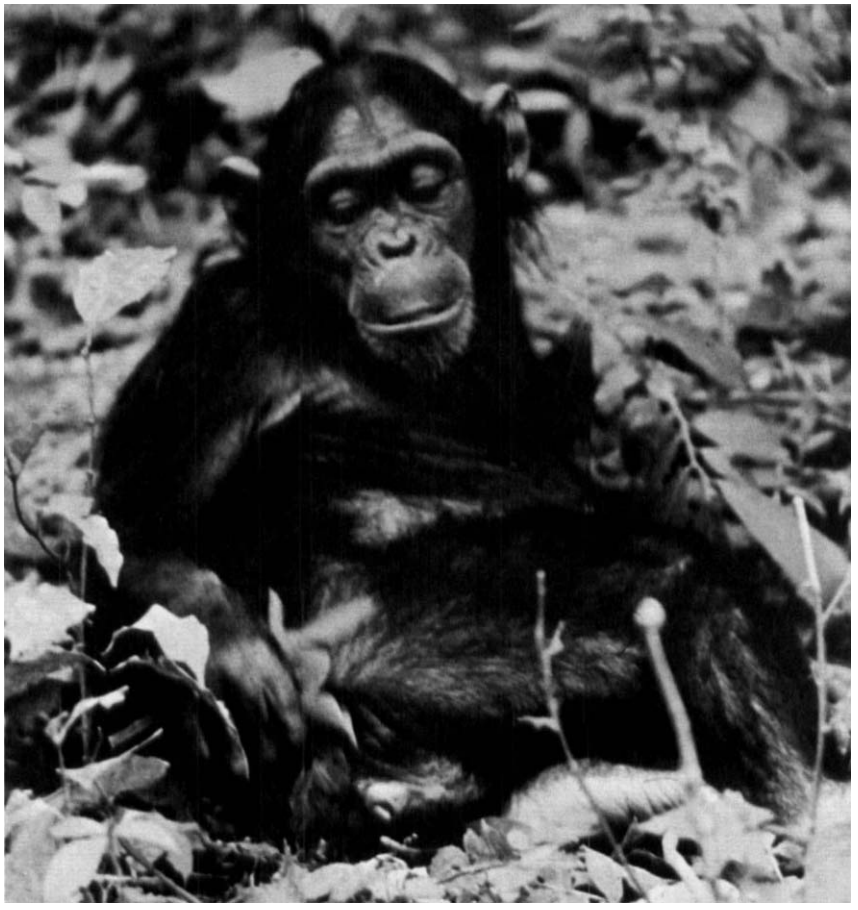


FIG. 20. Juvenile wipes blood from her clitoris with leaves after being bitten during a squabble.

cerns an adult male chimpanzee who picked a leafy branch and laid it over himself during rain (Izawa and Itani, 1966).

Another example of tool-use is the painting and drawing behavior described for captive capuchins, orangutans, gorillas, and chimpanzees (Morris, 1962; Rensch, 1965). Yerkes (1943) observed frequent use of feces by chimpanzees to plaster cage walls and other objects. Köhler (1925) gave chimpanzees lumps of white clay: after tasting the substance the chimpanzees wiped their lips on some object and showed interest in the white smears this made. Soon they began moistening clay with their mouths and "painting" objects with their whitened lips: eventually they

used their hands to apply the clay rather like whitewash. A young orangutan made marks with its finger in the wet sand (Harrison, 1962) and one 2-year-old wild chimpanzee at the Gombe Stream did the same on one occasion.

Finally one strange "tool-using" pattern has been recorded in three different primate species—the use of bread to feed animals of different species. A West African *Cercopithecus* sp. which was kept as a pet often sat above the household dog and held out pieces of bread for which the dog begged. Sometimes the monkey then dropped the food to the dog (personal observation). A tame capuchin, similarly a household pet, held out pieces of bread to lure ducks to come within its reach, which it then caught and killed (Boulenger, 1937). And a group of captive chimpanzees often held bread out to domestic hens and then, when the birds were within reach, stabbed them with sticks, apparently as a form of "amusement." One female actually fed the hens, holding the food in her hand as the hen pecked at it, or throwing bread outside the bars and "watching benignly" as the birds fed (Köhler, 1925).

It is not within the scope of this paper to discuss the many and varied ways in which objects are used as tools by home-raised apes (e.g., Kohts, 1935; Hayes, 1951).

