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Guidelines for the Rehabilitation, Release, and Post-release Assessment of Chacma Baboons (*Papio ursinus*) for Reinforcement

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Abstract: There is a current global biodiversity loss at a rate 100 to 1000 times greater than the rate of natural extinction. Human activity, specifically human population growth and the necessary actions to sustain them, has led to habitat destruction, the rise of invasive species, climate change, and over exploitation of natural resources. In South Africa, an increasing number of nonhuman primates have entered into rehabilitation centers due to animal-human conflicts. The high accumulation of these primates has led to an increase in the need for group formation and releases at rehabilitation centers. Although the International Union for Conservation of Nature (IUCN) has published generic guidelines for the release of nonhuman primates, it recommends species-specific guidelines be published for optimal release success. Additionally, they emphasize the importance of following best practice management approaches to maximize conservation efforts and individual welfare of displaced species, while also aiming to provide guidance on the best practice approaches. To date, there are only a few published species-specific rehabilitation and release protocols for primates. We, therefore, created species-specific guidelines for the rehabilitation of chacma baboons (*Papio ursinus*) for reinforcement. The proposed guidelines are based on psychological well-being, social and individual behaviors, and the ecology of chacma baboons (*Papio ursinus*) for rehabilitation, release, and post-release assessments. Our guidelines include seven distinct steps: arrival, conspecific resocialization, housing, training, and preparation, pre-release assessment, release-site selection, release, and post-release assessment. We provide detailed information and examples of each step based on the protocols from the Riverside Wildlife Rehabilitation Centre (Riverside), a rehabilitation center in the Limpopo province of South Africa that has had successful rehabilitation and release projects for chacma baboons, among other primates. Since rehabilitation centers are limited by factors such as location and resources, this is meant to be a "best practice" model for this specific baboon species. The goal of these guidelines is to help assist future rehabilitation and releases, as well as provide a foundation to those who wish to modify the guidelines to create other species-specific rehabilitation steps.

Keywords: Chacma baboons, *Papio ursinus*, guidelines, conservation, rehabilitation, population reinforcement

Introduction

Wildlife rehabilitation is the multidisciplinary professional practice that involves displaced, sick, injured, or orphaned animals, which are taken into human care in order to regain health and skills required to survive in the wild (Molony *et al.* 2006; South African Wildlife Rehabilitators Association [SAWRA] 2009). This includes weaning of human dependency and contact, and the active reinforcement of natural behaviors that can help individuals survive in their natural habitat once released. Natural behavior patterns of primates in rehabilitation are reinforced through species-specific rehabilitation protocols and husbandry, as well as regular scheduled medical assessments in order to achieve reintroduction (release) and to ensure survival in the wild. These individuals can be ideal candidates for population restoration projects, or any conservation movement and subsequent release (translocation) of an organism into its species' indigenous home range (IUCN SSC 2013).

The rehabilitation of the individual is undoubtedly for the individual's welfare, but if projects use species-specific approaches and adhere to the IUCN guidelines, the addition of these individuals enhances population viability and genetic diversity; both of which fulfill the purposes of

reinforcement as specified by IUCN (i.e., the intentional movement of individuals into an indigenous range with an existing population of conspecifics [IUCN SSC 2013]).

The *IUCN Guidelines for the Placement of Confiscated, Live Organisms* (2019) identified four options for long-term management of displaced, confiscated, or rescued wildlife: returning the animal back to its country of origin (repatriation), translocation, captive care for the remainder of the animal's life, or euthanasia. Life-long captivity is impractical for many centers because they cannot hold the compounding numbers of rescued animals (Gruesen 2007; Ebua *et al.* 2017), and it is only recommended if the animal cannot be returned to the wild, due, for example, to insufficient life history and ecology of the individual, or because the individual requires particular physical or emotional needs for the remainder of its life, or there is no available habitat (SAWRA 2009; IUCN 2019). In most cases, reinforcement through rehabilitation and release is a reasonable solution to the overpopulation of confiscated animals, even if a species is not yet considered endangered.

