RETURN OF THE NATIVE

FOREST COGNITION IN REHABILITANT ORANGUTANS

by

A. E. RUSSON

Glendon College-York University, Toronto Ont. M4N 3M6, Canada

Based on a paper presented at The XVIIth Congress of International Primatological Society

Antananarivo, Madagascar, Aug. 9-15, 1998

Despite efforts to secure orangutan survival in the wild, the situation in Borneo in 1998 is probably the worst it has ever been. The Bornean orangutan population is badly fragmented, most subpopulations are isolated in unprotected areas, and those few in reserves are ineffectively protected. Illegal capture seems on the increase, despite stepped-up enforcement. The government admitted its plan to convert one million hectares of peat swamp forest to rice farms would displace 2000 wild orangutans. On top of all that, 1997-98 saw Borneo devastated by the worst drought and fires in almost a century. Herman Rijksen estimates that these disasters alone cost 30% of the Bornean population, leaving the total as low as 15,000.

This situation seems to be fulfilling predictions that orangutan conservation aimed at preserving large undisturbed areas will probably end in the near future, as remaining sites are exhausted. Unfortunately for orangutans, survival may lie only in managed populations, in "designer" habitat subject to sustainable and integrated use. Such conditions spell the need for conservation programs to take behavior into account. Behavior is strongly controlled by cognition in primates and cognition may operate differently in great apes than it does in other primates, so cognition should be of central importance to orangutan protection plans. This paper discusses the importance of cognition in orangutan foraging--in particular, food processing and food identification--and what that implies for the reintroduction of ex-captive orangutans to free forest life.

My discussion is based on data I collected annually, from 1995 to 1997, on ex-captive orangutans reintroduced to Sungai Wain Protection Forest by the Wanariset Orangutan Reintroduction Project (ORP). My aim in studying these orangutans was discovering how they obtain their foods and what intellectual processes they use to do so. Sungai Wain forest lies just outside the city of Balikpapan in East Kalimantan, Indonesia. Officially, it covers 11,000 ha of lowland mixed dipterocarp forest with extensive swamp areas. In actuality, human encroachment had reduced the size of the forest to about 7,500 ha by 1997 and the drought and fires of 1997-98 further reduced it to about 3,500 ha. ORP released ex-captive orangutans into this forest from 1992 to 1996. In total some 85 orangutans were released, in groups, on at least 6 occasions and at 5 different sites. The orangutans released varied in age from older infants to adults, most falling in the younger juvenile to adolescent range. Data collection involved full-day follows (i.e., following one target orangutan through the course of the day) and event sampling (i.e., collecting information on every event of interest, in this case, bouts of eating particular foods). I accumulated about 400 hours of observation in each of the three years, on a total of 10 different orangutans. I managed to follow one of these orangutans in all three years, six in two consecutive years, and three in one year only. In addition, I observed orangutans in the sixth group released into Sungai Wain Forest for the first two months after they were freed.

FOOD PROCESSING

"Food processing" is the term used to refer to the readying of food items for consumption after they have been identified and located. It is considered a tough intellectual problem for great apes, including orangutans, because some of the foods they rely on are extremely difficult to process. Some of these foods are hidden underground, for instance, and have to be dug out; others are protected by nasty spines, like rattans or durian fruit, by tough unpleasant flavours or even toxins, like some bitter plants, or hard shells, like coconuts. The techniques for obtaining these foods can be lengthy and complex, and complex techniques require complex intelligence.

Orangutans appear to organize their food processing as follows. They use various *operations* in food processing, where by operation I mean a type of food manipulation. Table 1 shows common operations the orangutans use in Sungai Wain. Some operations are simple actions, like biting or pulling, but others involve several actions, combined. *Lathering*, for instance, involves wetting chewed-up food (usually with saliva), grabbing a hank of hair, then spitting and sucking the mix through the hair. Each operation is commonly used in the processing of several foods: Orangutans use *lathering,* for instance, as one part of their processing for mango seeds, some *Diospyros* fruits, and bathsoap. Orangutans sometimes use each operation alone but they more commonly combine one operation with others to form a more elaborate processing *strategy*. Removing bark, for example, can involve the strategy of first *scoring* the bark, biting it repeatedly along a length to loosen a long strip, then *tearing off* the loosened strip, or the slightly different strategy of repeatedly biting off pieces of bark in an orderly pattern, like nibbling off small bits to make a long trench along the underside of the bark.