5. Ability of Primates to Use Objects as Tools in Laboratory Experiments

Some monkeys, gibbons, and the great apes have been the subjects of laboratory experiments designed to reveal the extent to which they are capable of using tools to solve a variety of problems. Chimpanzees, in particular, have been extensively tested in this way.

a. Food out of Reach beyond Cage Bars. Capuchin monkeys *(Cebus* spp.) may use objects as varied as sticks, wire, rope, cardboard, and cloth to pull in food baits (Klüver, 1937). An individual chacma baboon *(P. ursinus)* used sticks to rake in food (Bolwig, 1961).

Yerkes tested the gibbon in this situation and found that it was able to pull in fruit with a rake provided the bait was between the cage and the rake at the start of the experiment. A gorilla was unsuccessful until the experimenter demonstrated the procedure. The orangutan was able to draw in food with a rake and also by throwing out and drawing in pieces of cloth (Yerkes and Yerkes, 1929). Chimpanzees are invariably able to solve this problem (e.g., Köhler, 1925; Yerkes and Yerkes, 1929; Birch, 1945; Schiller, 1949). Once a chimpanzee was reasonably experienced in this test situation, Köhler (1925) observed that, although it occasionally picked up an unsuitable implement, it normally abandoned this as it walked toward the bars and set off in search of more

suitable material (e.g., a longer stick). One individual, however, held two short sticks in her hand in such a way that they "looked" like one long stick and repeatedly tried to use this inappropriate tool. Chimpanzees frequently showed object-modification or tool-making in this situation (see Section B,6 below).

b. Food Objects Hung out of Reach. The chacma baboon mentioned above solved this problem by placing against the wall a stick, which she then used as a ladder (Bolwig, 1961). A *Cebus* monkey, *C. capucinus;* (Bierens de Haan, 1931), an orangutan (Yerkes and Yerkes, 1929), and chimpanzees (Köhler, 1925; Yerkes and Yerkes, 1929) successfully climbed sticks in this situation. The animal holds the stick upright under the food and then climbs up fast, seizing the reward as the stick falls. Cebus monkeys and chimpanzees are able to drag boxes underneath hanging food in order to reach it: one capuchin was able to stack three boxes in this way (Bierens de Haan, 1931), and chimpanzees may pile up one on top of the other up to five boxes (Köhler, 1925; Schiller, 1949). An orangutan and a gorilla, however, were able to use boxes in this way only after being taught (Yerkes and Yerkes, 1929). Chimpanzees (Köhler, 1925) and an orangutan (Yerkes and Yerkes, 1929) attempted to pull the experimenter under hanging fruit in order to climb him, and one chimpanzee tried to pull his conspecifics in the same way.

c. Food Objects inside Boxes. Chimpanzees have successfully used long poles or rods to push food through a long, narrow box or tube open at both ends; this test involves the use of a tool to push the reward *away* from the animal in the first place (Yerkes, 1943; Khroustov, 1964). An orangutan solved this problem spontaneously, but a gorilla was unable to do so without being taught (Yerkes and Yerkes, 1929).

Other problems involve the opening of closed boxes with keys, levers, screwdrivers, and so forth, but in most cases the use of the tool must first be taught and need not concern us here (e.g., Rensch and Döhl, 1967; Rensch and Dücker, 1966).

6. *Object Modification or Toolmaking*

We may consider the seemingly simple act of breaking a branch from a tree as an initial step in the modification of an object for use as a tool. Laboratory chimpanzees unacquainted, or at least unfamiliar with, trees may not "perceive" an attached branch as a potential tool with which to reach food outside the bars. Schiller (1949) states that finally his chimpanzee subjects broke off branches, but that this was an expression of

frustration which bore no relation to the problem in hand. Only when the branch was thus separated from the tree could it be perceived as a tool. Köhler (1925), however, whose group of chimpanzees was more familiar with trees, reported that some of his subjects broke off branches for tools with direct reference to the problem in hand, although most of them did not immediately come to this solution. In the instance of the wild chimpanzee male at the Gombe Stream who hit a banana from a human hand with a stick, the breaking off of the implement caused no greater difficulty, once he had found the solution to the problem, than would be the case with a man. It is of interest, too, that a wild-born baboon was also able to solve a problem that involved breaking a branch from a tree for use as a tool (Bolwig, 1961).