Species-specific guidelines are needed for optimal success (Beck *et al.* 2007) but other than conservation-based guidelines for gibbons (Cheyne *et al.* 2012) and welfare-based guidelines for vervet monkeys (Guy and Curnoe 2013), there are no other known published guidelines. However, the updated IUCN guidelines for managing confiscated animals not only recognizes the increasing amount of displaced and confiscated individuals, but also emphasizes the importance of following best practice management approaches to maximize conservation efforts and individual welfare of displaced species (IUCN 2019). Most importantly, the guidelines recognize the need for action against the extinction of all species, regardless of their conservation status.

A recent assessment has determined approximately 60% of nonhuman primate species are threatened with extinction, while 75% of all extant primate species are globally decreasing (Estrada *et al.* 2017, 2019; IUCN 2020). The most common threats to primates are total habitat loss as a result of agriculture (affecting 76% of species), logging and wood harvesting (60%), and livestock farming (SAWRA 2009; Estrada *et al.* 2017, 2019; IUCN 2020). The growth of urban development and agriculture are direct consequences of human overpopulation, and the requirements for sustaining a human population beyond the environment's carrying capacity (Bernstein *et al.* 1976; Geist and Lamben 2002). The ability to subsist as an opportunistic feeder has enabled baboons (*Papio* spp.) to thrive near human populations. In southern Africa, most of the conflict between humans and chacma baboons (*Papio ursinus*) involves crop-raiding behavior and preying on livestock (Stolz and Keith 1973; Naughton-Treves *et al.* 1998; Pahad 2010), and baboons, therefore, tend to be considered pests by African farmers. Retaliation by farmers results in injury or death through practices such as poisoning, trapping, and shooting (SAWRA 2009; Smit 2010; Guy and Curnoe 2013). Baboons that live in close proximity to humans are also in danger of being hit by traffic and hunted for medicinal purposes (Alves *et al.* 2010; Smit 2010). Increased overlap between their natural range and human settlements has resulted in populations in the South African Cape Peninsula being considered potentially threatened and worth protecting (SANBI, 2014). As a result, injured, sick, and orphaned baboons tend to be sent to wildlife sanctuaries or rehabilitation centers (Wimberger *et al.* 2020; as seen at Riverside).

Although common baboon species are all listed as Least Concern by the IUCN and the South African Mammal Red List, baboon numbers have declined in the past 30 to 40 years (Hoffmann and Hilton-Taylor 2008; Kingdon *et al.* 2008; Stone *et al.* 2012; Hoffman *et al.* 2016; Turner *et al.* 2017; Sithaldeen 2019), and the increasing number of individuals in rehabilitation centers has led to difficulties in providing space and shelter. To address these issues, centers are rehabilitating and releasing troops back into the wild. One such rehabilitation center in the Limpopo province of South Africa has been successful in rehabilitation and release projects for chacma baboons. Riverside Wildlife Rehabilitation

Box. The seven steps for the rehabilitation and release of chacma baboons, *Papio ursinus*.

Step 1: *Arrival*
Intake. Quarantine clinic or infant care.
Step 2: *Conspecific resocialization*
Processed. Individual integrated into troop. Monitoring.
Step 3: *Housing and release preparation*
Less human contact. Encourage natural behaviors.
Step 4: *Pre-release assessment*
Behavioral assessment of individual. Troop formation and activity budget. Final health assessment.
Step 5: *Release site selection*
Criteria for a release site.
Step 6: *Release*
Transportation plan. Soft release (preferred).
Step 7: *Post-release assessment*
1-year monitoring. Establish and assess criteria for success.

Centre (Riverside) has created and implemented its own rehabilitation methodology that is regularly refined for optimal success.

