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Control of Behavioral Development in the Context of Reintroduction Programs for Birds

Michael P. Wallace

Conservation and Science, Los Angeles Zoo, Los Angeles, California

Only over the last few decades has there been a concerted effort to develop and refine release methods for threatened species. With the goal of achieving self-sustaining wild populations, three main techniques have been employed: parent-rearing, cross-fostering, and isolation-rearing. Although there are many considerations in developing or selecting the most efficient method for any given species, the behavioral aspects of preparing birds for release are important. The concept of different life history strategies may also help in designing a preparation and release methodology. The degree of interspecific and intraspecific sociality also is important in the development of effective behavioral preparation of individuals for release. © 1994 Wiley-Liss, Inc.

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INTRODUCTION

With the dramatic increase in numbers of endangered species over the last 50 years, there has been a concomitant need for the development of methods for captive propagation and for preparation of captive-born progeny for release to the wild. The development of effective techniques for release programs has been slow. Griffith et al. [1989] listed 93 species of birds and mammals in translocation or reintroduction programs from 1973, when the Endangered Species Act was first formulated, through 1986. Nearly 60% were bird species. Most of those were waterfowl or gallinaceous birds, but also included a few raptors.

A successful reintroduction should result in a wild, self-sustaining population. Griffith et al. [1989] examined several variables associated with success of a reintroduction, such as a large number of founders, balanced demographics in the release

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Address reprint requests to Michael P. Wallace, Curator, Conservation and Science, Los Angeles Zoo, 5333 Zoo Dr., Los Angeles, CA 90027.

TABLE 1. Relation of r- and K- selection characteristics to various release strategies

r-Selection characteristics	K-Selection characteristics
short life span	long life span
produce many young	one or few eggs
short parental dependence period	long parental dependence period
low survivorship of offspring and adults	high survivorship of offspring and adults
population fluctuates greatly	population stabilizes near carrying capacity
reaches sexual maturity quickly	reaches sexual maturity slowly
high intrinsic rate of population increase	low intrinsic rate of population increase
Species tending toward r-selection:	Species tending toward K-selection:
Masked bobwhite quail	California condor
Bali mynah	Whooping crane
Guam rail	Trumpeter swan
Peregrine falcon	Bald eagle
Consequences	Consequences
larger number of releases and individuals needed	fewer releases needed to establish population
short incubation and fledging period	protracted incubation and nestling period
shorter, less complicated release process	longer parental dependance and release process

population, a high rate of population increase, a low degree of competition, limited environmental variation, control of limiting factors, and suitable habitat.

Variables relating directly to the fitness of release candidates themselves, e.g., proper diet, hygiene, and standardized husbandry techniques, are important to produce healthy individuals for release. However, adequate behavioral preparation during the captive rearing and release phases are also crucial elements for a successful reintroduction. Whereas behavioral aspects of rearing and release programs, such as with some species of birds of prey, have been adequately developed, most are still in an experimental phase [Temple, 1978]. The consequences of malimprinting, such as inappropriate socialization, and interspecific breeding attempts must be avoided [Lewis, 1990; Wallace and Temple, 1983]. Equally important is the need with some species to supply a degree of training before and (sometimes) after release to increase the chances of success [Horwich, 1989; Wallace and Temple, 1987].

To develop techniques for releasing birds, or even when selecting among existing methods, it is important to be familiar with the behavioral and physiological ontogeny of the species. The most successful releases will occur if a bird is prepared in a manner consistent with its natural inclinations. Two factors—the life history strategy and the degree of sociality of a species—are the most important behavioral considerations in developing a successful release program for a species.

The concept of a life history strategy gives some perspective on the characteristic means of survival of a species. Bird species, as other animals, have evolved differences in the details of their life histories. Species can be characterized with a life history pattern that lies along a continuum from those with a high intrinsic rate of population increase and great fluctuations in population numbers (r-selected) to others that do not naturally fluctuate dramatically about a relatively stable carrying capacity (K-selected) [Pianka, 1970]. Features shown by species using this concept are listed in Table 1. The comparison is useful in developing and understanding methods for rearing, preparing, releasing, and maintaining species in reintroduction programs.