That it is, in fact, necessary for chimpanzees to become familiar with objects before they can use them as tools, let alone modify them in toolmaking, has been demonstrated by Birch (1945) and Schiller (1949). In addition Köhler (1925) and Schiller (1949) showed that certain complex manipulatory patterns involved in object modification (such as fitting two tubes together) could not be solved when the chimpanzee was "concentrating" on a food bait. Once the manipulation had been satisfactorily accomplished during free play, however, the pattern was normally available for use during a test situation. This fact should not surprise us: it is unlikely that an Australian aborigine who had lived all his life in the bush would immediately be able to use a pair of fire tongs to pick up a piece of coal which had fallen from the fire.

In the wild, of course, all the patterns used by the Gombe Stream chimpanzees in the modification of objects for tool-use—such as the stripping of leaves from twigs, the pulling of fibers from bark, or the crumpling of leaves for a "sponge"—are readily available. Such manipulations of twigs and leaves occur daily during feeding and nest-making (van Lawick-Goodall, 1968).

In captivity, extensive experiments have been conducted in order to find out to what extent the chimpanzee is capable of toolmaking. It has shown itself capable of breaking splinters or boards from boxes for use as "sticks"; uncoiling part of a length of wire for the same purpose; removing sand or rocks from boxes so that they may be pulled under a hanging bait; bending a few long thin straws in half to make a firmer "stick"; and fitting two and even three tubes together to form a long tool—provided, of course, it has become familiar with these objects prior to the test situation.

The most far-reaching experiments to date on the chimpanzee's capacity for toolmaking are those of Khroustov (1964) summarized by

Tobias (1965). A chimpanzee, having solved the simple problem of pushing a food bait through a hollow tube with a rod, was subsequently required to perform modifications of increasing complexity on a variety of materials in order to obtain a tool that could be inserted into the tube. The ape managed to break cross pieces from the ends of a stick, and to break suitable fragments first from rectangular and then circular boards of wood. After a series of experimental sessions, the above requirements were satisfactorily met. It was noted that the chimpanzee, when breaking off suitable splinters, followed the grain of the wood: when false grain was superimposed the ape initially tried to follow this, but subsequently broke off his tool along the true grain of the wood. As a final experiment the chimpanzee was presented with material which it could not break with its teeth or hands, together with a Chellean hand axe. At no time, however, did the chimpanzee attempt to use the implement provided, even though, for the first time in the series of experiments, he was repeatedly shown the correct use of the axe. Unless further experiments along these lines, perhaps with different materials or different individual chimpanzees, prove that a chimpanzee can, in fact, use a tool to make a tool, we must conclude that this stage of sophistication in toolmaking is beyond the mental capacity of apes.

7. Evolution and Development of Nonagonistic Tool-Use in Primates

It is of interest to consider the behavioral contexts from which this type of tool-using may be derived, and also the extent to which individual experience and learning play a part in the development of tool-using patterns.

a. Behavior from Which Tool-Using May Be Derived. The hands of living primates are well adapted to grasp and handle a variety of objects (Napier, 1960). Furthermore, monkeys and apes, both in the wild and in captivity, do manipulate things constantly, not only during feeding, grooming and so on, but also, particularly in the case of youngsters, during play and during exploratory behavior, when new or unusual features of the environment are carefully examined (e.g., Köhler, 1925; Yerkes and Yerkes, 1929; Menzel, 1964; Butler, 1965; van Lawick-Goodall, 1968). Schiller (1949) has suggested that many of the manipulative patterns observed in primates may be "innate" and that from such patterns adaptive behavior such as tool-using may be derived.

In captivity *Cebus* monkeys, as we have seen, may hammer open hard food objects against the ground or a rock. In addition, these monkeys frequently pick up stones and other objects and bang them against the

ground, apparently as a form of play activity (Hill, 1960). Thus *Cebus* monkeys show a tendency to use objects as hammers from which purposeful tool-using may well be derived.

Young chimpanzees in captivity, if allowed to play with sticks, normally use these to poke or tap at a variety of objects before touching them with either hands or lips (Menzel, 1964; Butler, 1965). In addition chimpanzees, as well as other primates, may actually manipulate levers, buttons, and so on in test situations for no other reward than the performance of the activity (Schiller, 1949; Harlow, 1950). It is not difficult, then, to imagine that a young chimpanzee in the wild, as he played by a termite nest, might first of all scratch enquiringly at a spot of damp earth sealing a termite passage, and secondly poke a grass stem or twig into the hole which he thus revealed. Provided the youngster was familiar with termites (and all of the primates at the Gombe Stream feed on the winged forms of these insects) he would undoubtedly eat the insects which he found clinging to his "tool." Such a reward would undoubtedly induce him to push the twig once again into the hole.