Here, we present guidelines as a "best practice" model for the rehabilitation, release, and post-release assessment of chacma baboons based on species-specific behavior and ecology. The guidelines are in accordance with the current primate rehabilitation and reintroduction guidelines (Baker 2002; Cheyne *et al.* 2012; Guy and Curnoe 2013) and IUCN's guidelines for managing confiscated animals (IUCN 2019), and also integrates the South African Wildlife Rehabilitators Association's Minimum Standards (2009) and the successful welfare-based practices implemented at Riverside. Our recommendations for a best-practice model are split into seven distinct steps: arrival, conspecific resocialization, housing, and release preparation, pre-release assessment, release-site selection, release, and post-release assessment (see Box). Our goal is to improve methods of rehabilitation to optimize the successes of future releases, offer recommendations to those looking for alternative or more effective methods, and establish a framework which demonstrates how species-specific guidelines are created.

Figure 1a. Quarantine. a: Indoor quarantine section; b: outdoor quarantine shed (quarantine uniforms, cleaning equipment, etc.); c: outside quarantine section. Photograph by Rachel Fuller.

Figure 1b. On-site animal clinic. a: Clinic building, b: outside clinic section. Photograph by © Mayke Boellaard.

Recommendations for a Best-Practice Model

Arrival

When a primate first arrives at a center, the individual's history should be immediately collected and recorded on an intake form (Guy and Curnoe 2013; as employed at Riverside). The intake survey includes information such as current physical condition, where the animal came from, the circumstances and location of where the primate was found, if the individual was a pet, and if so, for how long and what it was fed. This standardized intake survey is the first record of a long list of documented progress forms and reports that will accompany the new arrival for the remainder of its tenure in the rehabilitation program up to and including release. The individual's history, along with an assessment of its physical and psychological well-being, is necessary when rehabilitating primates because it determines the needs of the individual at the center and whether it can be admitted to the rehabilitation program or not.

Depending on the age of the new arrival, the baboon may either be assigned a human or conspecific surrogate mother and then kept in a nursery enclosure, or they are quarantined and undergo a medical assessment and treatment (Fig. 1a) before conspecific resocialization. Since infant baboons depend on their mothers for survival, any arriving infant should be given to a human caregiver(s) until the individual can mostly eat and drink by themselves (Pan African Sanctuary Alliance [PASA] 2016; as employed at Riverside). Once this occurs, the individual should either join a nursery enclosure with conspecifics of similar age or, preferably, be bonded to a baboon surrogate mother in an establishing troop (see section on *Conspecific resocialization*). Since adoption does occur in wild baboon troops, a subadult or adult female is a recommended candidate as a foster mother, although any older female can become the mother figure or comfort provider of a new infant occupant (Dewirst 2019; as seen at Riverside, R. Fuller, pers. obs.).

All new arrivals undergo clinical assessment, as well as pathology. A fecal smear is done to analyze known clinical abnormalities that are markers or precursors for both infectious and non-infectious parasites. A tuberculosis test is also administered by means of an intradermal injection method, a skin-testing procedure that shows a positive reaction within three days (Viggers *et al.* 1993; Guy and Curnoe 2013; as employed at Riverside). If needed, the appropriate care or remedial steps are taken as determined by the findings of the assessment and pathology. The appropriate care and housing is assigned depending on the age of the new arrival (see Tables 1a and 1b).

Any individual past infancy (>1.5 years) should be quarantined for at least 31 days and undergo a medical assessment and treatment. IUCN recommends a minimum of 31 days in quarantine, with 90 days being ideal (Baker 2002). For chacma baboons, we recommend up to 40 days

Table 1a. Developmental stages of *Papio ursinus*.