Table 1: Orangutan food processing operations

Manipulators used	Operation
Hands + feet	pull out (using 2 or 3 hands) tear apart (using 2 or 3 hands) break apart (using 2, 3, or 4 hands) dig wipe/swipe hold item open hold item (to store it) hold items (collect several items)
Hair	daub sponge rub
Mouth	pick up remove skins or seeds fold suck or lick make suds bite (to hold, crack, or score item)
Mouth + hands + feet	pull out (using 2 or 3 manipulators) tear apart (using 2 or 3 manipulators) break apart (using 2, 3, or 4 manipulators)
Mouth + hair	lather
Tool and proto-tool use	glove/cushion plate/spoon/cup hammer probe-lever vehicle tree brace reach extender shelf

Foods that require the most complex strategies--difficult foods--have been my focus of study. In Sungai Wain, there are two main causes of food difficulty: *Heavy defenses* and *arboreal location*. Both create difficult intellectual problems.

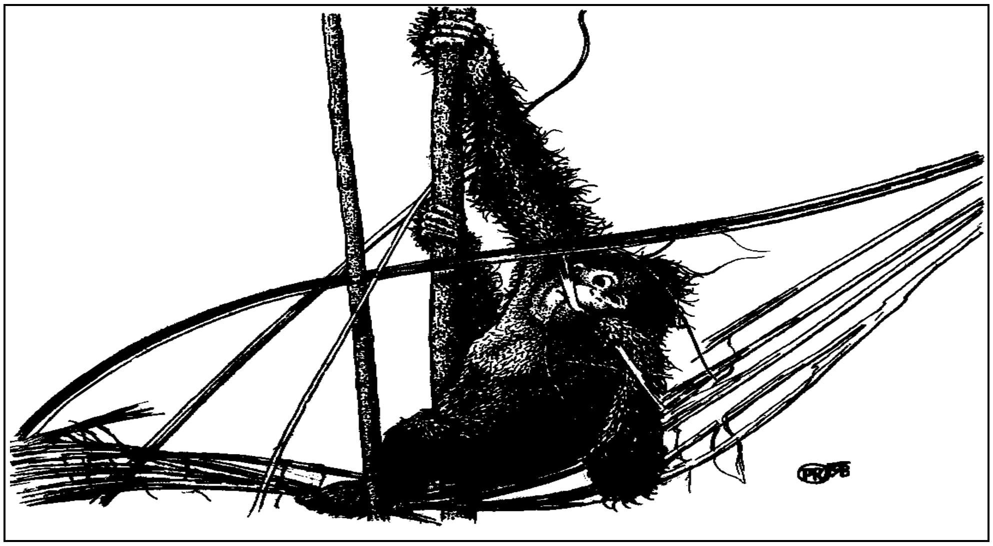
Heavily defended foods. Many orangutan foods are armed with devices expressly designed to discourage predators, like hard shells, toxins, or thorns--in other words, they are heavily defended. In Sungai Wain, orangutans cannot simply avoid these heavily defended foods because many of them are the *permanent* foods on which they rely to survive periods of food scarcity--termites, rattans, and palms. The orangutans' mature strategy for obtaining termites from nests offers an example of how complex it can be to process heavily defended foods.

Nest-building termites in Sungai Wain do not build the great mounds that are famous in Africa; their nests are smaller and shaped like basketballs, lumpy footballs, or drooping lobes. The basic strategy that the orangutans use to obtain these termites is to get a chunk of a nest, break it open, then suck termites from its exposed cells. This already involves some complexity because getting a chunk of nest means either digging it from underground or breaking it from the main body of the nest; and breaking it open may require considerable strength and fiddling. This basic strategy is only the foundation for the mature strategy that experienced orangutans build, however, and it is simple in comparison.