One would predict that large numbers for individuals of species such as the masked bobwhite quail (*Colinus virginianus ridgwayi*) or the Bali mynah (*Leucopsar*

rothschildi) would need to be released as one of the requisites to establish populations, since they have a high reproductive rate offset by a comparatively high natural rate of mortality. With many young produced over a short time period, parental attention to each offspring is limited and the parental dependency period for these species is relatively short. The opposite is true for cranes and condors. To increase the chances for successful release with these species, greater care should be given to the preparations of each release candidate and more long-term monitoring after release should be required to match the longer dependency period offspring normally receive from their natural parents.

The degree of sociality in a species is also important in how release candidates are prepared and releases conducted. For example, the release process of the nonsocial raptors is markedly different from parrot species that communicate visually and auditorially and flock communally in the wild [Temple 1978; Snyder et al., 1987]. The three main methods currently used for rearing birds for release are parent-rearing, cross-fostering, and isolation-rearing.

PARENT-REARING

In parent-rearing, the natural parents of the chick rear the young. In foster parent-rearing by conspecifics, other adults of the same species raise the young. Both methods insure adequate species imprinting and socialization. For example, Bali mynahs are reared to fledging by their parents in holding pens at release areas within the Bali Barat National Park on the island of Bali. The family groups are managed so that the offspring are isolated from visual and auditory contact with humans. After fledging from natural looking nest cavities into a pen, the young birds are allowed to acclimate to their surroundings for a period before having access to the outside and allowed full freedom. Food and water are kept available at the site until their foraging reaches a point of effectiveness where it is no longer required. Twelve Bali mynahs released in this fashion in 1992 were quickly assimilated into a wild flock. Pairs formed, and young were successfully reared from released birds within the first year [Seibels, 1993].

Guam rails (*Rallus owstoni*) are reared by their parents within exhibit and off-exhibit space in zoos throughout the United States [Sheppard, 1985; Derrickson, 1986; Shelton, 1986]. Some time after fledging, offspring slated for release are gathered and shipped to Guam and held in staging pens for a period to adjust to the climate. Insects and other natural food are provided before release on the remote and snake-free island of Rota. The loss of the rail on its home island of Guam is attributed to predation by the brown tree snake (*Boiga irregularis*), an introduced species from other regions of Indonesia. Although there were no losses to this snake on Rota, high mortality from vehicles and predation from cats after the first releases occurred and difficulties with radio transmitters inhibited effective monitoring of the birds (Witteman et al., 1990). With a better understanding of the mortality factors and subsequent modification of release preparations (and predator control), it may be possible to increase survivorship [Derrickson, pers. comm.] of future release candidates.

Thick-billed parrots (*Rhynchopsitta pachyrhyncha*) have been reared for release using parent-rearing methods. Birds have been reared by their parents in zoos and with private aviculturists and transferred to the release site after fledging, as well as reared on site by their parents. After months of training on natural food sources of

pine cones and acorns and habituation with more experienced members of the flock, they were released in groups within the Coronado National Forest of Arizona's Chiricahua Mountains. From several such releases, it is evident that there is much higher mortality in captive-reared birds than the wild-hatched translocated birds from Mexico with which they were released [Snyder, 1994].

Flocking behavior appears to be an important antipredator activity for thick-billed parrots. The captive-reared birds showed an inadequate tendency to flock and seemed to have trouble keeping up with the group after release, as it moved from one feeding area to another. They ended up in poor nutritional condition and appeared to be more vulnerable to predation, as a result [Snyder, pers. comm.]. Thick-billed parrots do not have a call repertoire, comparable to other parrots (e.g., Amazon parrots), that exhibits localized dialects among clan members of the same species [Snyder et al., 1987]. Vocalizations, however, likely play an important role in parent-offspring communication in this species. Without the actual parent flying with and calling from the flock as an inducement to follow, released young thick-bills may lack sufficient motivation to maintain contact. If this is the case, using captive-reared, thick-billed parrots in release programs may not be cost effective, compared to translocating wild birds from populations in Mexico, unless techniques can be developed for giving young birds training during development.