Class	Age	Additional Notes
Infant-1	0–8 months	Infant has black fur (natal coat). Black spots in tail and shoulders remain longest. Skin pink or red from skin vascularity – ears and nose retain pink longest.
Infant-2	8 months–18 months	Weaning period: ~10–15 months. Natal coat gradually sheds and lighter brown fur appears. Skin pigmentation gradually darkens to a brown-black color (as in adults). Growth spurts.
Juvenile-1	1.5–3.5 years	Individual experiences growth spurts. Face wrinkles disappear by the end of this period. Scrotum starting to transition from pink to grey near end of this period.
Juvenile-2	Females: 3.5–5 years Males: 3.5–6 years	Females continue to physically grow. Males experience testicular enlargement and descend but are not fully developed. Canines appear.
Subadult	Females: n/a* Males: 6–9 years	Males undergo partial development of secondary sexual features (mantle, fully developed canines, testes enlarged). Subadult males are larger than females but not as large as adult males. Males develop white streaks on muzzle. Males develop canine ridges.
Adult	Females: >5 years Males: >9 years	Females experience menarche and tumescence of sexual skin (estrus). First pregnancy is around 6 years of age, and fully grown by age 7. Female nipples are button-like when nulliparous, elongated in more mature multiparous females. Male secondary sexual features fully developed and are roughly twice the size of adult females.

*Sub-adulthood is not always considered for females; late female juvenility is sometimes considered sub-adulthood (3–5 years of age). Modified from Alberts *et al.* (2016, 2020), with additional compilation of the following sources: Altmann (1980); Harvey *et al.* (1986); Melnick and Pearl (1986); Rhine *et al.* (1988); Jolly (1993); Bentley-Condit and Smith (1997); Alberts and Altmann (2001); personal observation at Riverside.

in quarantine. Isolation through quarantine is not recommended for any young Juvenile-1 age arrivals (for age classes, see Table 1a), and should never occur with any Infant-1 baboon, since psychological trauma is associated with young primates deprived of contact and affection given by maternal figures (Harlow 1958). Quarantine can vary depending on the age, behavior, and circumstances in which a Juvenile-1 baboon arrives but should be mandatory for all individuals past 3.5 years of age. Quarantine is essential because the required medical assessments must be conducted away from other wildlife occupants at the center in order to mitigate and reduce possible exposure, spread, or contamination to other wildlife and the general populace at the center. Chacma baboons are susceptible to some of the same pathogens as humans and should undergo a more thorough medical assessment by a veterinarian, or a similarly trained and qualified professional. Some pathogens known to affect both baboons and humans are the Zika virus (Gurung *et al.* 2018, 2019), measles, tuberculosis, and some herpes virus types (i.e., cytomegalovirus, hepatitis A virus, Epstein-Barr virus; Drewe *et al.* 2012). Baboon species are also susceptible to many parasitic worm species (Nunn and Altizer 2006; Ravasi 2009) and should be tested for those known to the region that the baboon came from. A behavioral assessment should also be conducted on the new arrival since most are traumatized or have been socially isolated from conspecifics and can therefore display abnormal behavior.

Table 1b. Age to corresponding enclosure*

Class	Resocialization Enclosure
Infant-1	Nursery Enclosure
Infant-2	Juvenile Enclosure
Juvenile	Juvenile Enclosure
Juvenile-2 to Adult	Semi-wild enclosure (main troop housing)

*As employed at Riverside

Conspecific resocialization

Once the quarantine period is over and the arrival is considered healthy, the individual should be processed, assigned an ID, and integrated into an introduction enclosure. To be processed out of quarantine, another clinical assessment needs to be done and should include prophylactic anthelmintics (parasite preventative drugs) to be administered (as employed at Riverside). Additional remedial care should be administered on a case-by-case basis. Morphological measurements are conducted and kept for the individual's records, along with documenting any physical abnormalities and anomalies (distinctive or unique markings for identification used for visual aid; for example, toe missing, shortened tail). For identification, microchip implants (transponders) are preferred (SAWRA 2009), placed 40 mm from the base of the skull at the nape of the neck (as employed at Riverside). The World Small Animal Veterinary Association (2018) also states for individuals >17cm from the spine to the shoulder blade, implant subcutaneously at the base of the left ear, for individuals <17cm, implant subcutaneously between the shoulder blades. Arrivals of young individuals (i.e., infants and juveniles) are usually staggered throughout the year because chacma baboons breed year-round (Bercovitch and Harding 1993), and rehabilitation centers receive injured or rescued individuals all year (as seen at Riverside). As a result, new arrivals may either be added into an established troop, or they may be chosen along with a few individuals to form a new troop (for troop demographics, see Table 1a).