In the mature strategy, orangutans first collect several chunks of termite nest, not just one, test each for termites, and discard any that are empty. Once they have 'enough' (however they decide what that is), they take one chunk in one of their hands--the working chunk--and store the others in their feet to be eaten later. Then they set about breaking the working chunk open. They crack a small piece off the chunk using their hands or teeth, pick it up with lips or fingers, suck the exposed surface to extract the termites, and eat them. They might turn the piece over and around to get all the good spots, flick a bit of debris off its surface with the tip of a finger, or pick out a bit of food between thumb and forefinger. If the piece is rather big, they may break smaller bits from it and suck the bits. Then, if the situation merits, they may also break crumbs from the bits, then rubble from the crumbs, and so on. All these good nest fragments have to be held, probably to distinguish them from discarded fragments and to keep track of what's yet to be done. Some orangutans have an orderly system for holding their various fragments: They hold the working chunk in one hand and everything else in the second hand--the piece is held normally, the bit is pinned at the base of the palm with the tip of the third finger, a crumb is balanced on the wrist, and any rubble is balanced farther up the wrist. They even work over these various fragments in order, from smallest to largest: As each smallest piece is cleaned out, they discard it and reactivate its immediate 'mother' piece. Once the working chunk itself is emptied, they move one of the chunks stored in their feet into one hand to become a new working chunk, then they start all over again. The whole enterprise can take over an hour.

Arboreality. Arboreality has been studied as an intellectual challenge for orangutans but most of the work has focused on the difficulties of arboreal travel. In fact, *food*, not travel, is considered the main reason that primates are in the trees and the major influence on their locomotor habits. Arboreal food processing--obtaining food that is located up in the trees--presents more difficult problems than food processing on the ground because it adds the task of establishing a position in the trees that allows accessing and working on the food. Arboreal positioning can be complex on its own. The increase in difficulty it causes goes beyond simply adding arboreal to food processing complexities, for three reasons. First, the two problems use different cognitive abilities. Processing food mostly uses cause-effect reasoning because it involves acting to change the world (e.g., pulling a fruit off a branch, breaking a coconut open), whereas positioning mostly uses spatial reasoning, figuring out how to place oneself in space relative to food. Second, arboreal positioning and food processing *affect* each other: The food processing job affects what position is taken, and the current position affects the technique used for processing food. One orangutan put so much force into breaking a termite nest that he lost his balance and almost fell off the branch on which he was sitting. Many orangutans take one position to pull a coconut off its stalk then change to a different position to break it open. Or, stuck in an awkward position relative to the fruit they want, they pull in or break off the fruiting branch rather than pick off the individual fruits. Third, orangutans have too few manipulators to handle the two tasks independently. They commonly use three manipulators to secure their arboreal position when feeding. They may also need three manipulators for food operations that use force. The total number of manipulators they have is only five--four hands and one mouth--not always enough for both tasks.

Orangutans do cope successfully with difficult arboreal foods, so their solutions to the two tasks must somehow be interconnected. You can see interconnections happening in a couple of obvious ways. Orangutans sometimes *share one manipulator* between the two tasks, as in Figure 1. The figure shows Paul, an older juvenile male, working on tearing open the leaf stalk of *bandang*, a wild coconut palm. Orangutans open the stalk for the pith inside, which they tear out and chew it for its juice. In the figure, Paul has torn open the stalk and is in the process of biting out and chewing lengths of pith. His left foot is placed on the lower bow of the torn leaf stalk and it is jointly working on arboreal positioning and food processing: Some of his weight is on that foot, so it is contributing to maintaining position; that foot is also holding the stalk so that he can remove the pith, so it is at the same time contributing to food processing. Orangutans may also *"loan" a manipulator* from one task to the other, usually for a few seconds at a time. Using the example in the figure, Paul’s left foot might let go of the stalk’s bow, swing over to help his hand and mouth tear pith for a few seconds, then swing back to its original job of holding open and leaning on the bow.