Schiller (1949) found that young captive chimpanzees, once they had mastered a complex manipulatory pattern, frequently performed the actions, when not necessary, as a form of play. We have already seen that wild chimpanzee infants may prepare "tools" by stripping off leaves, shredding bark, and so forth, apparently as a form of play activity. In addition, a two and a half-year-old infant (i.e., soon after he had begun to use tools for termite-fishing in the correct context) was twice seen using grass tools out of context: once he pushed the stem twice through the hair of his own leg, each time touching the tool with his lips after withdrawal: once he pushed it carefully, three times, into another chimpanzee's groin. This "practising" of a tool-using pattern out of context is important, since it means that the behavior is readily available and may be adapted to new purposes. This, as we shall see below, may play an important role in the development of tool-using patterns in individual animals.

Thus it is suggested that the use of objects in connection with feeding may have evolved from a combination of certain investigatory and manipulatory behavior patterns which, in certain cases, became reinforced by food rewards.

b. Development of Tool-Using Behavior: Learning and Experience. Infant chimpanzees, both in the wild and in a variety of captive conditions, manipulate objects in a number of different ways during play and exploratory behavior, as do the other apes and many monkeys (e.g., Yerkes

and Yerkes, 1929; Menzel, 1964, 1966; Butler, 1965). In many primates, including man, manipulative prowess gradually increases throughout childhood (e.g., Schiller, 1952; Mason *et al.*, 1959; Gesell, 1940) and Schiller (1952) found that the gradual increase in manipulatory skill of individual chimpanzees could be correlated with a gradual improvement in their ability to solve problems which entailed the use of objects as tools. This gradual improvement of manipulative ability is well demonstrated by wild chimpanzee infants in their handling of branches and twigs during feeding and nesting, as well as in tool-using situations (van Lawick-Goodall, 1968).

I have already suggested that a chimpanzee might develop a tool-using pattern, such as "fishing" for termites, from manipulatory patterns through trial-and-error learning. The repetition of such a pattern during infant play may, on occasion, lead to a new tool-using technique: for example, when the 3½-year-old infant used a grass stem, with the termite-fishing technique, to extract water from a hollow. As he sucked the moisture from the end, the grass became more and more crumpled until he had formed a "sponge." On another occasion a 4-year-old, when drinking with a "sponge," dropped it into the water bowl. She was unable to reach it with her fingers and, after a moment, picked a twig, stripped it of leaves and poked with it into the bowl. She touched the end to her lips, dropped it and then repeated the process with another twig. Her "purpose" in picking the twigs was unclear: nevertheless the availability of the pattern means that, in similar circumstances, it might be possible for a chimpanzee to use one tool not to *make* another, but at least to obtain a tool that is out of reach.

In addition to its ability to solve a problem through trial-and-error learning, the chimpanzee, and undoubtedly a number of other mammals as well, has evolved an ability that "supplements trial-and-error procedure by making possible forms of behavioural adaptation which strikingly resemble those which, in us, are known to depend upon perception of relation, ideation, insight or understanding" (Yerkes, 1943). The literature contains a number of descriptions of the sudden "purposeful" behavior of chimpanzees when they have, apparently through such "insight" or "ideation," perceived the solution to a test problem involving the use of objects as tools (e.g., Köhler, 1925, p. 23; Yerkes, 1943, pp. 135–136). A similar change in behavior, from the frustrated shaking of grasses to the sudden deliberate picking of a stick, was observed when the wild chimpanzee at the Gombe Stream solved the problem of how to obtain a banana from a human hand.

Finally we should enquire whether, over and above trial-and-error learning and occasional insight learning, tool-using patterns may be acquired, and thus transmitted from one generation to another, by means of observational learning. That some primates can, indeed, gain experience in the solution of novel problems through watching the actions of others has been shown experimentally (e.g., Darby and Riopelle, 1959; Warden *et al.*, 1940; Hayes and Hayes, 1952). It appears that the chimpanzee is actually able to acquire a *new motor pattern* by observation alone: the home-raised chimpanzee, Vicki, not only applied lipstick in the correct manner, but also pursed her lips whilst doing so, as she had seen Mrs. Hayes do on many occasions (Hayes and Hayes, 1952). This is one of the few observations which points to true imitation in mammals (Aronfreed, 1969).