Resocialization is done by relocating the individual(s) from one enclosure to the next appropriate enclosure (for housing enclosures based on developmental stages, see Table 1b). These integrations should be a gradual process to reduce stress and should take into account the lack of experience of some arrivals with regard to socialization with conspecifics (Guy and Curnoe 2012; as employed at Riverside), especially when Infant-1 and Infant-2 individuals are being integrated into a nursery troop. Infant-1 baboons being integrated with Infant-2 baboons should always be accompanied by the human surrogates to mitigate animosity from the current Infant-2 troop housed in the infant enclosure (as employed at Riverside). PASA (2016) recommends an infant or juvenile should be integrated into a nursery troop or a mixed demographic troop with a stable tempered female who is likely to adopt the infant or juvenile, or form an alliance (as employed at the Centre for Animal Rehabilitation and Education 2017). At all times due care is given to the troop structure in order to achieve a balanced, mixed demographic (Table 2). The protocol for the resocialization of Infant-2 baboons with Juvenile-1 baboons is the same as integrating infant baboons together, with the exception of mild sedation of the new arrival and/or incorporating an introduction enclosure (SAWRA 2009; as employed at Riverside). Especially for infants and human-raised ex-pets, the primary caregiver(s) for the new individual should be present and assist with conducting the integration for the new-comer's reassurance, and to control the interactions between the new individual and their conspecifics (PASA 2016; as employed at Riverside). New individuals should be gradually introduced to troop members, rather than all at once (PASA 2016; as employed at Riverside), and should make use of an adjacent introduction enclosure to the troop housing enclosure (SAWRA 2009; Guy *et al.* 2012; PASA 2016; as employed at Riverside; Figs. 2a and 2b). The introduction enclosure must also provide secure areas due to the fact that the other two sides of the introduction enclosure are not in direct contact with the main troop housing enclosure. The use of an introduction enclosure is critical in this step because baboons are fiercely territorial and any new arrival will be seen as a threat to the current troop housed in the main troop housing enclosure. The introduction enclosure is only opened and the Juvenile-1 animals are allowed to venture into the main troop housing enclosure once all interactions between the new arrival and the main troop have been observed—these positive signifiers will be: lip smacking, grooming, presenting, and submission, through the enclosure bars or mesh before final integration.

Also, a section that only the new arrival has access to is recommended because it can be a safe area and can also

Table 2. Chacma baboon, *Papio ursinus*, group demographics.

No. of adult males	No. of adult females	Approximate ratio of adult males: adult females	Total population	Source
5	21	1:4	53	Hall (1962) in Davidge (1978)
3	12	–	28	
2	8	–	26	
1	10	1:10	20	
8	8	1:1	34	Hamilton *et al*. (1975)
4	6	2:3	28	
5	7	5:7	17	
14	38	7:19	108	
8	24	1:3	70	
5	6	5:6	39	
2	2	1:1	7	
11	11	1:1	30	Stoltz & Saayman (1970) in Davidge (1978)
18	31	1:2	77	
9	18	–	37	
16	21	4:5	45	
19	24	5:6	60	
12	28	3:7	85	Davidge (1978)
4	18	2:9	57	King *et al*. (2009)
4	10	2:5	32	
6	6	1:1	115	Pebsworth *et al*. (2012)