In Hokkaido, Japan, the red-crowned crane (*Grus japonensis*) population is receiving reinforcement, since farmlands previously too dangerous and unacceptable to cranes have been made prime breeding habitat. Nonflighted males lure wild females into enclosures, breed, and the pair then rears the young, who fledge into the local wetlands. These cranes remained tame after release and were retrapped, forced to overwinter indoors, and not allowed to migrate. Released again in the spring to the local marshes, they eventually bred, reared young that fledged naturally, and migrated with the wild flocks. At maturity the cranes reproduced with other offspring of the tame flock as well as with wild birds, but showing strong philopatry, many chose the previously unused marsh habitat close to farms, thereby increasing the functional portion of the species range [Konrad, 1976].

Several methods have been used to rear, prepare, and release peregrine falcons (*Falco peregrinus*) to the wild [Temple, 1978]. The preferred technique used by the Peregrine Fund personnel at the World Center for Birds of Prey in Boise, Idaho, is to recycle breeding pairs by pulling eggs of the first and second clutch, artificially incubate the eggs, and hand-rear the chicks for the first 7–10 days, while assessing their health. By then the parents or other conspecific pairs receive the week-old chicks and rear them to a stage near fledging. They are then taken to a release site where they remain in isolation from human contact and are allowed to fledge to the wild. Two to 4 weeks later, the young falcons are independent of any food subsidy from humans and soon leave in search of prey [Calvin Sandford, pers. comm.; Sherrod et al., 1982].

CROSS-FOSTERING

Cross-fostering has been used as a technique to rear, prepare, and release young when it is not practical to allow captive parents to participate in the care and fledging process of their offspring. Many captive-hatched peregrine falcon chicks have been placed in wild prairie falcon (*Falco mexicanus*) nests where they were successfully

reared and fledged to the wild without obvious problems [Sherrod et al., 1982]. Subsequent pair formation of falcons fledged by this method appears to be normal and directed appropriately toward their own species. More social species, such as cranes, have shown mixed results from cross-fostering efforts [Lewis, 1990].

Nearly 300 whooping crane (*Grus americana*) eggs have been placed in sandhill crane (*Grus canadensis tabida*) nests at Grays Lake, Idaho. The experiment was an attempt to develop a distinct population of whooping cranes that would follow the migratory pattern of their sandhill foster parents that nest in Idaho and winter along the Rio Grande in westcentral New Mexico [Drewien and Bizeau, 1978]. Hatchability was reasonable (72%). Of the 209 chicks that hatched, however, only 84 chicks fledged due to coyote predation and inclement weather. Most cranes that fledged died from collisions with power lines and wire fences. The cranes that survived to maturity appeared to have difficulty forming pair bonds with their own species. The combination of high mortality in young birds and lack of natural recruitment from breeding caused the Grays Lake whooping crane population to decline to only 13 birds by 1991 [Drewien et al., 1989; Lewis, 1990].

The recovery plan for the endangered masked bobwhite quail calls for the release of 2,000 birds per year of this extremely r-selected species. To reduce mortality of the young birds, researchers have experimented with artificial methods of increasing their experience with predators. Specifically, defensive behavior response time to predators has been decreased through the use of hunting dogs to simulate wild canids, and trained hawks to simulate danger from wild raptors [Ellis et al., 1978]. Effective but labor intensive, these techniques proved less efficient than the innovative cross-fostering method currently used. In this method, adult male Texas bobwhite quail (*Colinus virginianus*) are vasectomized prior to release with groups of incubator-hatched masked bobwhite quail. By capitalizing on the tendency for male adult quail to shepherd dependent young to food and cover and teach appropriate responses to predators, mortality rates can be lowered significantly in released young [Dobrott, 1993]. The recovery plan calls for a mixture of habitat restoration and continued releases of large numbers until wild populations are self-sustaining.

ISOLATION-REARING

When parents or foster parents are not available or practical, isolation-rearing may be a viable alternative for producing behaviorally adequate young for release. This method, however, is labor-intensive, resource-demanding, and time-consuming. The main objectives are to promote imprinting on the appropriate species, adequate socialization in species when appropriate, and to avoid any habituation of the individuals to humans that might result in maladaptive behavior after release. It may be necessary to introduce release candidates to some kinds of negative experience in preparation for the specific hazards a species may encounter in the wild, as is currently being done with California condors (Gymnogyps californianus). In order to ensure that they are old enough to react appropriately, this type of training is more effective and free of adverse side effects only if applied at, or after, the natural fledging period, so as not to overcomplicate the nestling's rearing environment. There is a danger that the confined nesting will habituate to the stimulus if there is no opportunity to "escape" the perceived danger.