Efforts to make sense of the intellectual complexities behind food processing strategies like these have focused on general mental processes that build expertise rather than on any specific ability. For one thing, orangutan food processing expertise is the product of a variety of abilities, not just one, including causal reasoning (understanding causes and their effects), logical reasoning (understanding that various alternatives can solve a problem), and imitation (acquiring expertise, in part, by observing companions work). And orangutans may use several of these abilities at a time to solve one single food problem--just as humans may use a whole set of tools to fix something, not just one. For another thing, the notion of abilities doesn't cover the question of level--what level or degree of complexity do they use in their reasoning about food? Compared with humans, for instance, do they reason at the level of a 1-year-old, a 3-year-old, or an adult? Compared to other cognitive problems they solve, is food processing more or less difficult?

In exploring levels, most work has focused on whether the intelligence that great apes apply to food processing might be hierarchical--that is, whether it operates via mental *programs* that mix and match sets of basic skills, selected from the individual's whole repertoire, into complex packages. These programs become *higher level* skills themselves, rather than sets of basic skills simply strung together in a chain. This is the way that complex human intelligence appears to operate. Researchers have found that chimpanzees and mountain gorillas do use hierarchical intelligence in food processing. So, in fact, do these rehabilitant orangutans. That means that the level of reasoning they apply to food processing problems equals that used by other great apes; it also matches the highest level great apes have achieved in solving other problems, it surpasses the level achieved by human infants, and it approaches the level characteristic of human children under about 3 to 3.5 years of age.

In orangutans' arboreal food processing, a yet more difficult problem, a second facet of intelligence may be operating. This is *cognitive integration*, the interconnected use of several distinct abilities in solving a single problem. Many problems are solved best, or only, by applying several abilities interactively rather than any one alone. Despite its obvious utility, cognitive integration is considered a highly sophisticated process that can operate only in cognitive systems that are hierarchical. For that reason, it is commonly believed to be exclusively human--even though evidence on other primates is very slim. If orangutans' food processing strategies are hierarchical and their solutions to combined arboreal-food processing problems are interconnected, however, then the cognition that governs these combined solutions must be integrated too. That means that orangutans' processing of difficult arboreal foods may use reasoning be even more complex than the reasoning great apes have demonstrated elsewhere.

If orangutans' food-related expertise is extremely complex, it is important to discover how they acquire it. Orangutans, like humans and other primates, rely heavily on learning for their expertise, so very complex skills may require very extensive learning. This is indeed the case: Orangutans' mature food processing strategies are very *slowly acquired*. Many ex-captives know nothing of them when they are first released and some have taken over two years to build relatively mature strategies *after* they discover the basic operations. Acquisition may be slow because of several cognitive factors. For one thing, development limits how quickly acquisition can proceed**:** For the most difficult food the orangutans eat in Sungai Wain forest, palm hearts, my limited data suggest that the ex-captives don't acquire the mature strategy, which is based on dividing the job into smaller subtasks, until they are at least six or seven years of age. Individuals younger than that just don't seem to be able to figure it out. For another, some orangutans invent dead-end and inefficient strategies and persist in using them despite the fact that they consistently fail. One orangutan, for instance, tried to open termite nests by bashing them against hard surfaces. It never, ever, worked but he kept doing it for months. Some orangutans have taken up to one or even two years to abandon inappropriate strategies, and it is only once they have done so that they can even *begin* to devise more effective ones.

It is important to understand *how* orangutans go about acquiring their food processing strategies--especially whether each invents it independently or whether they rely on some sort of tutoring. Among the ex-captives, for any one strategy, some invented it while others acquired it socially. Kiki, for instance, discovered on her own how to tear open bandang leaf stalks for their juicy pith about a month after she was released into the forest. It is clear that she discovered this on her own because none of the others in her release group ate this food yet. Two of her companions, Siti and Ida, began to scrounge pith from Kiki almost as soon as Kiki discovered how to get it. Within a week, Siti could get it on her own. In fact, the extent to which the ex-captives learn socially rather than by independent invention is striking. There are many examples. Regular companions often use the same unusual processing strategies that no one else ever uses, so they must have learned them from each other, at least in part. Orangutans who are expert in forest living have sometimes been moved to unfamiliar sites. When they first arrive at the new site, they systematically follow an orangutan who is already familiar with the new site for the first few days, probably to learn the ropes. The newcomers and the residents also watch one another's foraging and scrounge from each other, so the learning can go both ways. On several occasions, an observer whom we knew was naive about a particular food watched an expert eat it, then tried that same food using the same processing strategy immediately after watching. This underlines the importance of supportive social structures in orangutans' adaptation to forest life.