Figure 2a. Introduction enclosure attached to juvenile baboon enclosure ("Monty"). a: Transfer cage, used for conspecific resocialization enclosure; b: "Monty", the juvenile baboon enclosure; c: double door airlock. Photograph by Rachel Fuller.

be private space for surrogate mother bonded babies that are still partly dependent on milk or formula (PASA 2016; Du Toit 2018). If an infant or juvenile is bonded with a surrogate mother, the dyad must be reintegrated back into the troop, beginning with low-ranking females to high-ranking females, then males (PASA 2016). All interactions between the dyad and the males should be positive (for example, lip smacking, grooming, presenting, and submission of infant/juvenile to the male) through the enclosure bars or mesh before final integration, for the safety of the infant or juvenile. Any integration process generally takes a few weeks to a month (PASA 2016); however, this process should be steady and must progress based on the new individual's needs (most individuals, especially younger arrivals, are traumatized and could therefore need more time to adjust).

Juveniles should also be integrated into a similarly aged troop, if not a troop of mixed demographics (Table 2). Juvenile-1 age females (see Tables 1a and 1b) can be integrated into younger aged troops; they are most beneficial here because they provide comfort and reassurance to younger troop members, as well as decrease older male juvenile bullying (PASA 2016; as seen at Riverside). Older male and female juveniles should be integrated into a troop of similar age or a troop of mixed demographics (PASA 2016; as employed at Riverside). Adult integration into a mixed demographic troop is a complex, gradual process, which requires alliances to form and should also not be rushed. A new female generally gains the most support from males faster, especially if she is in estrus; however, alliances need to form with other females and can take up to two years (PASA 2016). Since infanticide is seen in wild baboon populations (Cheney and Seyfarth 2007; Palombit *et al.* 2000), it is not recommended to introduce new adult males into a troop with infants until the infants are juveniles, or at least have lost their natal coat (Baker *et al.* 1996; see also Table 1a). Males are also easier to integrate into a troop by first gaining support from females. Once a new male is introduced to a troop, it is recommended to have two higher-ranking females accompany him around the alpha male (accompanying females should not be in estrus as this could increase aggression; PASA 2016). When a new individual is added to a troop, volunteers and staff should assist in all-day behavioral monitoring (for example, abnormal or extensive violent physical behavior [given and received]).

The geographic origins of the baboons should be considered when forming troops for release. To reduce hybridization and genetic admixture, it is best to release individuals with known geographic origins into sites that have chacma baboon populations. Baboon species and subspecies can interbreed, live in different species' troops, and have fertile offspring (Jolly 1993; Alberts and Altmann 2001; Detwiler *et al.* 2005). However, because these hybrids and their relationships with independent baboon species are not well

Figure 2b. Conspecific resocialization before entering semi-wild. "Main camp", a semi-wild enclosure with a new baboon in the transfer enclosure, used for conspecific resocialization. Photographs retrieved from Riverside's website <https://www.riversidewrc.com/>.

studied (Zinner *et al.* 2015; Martinez *et al.* 2019; Rogers *et al.* 2019), it is best recommended to have distinct troops based on geographic origin until further genetic studies are done.

The integration process is followed by a rigorous monitoring routine, conducted continuously throughout the new arrival's tenure in the rehabilitation program. A standardized template is used in order to instruct, guide and facilitate the monitors (as employed at Riverside). Once the individual(s) have been moved into an introductory enclosure, human contact is minimized to the bare and absolute minimum (as employed at Riverside). This gives the individual(s) enough time to be "weaned" from human contact. Also, troop behavior needs to be monitored, in particular, dominance relationships. Most baboon species live in multi-male, multi-female groups stabilized by a dominance hierarchy. Sexually mature males emigrate from their natal group while females almost always stay in their natal troop and maintain their rank (Bergman *et al.* 2003), creating a stable dominance hierarchy of matrilines. As a troop is forming, the dominance hierarchy may be unstable, and introducing certain individuals (i.e., adults, older juveniles; see Table 1a) can lead to heightened aggression. Although aggression and increased stress is a common occurrence seen in wild conspecifics during integration (Melnick and Pearl 1986; Smuts 1986) and introductions of adults and subadults in rehabilitation centers, prolonged aggression indicates a possible need for the removal of an individual and transfer to a different troop.