In the wild, of course, infant chimpanzees have much opportunity for observing tool-use in adults. At the Gombe Stream, infant chimpanzees often watched adults intently as they used tools (e.g., Fig. 14) and sometimes, too, picked up and used tools that adults discarded. Twice a 3-year-old, after watching his mother wipe her bottom, picked leaves and did exactly the same himself. On neither occasion had he himself defecated, nor was there any sign of dirt on his bottom. In addition, as we have seen, infants too young to use tools for termiting, nevertheless began to prepare tools in a manner similar to adults, stripping off leaves and so forth, during the termiting season. Finally, one observation suggests that the adults may learn by observation: one female used a stick vigorously on a banana box the very first time she moved out into the feeding area. It seems most unlikely that she would have shown this response on a first encounter with boxes and bananas unless her behavior bore reference to the fact that she had watched, from the security of the surrounding trees, other chimpanzees behave in a similar way.

Bearing in mind the facts presented in the discussion above—the young chimpanzee's frequent investigations of his environment together with his innate tendency to manipulate and play with objects—it would seem reasonable to assume that chimpanzees probably show tool-using behavior of some sort or other throughout their range. This indeed is probably so, since examples of tool and/or weapon use have been gathered from Tanzania (in the eastern limit of the chimpanzee's range) and from Liberia (in the west), together with evidence also from other Central and West African countries (Savage and Wyman, 1843–1844; Merfield and Miller, 1956; Kortlandt, 1963; Izawa and Itani,

1966). If at least some tool-using patterns may be individually "discovered" and passed down through observational learning and imitation, then we should expect to find at least some different "cultural traditions" in chimpanzee groups that are geographically separated. Unfortunately our knowledge of tool-use for nonagonistic purposes, in areas other than the Gombe Stream, is not extensive: nevertheless the fact that in West Africa chimpanzees may use rocks as hammers, a behavior that has not yet been seen at the Gombe Stream, suggests that such, indeed, may be the case.

V. Concluding Remarks

There are tool-using invertebrates in the truest sense of the word, but there can be no question of such tool-using indicating "intelligent" adaptation. The larva of an ant-lion (Cicindelidae spp.) which flings grains of sand to knock struggling insects further into its funnel shaped pit is no more "gifted" than is the larva of a dragonfly (Anisoptera spp.) which has developed a hinged, elongated labium which it shoots out to grasp passing prey. One has evolved a behavioral mechanism which performs a similar function to the structural mechanism of the other.

It is when the motor patterns available to a given animal for the manipulation of objects can be adapted to new situations that tool-using, in itself, becomes of special interest. The American bald eagle shows what must be considered, for a bird, a remarkable diversity of tool-using performances. Moreover, it is just possible that the throwing of stones and the wielding of sticks with the *beak* represented, initially, spontaneous adaptations by which the birds solved problems that they were unable to tackle in the normal way, i.e., with their feet. Such versatility has not been observed in other animals below the level of the primates, although undoubtedly there are more tool-using animals and more tool-using patterns yet to be discovered.

Within the scope of existing knowledge it seems that, other than man, only the chimpanzee is able to adapt a variety of tool-using patterns to the solution of a rather wide variety of problems, both in captivity and in the wild. And this, it should be remarked, is not simply due to the anatomical structure of the chimpanzee: most of the higher primates have an opposable thumb and are capable of a type of precision grip (Napier, 1960), and all of them are certainly capable of grasping and poking around with a stick. In addition the ability to sit in an upright posture is widespread among the primates and this, as Tobias (1965) points out, is all that is needed for the hands to be freed for tool-use. It is undoubtedly a difference in the structure of the brain which dic-

tates the frequency of tool-using performances in primates. Man, of course, has gone several stages further than the chimpanzee: he is able not only to use a tool to make a tool, but he makes tools to a set and regular pattern, he makes them for future use and for the use of others. Also, as Tobias (1965) and others have pointed out, man is the only animal dependent on tools for his survival.

A final point should be made. Once a species has evolved to the point where problems may be solved through individual experience including "insight," and when solutions may be transmitted to others by observational learning and immitation, it is necessary to emphasize the importance of *individual* performances. Just as there are exceptionally intelligent and exceptionally stupid humans, together with a vast majority that are of average capabilities, so it is with chimpanzees (and many other creatures too, for that matter). Given the possibility of techniques being learned by one animal from another, therefore, the presence of an exceptionally gifted individual in a free-ranging community may be of supreme importance in the development of tool-using cultures. This factor undoubtedly played a vital role in the appearance of tool-using and tool-making in early man, as it continues to do today.

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