The most demanding type of species to rear in isolation for release to the wild

would be one that was strongly K-selected and highly social. The lengthy nestling and fledging stages mean an added burden of keeping the bird's captive and release environments free of factors that may adversely affect their behavior. The great need for social stimulation means that some appropriate (and believable to nestlings) stimulus must replace the lack of parental or sibling interaction.

Both Andean (*Vultur gryphus*) and California condors present these challenges. Because of the need to build the small population rapidly, it is more important that breeding California condors lay as many eggs as possible during the breeding season than it is to allow pairs to parent-rear their young [Wallace, 1990]. Since a study comparing parent-reared and isolation-reared Andean condors showed little difference in the success rate of birds released to the wild in Peru, it makes sense to rely more on isolation-rearing techniques with the benefit of increased production [Wallace and Temple, 1987]. A realistic leather-covered, fiberglass hand-puppet is provided for the chick from the first days of their 6-month nestling phase. By observing parent-offspring interactions, keepers can imitate the movements and reactions of adults to give chicks a realistic environment and are usually successful in cultivating positive social bonds. Not only does this give the condor chick a good beginning at imprinting to its own species, but effectively isolates the chick from human contact, thus preventing taming during the rearing process. In addition, the trusting chick adapts with far less trauma to changes, such as transfer to larger quarters or introductions to other chicks, when the surrogate parent is present.

Besides feeding and allopreening sessions several times a day by the puppet, the chick can see and have limited contact with condors of similar age by 2 weeks of age, and full contact with 1 or 2 individuals by 2 months of age. By the time juveniles are moved to the pre-release pens in the field at ~ 7 months, they know and have interacted extensively with the full release group of 4–6 other birds. With social bonds to other chicks established, the transition at 6–8 months from the cavelike rearing rooms, with no outside view and piped-in "sounds of nature" recordings for white noise to the release pen, represents a change mainly in physical environment. The fully grown chicks appear to gain confidence from one another, since the social dominance hierarchy that developed early in the group remains intact. Even with elimination of the puppets, the social group shows little disturbance by the transfer to the field, as indicated by normal feeding, sunning and bathing behaviors, and social interactions within the first few days after the move. If social bonding is not completed before the transfer, agonistic behavior may be seen over a period of several weeks.

Experiments early in the peregrine falcon rearing and reintroduction program showed that using puppets made a difference in how quickly a chick recognized a real peregrine parent as a source of food as opposed to a threat. Falcon chicks partially raised by puppets immediately begged from adults when placed on the nest ledge, compared with chicks that were trained to feed out of a bowl and were fearful and aggressive toward the parent for several days after introduction. Peregrine falcons can be isolation-reared without the use of a puppet (they are nonsocial raptors). As a result, this method is used in falcon production centers today, since puppet rearing is very labor intensive [Sherrod, pers. comm.].

Several hundred bald eagles (*Haliaeetus leucocephalus*) have been reared at the George Miksch Sutton Avian Research Center in Bartlesville, Oklahoma, and successfully released to the wild in several southern states. In part because this species

is more social than most raptors, and also shows a more K-selected tendency with an extended nestling period, researchers have used an adultlike puppet during isolation-rearing to attend the chick from hatching age through the third week. As with rearing condors, the use of puppets also allows the attendant the benefit of close proximity to the chick without compromising the need for isolation from human contact. The chicks are raised in separate tubs, adjacent to one another, to avoid sibling aggression typical of large eagle species [Meyburg, 1978]. By the second to third week they are in visual contact with several other chicks, and this is apparently sufficient exposure for their social needs. Aggression is minimal by the time the eaglets are placed in groups at the release pen. Appropriate pair bonds were developed when the birds reached maturity [Simmons et al., 1988].

Likewise, recent experiments with Hawaiian crows (*Corvus tropicus*) using puppets during the rearing phase have been successful so far. Seven Hawaiian crows were reared to fledging age with the use of an adultlike puppet head that had both a social function and introduced new types of foods [Harrity et al., 1993].