Established troops should have similar group compositions (i.e., group sizes, sex ratios, age ratios) to wild conspecifics in order to maximize survival (Baker 2002; Guy and Curnoe 2013). Baboon troops generally have between 40–80 individuals, but troop size can vary widely (07–185; Hamilton *et al.* 1975; Melnick and Pearl 1986). Ratios of adult males to adult females should be around 1:2 to 1:4 (Melnick and Pearl 1986; Henzi and Lycett 1995; Sapolsky and Share 2004). If possible, wild troops close to a potential release site should be studied to indicate the natural troop size of the region (Guy and Curnoe 2013), because troop size is influenced by a number of factors such as food resource availability, predation risk, and proper habitat (Cowlishaw and Dunbar 2000).

Housing and release preparation

Troops should occupy naturalistic enclosures that mimic their native habitat(s) (SAWRA 2009; Miller 2012; Global Federation of Animal Sanctuaries [GFAS] 2013; as employed at Riverside), which allows them to become accustomed to surviving in their natural habitat. Baboons live in many different habitats such as woodlands, savannas, shrub lands, and grasslands (Hoffmann and Hilton-Taylor 2008; Sithaldeen 2019). They are predominantly terrestrial, so providing as much land as possible to forage is recommended; additionally, they prefer sleeping on steep cliffs, trees, mountains, and hill tops to avoid predators (for example, lions, hyenas, and leopards; Altmann, 1980; Cheney and Seyfarth 2007; Bidner *et al.* 2018). Providing extra trees, or large branches when trees and cliffs within the enclosure are unavailable or scarce, is recommended so that this sleeping behavior, along with climbing and foraging, is encouraged. This also increases the complexity and environmental enrichment provided in the enclosures.

Baboons are omnivores, and are known to feed on grass, tubers, bulbs, bulbo-tubers, rhizomes, flowers, fruits, leaves, seeds, tree gum, bird eggs, and insects (DeVore and Washburn 1963; Hall 1963; Altmann and Altmann 1970; Hamilton *et al.* 1978; Tew *et al.* 2018). Natural foods should be provided to promote foraging behavior on the ground and in the trees, (see Table 3 for examples). Examples of natural food resources are *Acacia* spp. and *Ficus* spp. (Hamilton *et al.* 1987; Whiten *et al.* 1991; see also Table 3). If the natural enclosure does not provide enough food, provide the baboons with natural foods such as fresh fruits, vegetables, leaves, and insects, from other available locations, by sustainably growing them (Fig. 3), or by providing supplemental foods. Examples of supplemental foods include poultry seed mix and primate pellets; dog pellets can be used to feed baboons when primate pellets are unavailable (SAWRA 2009).

When animals are in a captive setting of any form, even in naturalistic enclosures for future release, they need enrichment to further develop a species-specific and natural behavioral repertoire, especially for those born in captivity or those rescued from the pet trade. Environmental and feeding enrichment is recommended (SAWRA 2009; GFAS 2013); for example, increasing the complexity inside the enclosure by moving substrates regularly, spreading extra food in different locations throughout the enclosure, and providing sturdy dog toys (for example, rigid balls, thick rubber toys; Brent and Butler 2005). However, effects of animal toys used with rehabilitating baboons has not been studied much, and so animal toys should be used variably and only with infant aged baboons, to prevent positive associations with humans.