The main conclusions I wish to draw from these findings are that for orangutans, food can present problems that are extremely challenging intellectually. Although orangutans are exceptionally intelligent, it can take them years, not weeks or months, to master the skills for obtaining some foods. And among the most difficult are some of the permanent foods that are essential for their survival. In short, it likely takes them years to acquire the skills needed to survive in the forest independently, especially through hardships like the droughts and fires of 1997-98.

FOOD IDENTIFICATION

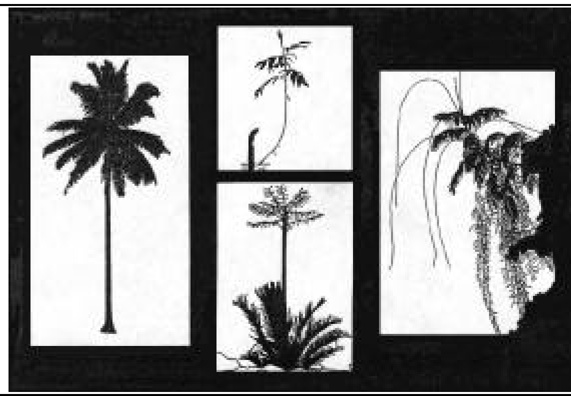
Even identifying food represents a major intellectual task for orangutans because their food repertoire is very broad and highly site specific. Across the four sites where long-term studies of orangutans have been undertaken--Ketambe in northern Sumatra and Gunung Palung, Tanjung Puting, and Kutai in Indonesian Borneo--orangutans have been found to eat from over 256 different plant species plus numerous invertebrates and other items. None of these plant species is eaten at all four sites, and 240 of them are eaten at only one site. This means that the identification of foods must be learned and remembered, and the sheer number of species involved must place a major mental load on both learning and memory.

Just how difficult this can be is evident in ex-captives. Many do not recognize even the common forest foods when they are first released into the forest. Identification comes slowly. In Sungai Wain, three orangutans observed after one to one and a half years' living in the forest ate from between 25-50 species, from a repertoire of over 180 known orangutan food species. Two of the three orangutans were unaware of key permanent foods that are embedded, like termite nests located underground. Embedded foods are of course especially difficult to discover because they are hidden.

Several cognitive factors probably contribute to these patterns--that orangutans can master knowledge of a very wide range of foods but that they broaden that knowledge very slowly. (1) *Orangutans are conservative in their food choice.* They resist experimenting with new foods, vegetation more than fruit, and they likely lose much exploratory zeal beyond immaturity. (2) *Orangutans may favor extending the depth over the breadth of their expertise*. Over time, I saw greater advances in their strategies for processing foods they already *knew* than in the identification of *new* foods. (3) *Orangutans may acquire knowledge of new foods extensively from social partners.* They try new foods if, *often only if*, they observe a trusted model eat them. I have observed this on at least six occasions: Most of the six naive observers scrounged the model's leftovers and at least four of the six added that food to their diet. *(4) Orangutans may categorize food plants, so they might add new foods based of their resemblance to a known food category.* There is ample evidence that many nonhuman species categorize things, so the possibility is open. Because categorization could compensate for the food conservatism and narrow focus, I'll discuss this possibility in more detail.

The Sungai Wain orangutans' feeding on palms suggests that they're categorizing them. Palms form a complex family of about 2600 species. Sungai Wain Forest alone supports over 40 species and it looks as if the orangutans there are coming to eat from them all. The question is how they learn to identify all these palms as food sources.