In some species that are being reared in isolation, the puppet idea has been extended to include whole costumes or working models of parents, thus enabling the attendant to achieve more than just proper imprinting, socialization, and avoidance of tameness to humans. A full body costume of white sheeting, loose fringes where wings would appear, and a puppet head on one hand enables an attendant to exercise fledgling cranes and escort them into appropriate feeding sites in a marsh habitat, while posing as an adult crane of the appropriate species. To condition the fledglings, adult contact calls encourage social bonding to the costumed attendant. Later, alarm calls are played by the costumed person as he or she makes "alarm movements" in response to the surprise appearance of non-costumed people [Claire Mirande, pers. comm.], a treatment that will elicit an escape response from young birds that is more appropriate for life in the wild. The artificial stimulus of the surrogate parent apparently helped chicks to generalize their social attachment to wild conspecifics after release. Once with wild birds, they successfully learned migration patterns and fine-tuned survival skills [Horwich, 1989]. Less rigorous methods of hand-rearing and releasing cranes met with failure, due to too much tameness to humans and lack of appropriate feeding behaviors [Nesbitt, 1979].

Experiments with the isolation-rearing and release of trumpeter swans (*Cygnus buccinator*) by the University of Wisconsin Wildlife Ecology Department at Madison had similar reliance on models and other adult likenesses to train young birds to show adaptive behaviors, thus achieving higher survival rates. After keeping chicks in pens and imprinting them to mounted specimens of adult swans, a floating swan decoy was effectively used to guide the cygnets to good feeding areas in a marsh. The chick attendants in this case used a blind covering a fisherman's float and hip waders to walk on the bottom or float through the marsh and were thus completely concealed from the cygnets as they followed the decoy. The decoy, tethered to the end of a stick, was towed by the attendant to likely feeding spots. A hinge at the base of the neck and head was used at first to lower the head to simulate feeding by the decoy, but this extra complexity was later deemed unnecessary and discarded. The mere presence of the decoy near likely feeding areas tended to intensify the feeding interest of the cygnets to the area. They were also led by the decoy to daytime roosting islands in the marsh where maintenance behaviors and sleeping could be done safely, reducing the danger from most predators. When potential predators such as raccoons (*Procyon*

lotor) or coyotes (*Canis latrans*) inadvertently appeared on the shoreline, the decoy parent "behaved" with appropriate avoidance maneuvers to lead the cygnets to safety. People, or a person with a dog, were also used to simulate a threat during training sessions. Until the cygnets could fly on their own, the decoy parent would lead the fledglings back to the safety of a cage to roost at night [Abel, 1993].

Using this fledging technique, a 75% first-year survivorship was reported, whereas swans reared by their parents or other adults and fledged from urban ponds showed only 25% survivorship after migration. Since strong philopatry is likely in this species, in this case the more labor-intensive decoy method has the potential to establish or increase populations rapidly in specific, appropriate habitats, and achieve more efficiently an expansion of their population and its range [Abel, 1993].

CONCLUSION

Most of the programs described here are in development, and some are more highly experimental than others. The various levels of historical involvement with each species tends to correlate with the rate at which success can be expected. Although it was not until the mid-1970s that birds of prey could be consistently bred in captivity, 2,000 years of close association with raptors through falconry has made the development of successful release programs with these species considerably less resource and time-consuming.

For species with long generation times, pertinent data are much slower to accumulate than with species that breed rapidly and mature early, and where results, positive or negative, therefore accumulate more quickly.

It is obvious that recovery methods for each species will emphasize different concerns, since logistics and mortality factors will be peculiar to a species, as will its degree of endangerment in the wild. For some species, each new release site may result in a change in methodology to accommodate differences in habitat and their effect on logistics, predation and food sources. Whether the differences are situational or species-specific, some solutions can be found in the rearing methods employed prior to release.

With an ever increasing number of species being threatened, there must be a concurrent effort to develop and refine cost-effective methods to reestablish them back into the wild. Having a number of techniques available for rearing and releasing different species is important. No one method will necessarily be efficient and successful in every situation, but one will likely be the most effective for a specific set of conditions.

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