All palms resemble one another in that they share a few basic structures: All are perennial, woody, reproduce by seeds, and grow from a single apex embedded atop a trunk or stem. Beyond these features, however, palms vary widely. Most have a trunk but some are trunkless or climb; some distribute their leaves in a crown but others distribute them along the stem; many are edible but some are toxic; some have spines but others do not. Figure 2 offers a sample of the variabity in form found among the palms. Most people probably recognize the coconut, on the left, as a palm; the three others are palms as well, although they look distinctly different. This degree of variability makes it unlikely that orangutans learn to identify them as strictly individual species *or* as one undifferentiated group.



If you consider the processing strategies orangutans use to eat from these palms, it looks as though they sort palms into about four different categories based on some simple structural features: small immature palms (of all species), tree palms with crowns, tree or climbing palms with sheaths, and palms that do not climb. They eat the same range of food parts *across* palms--heart, fruit, leaves, immature flowering stalk, leaf stalk--but they use different processing strategies for the palm's heart for *each category* (Figure 3). The main differences in strategy are highlighted in italics; they look small but they are consistent.

immature palms (small)
pull out emerging new leaf shoot
bite off basal meristem tissue
crowned tree palms
subdivide emerging new leaf
pull out leaf sections
bite off basal meristem tissue
sheathed palms: nibung, climbing rattans
bite/tear apart stem below apex
bite/tear out inner meristem tissue
non-climbing palms: rattans, immatures (large)
bite/tear apart stem at base
bite/tear out inner meristem tissue

Figure 3. Processing strategies for palm hearts

It is also clear that orangutans distinguish between individual species within any category, because the details of their strategy can vary from one species to another based on such characteristics as whether the sheath is tough or tender, or whether a climber's stem is spiny or not. So it's not that they can't tell palms apart, it's that they group them based on some similarities.

The similarities they use are likely in part on simple *perceptual* *similarities*--different categories simply look different--but palms are so perceptually *dissimilar* that this is unlikely the whole story. Nibung (*Oncosperma horridum*) doesn't look anything like a climbing rattan, for instance, although the two seem to be in the same category in terms of how they're handled; nibung is a tree palm that looks something like the coconut palm shown in Figure 2. The processing strategies that are used to obtain parts of the palm that are embedded, like the palm's heart or the coconut jelly, suggest that the categories might be based on structural similarities that aren't perceptually evident. Embedded parts are invisible and they must be located in terms of where they are located *relative to* visible plant structures. The palm heart, for instance, is hidden inside the stem beneath a protective sheath; on climbing palms, it is located about three leaves down from the stem's apex whereas in non-climbers, it is located at the base of the stem. If categories are based on structural principles, they could be governed by cognition rather than perception. This would allow rapid identification of new category members, ones not yet experienced, by generalization. Orangutans can identify novel palm foods very rapidly: Experienced ex-captives who have lived in Sungai Wain Forest for over six years suddenly learned three new palm foods over a period of no more than six months, over the drought and fire season that plagued Borneo in 1997-98. And although they learned to identify these foods only very recently, they already used mature strategies to process them--the mature strategy for the relevant category. That suggests that once they recognized the similarity, they simply 'borrowed' a strategy they already knew to apply to the new food.

IMPLICATIONS FOR REINTRODUCTION

These various findings suggest that orangutan reintroduction, and probably other great ape conservation efforts, would benefit from considering cognition in several ways.

Complexity. Forest life poses difficult cognitive problems for orangutans and other great apes, not just easy ones. It requires intelligence just as complex as the intelligence that formal tests have elicited from great apes in captivity; it may even require intelligence that is more complex. Conservation programs for orangutans could therefore take advantage of high level abilities like imitation, insight, and classification--not just simple ones. Higher abilities likely offer faster learning and generalization than simpler abilities, so, for instance, management programs could focus on inducing principles or strategies rather than concrete details (e.g., strategies for food *types*) or on promoting desirable innovations (e.g., learning new foods).

Development. Although orangutans can function at high intellectual levels, they acquire their expertise very *slowly*. Experience founds much of their expertise but it must be *timed appropriately*: Offered when they are too young, it cannot be digested and offered when they are too old, it may meet reduced readiness for change. Development can also be a management tool, not just a limitation; for instance, orangutans' and other great apes' great flexibility early in life could be tapped.

***Sociality*.** The importance of sociality in orangutan cognition is beginning to be recognized. Orangutans use social information in identifying new foods, acquiring processing strategies, and probably cuing food location and availability. In addition, their social learning is channeled along social relationship lines: They learn from friends and kin, not strangers and foes. There are increasing hints that orangutans have *traditions* like those found in chimpanzees, so some form of *culture* or *proto-culture* may be operative.

So, projects that disturb communities or move individuals risk destroying expertise critical to local survival, especially expertise that is not readily reinvented. Newcomers may have difficulty adapting to new habitat because they have difficulties integrating into the community; for instance, lack of social relationships may handicap their acquisition of locally important expertise. Projects could also tap this social transmission, as for example by 'seeding' a community with expertise by teaching selected members such things as knowledge about foods or how to use conservation devices.

***Permanent foods*.** Projects evaluating or designing potential orangutan habitat should assess permanent foods as well as the dominant dietary item, fruits. Permanent foods may tend to be difficult, so consideration should be given to the difficulty of independently discovering them, especially the embedded ones, and the slow rate at which orangutans acquire the necessary processing strategies.

CONCLUSION

Orangutan and other primate rehabilitation/reintroduction projects have been criticized for low success rates. Most problems are behavioral deficiencies in rehabilitants that are commonly attributed to the apes' ineptitude. From a cognitive perspective, these programs themselves have deficiencies that make it equally likely that the failures stem from unreasonable expectations and poor programming. Unreasonable expectations include the amount of time needed to build forest skills and the conditions--social, developmental and ecological--that promote these skills. Poor programming includes poorly managed human contact and the problematic learning conditions it creates. Programs better tuned to species' characteristics have improved success rates. Consideration of cognitive limitations and stengths can likely enhance them yet more.

Cognitive specialists should have a lot to offer conservation plans for great apes. If existing programs haven't worked all that well, part of the reason may be that behavioral and cognitive specialists not been consulted, nor have they taken the initiative to become involved. We hope to help turn the tide.

BIBLIOGRAPHY

Beck, B.B., Rapaport, L.G., Price, M.S., & Wilson, A. (1994). Reintroduction of captive-born animals. In P.J.S. Olney, G.M. Mace, & A.T.C. Feistner (eds.), *Creative Conservation: Interactive Management of WIld and Captive Animals*, pp. 265-284. London: Chapman & Hall.

Beissinger, S. R. (1997). Integrating behavior into conservation biology: Potentials and limitation. In J. R. Clemmons & R. Buchholz (eds.), *Behavioral Approaches to Conservation in the Wild*. Cambridge, UK: Cambridge University Press, pp. 23-47.

Box, H. (1991). *Primate Responses to Environmental Change*. London: Chapman & Hill.

Fox, E.A. & van Schaik, C. (in press). Intelligent tool use in wild Sumatran orangutans. In S.T. Parker, H.L. Miles & R.W. Mitchell (eds.), *The Mentalities of Gorillas and Orangutans*. Cambridge, U.K.: Cambridge University Press.

Jones, D.L. (1995). *Palms Throughout the World*. Smithsonian Institute Press: Washington, D.C.

Kleiman, D.G. (1989). Reintroduction of captive mammals for conservation. *BioScience*, *38,* 152-161.

Kleiman, D.G., Beck, B.B., Dietz,J.M. & Dietz, L.A. (1991). Costs of a re-introduction and criteria for success: Accounting and accountability in the golden lion tamarin conservation program. *Symposium of the Zoologial Society of London*, *62*, 125-142.

MacLean, I. G. (1997). Conservation and the ontogeny of behavior. In J. R. Clemmons & R. Buchholz (eds.), *Behavioral Approaches to Conservation in the Wild*. Cambridge, UK: Cambridge University Press, pp. 132-156.

van Schaik, C.P., Fox, E.A., & Sitompul, A.F. (1996). Manufacture and use of tools in wild Sumatran orangutans: Implications for human evolution. *Naturwissenschaften*, *83*, 186-188.