Minimizing human contact as soon as possible helps reduce habituation, which is another vital step to rehabilitation. Habituation could lead to baboons associating food with humans, which could encourage them to seek out human company once released (Guy *et al.* 2011; Guy and Curnoe 2013). Similar to Guy and Curnoe (2013), if possible, it is recommended to follow the methods provided by Suarez *et al.* (2001) for brown capuchin monkeys (*Sapajus apella*). Make sure food and humans are not associated with one another by covering one or two enclosure walls with mesh or include fencing with synthetic material and provide food through a window (Suárez *et al.* 2001; Guy and Curnoe 2013). Although it has been previously recommended that feeding times should be varied to reduce predictability (Guy and Curnoe 2013; Suárez *et al.* 2001), baboons are very routine oriented throughout the day. To reduce stress and potential inter-troop aggression, especially when food in natural

enclosures is scarce (for example, during the dry season), provide "meals" regularly throughout the day in a general time frame, and have food resources available to promote foraging (SAWRA 2009; as employed at Riverside).

Predator awareness, or predator avoidance, is also necessary for post-release survival (GFAS 2013). Ex-pets and captive born individuals most likely have not been exposed to predators, and therefore may not display appropriate predator avoidance behaviors. These inexperienced individuals could learn from wild baboons by adding them to a mixed troop comprised of ex-captive and ex-wild baboons (as seen at Riverside, R. Fuller, pers. obs.). However, this is not always feasible, and, in addition, further predator avoidance preparation or training may be critical. Natural enclosures can permit visual exposure and awareness of predators. If this is not possible by natural occurrence at the rehabilitation center, then other methods should be used. Intentional direct exposure to predators themselves or related species, silhouettes, or model predators are used in animal rehabilitation to establish predator-avoidance behavior (Brown *et al.* 1992; McLean *et al.* 2000; Shier and Owings 2007; Arnold *et al.* 2008; Guy and Curnoe 2013). One recommendation is playing audio baboon predator alarm "wahoo" calls when showing a model predator (lions, leopards, crocodiles; Fischer *et al.* 2002), since this call has been associated with predator avoidance behaviors (Kitchen *et al.* 2003; Cheney and Seyfarth 2007). Playbacks of "wahoo" vocalizations should put the individuals on alert, encourage troop protective behavior (for example, attacking the predator), elicit alarm calls, or encourage them to run up trees, cliffs, and other arboreal locations (Cheney and Seyfarth 2007). However, the rehabilitation project should use any method that is most appropriate for the unique circumstances of the center. If more predator exposure is required in the event that an individual or troop has had little to no exposure and is not displaying appropriate predator-avoidance behavior, Guy and Curnoe (2013) recommend an extended period in the pre-release enclosure at the release site to increase the opportunity for exposure to predator species within a protected environment.

Table 3. Examples of natural food sources for the chacma baboon, *P. ursinus*.

Common name	Scientific name	Parts eaten*
Gum Arabic tree	*Acacia nilotica*	s
Red acacia tree	*Acacia seyal*	s
Umbrella thorn	*Acacia tortilis*	bl, fr, g, l, p, s
Fever tree	*Acacia xanthophloea*	bl, fl, g, l, s, t, ys
Baobab	*Adansonia digitata*	fr
Bee sting bush	*Azima tetracantha*	fr, l
African caper	*Capparis tomentosa*	fr
Sjambok	*Cassia abbreviata*	p
Bushwillow	*Combretum microphyllum*	s
Bermuda grass	*Cynodon dactylon*	l
Sicklebush	*Dichrostachys cinerea*	b, l, p, r
Jackal berry	*Diospyros mespiliformis*	fr
Bush guarri	*Euclea schimperi*	fr
Star grass	*Hypoxis gerrardii*	c
Large-leaved rock fig	*Ficus abutilifolia*	fr
Transvaal gardenia	*Gardenia volkensii*	fr
Sausage tree	*Kigelia africana*	fr, n
Desert thorn	*Lycium spp.*	bl, fr, l
Atil	*Maerua crassifolia*	fr
Wild teak	*Pteroearpus angolensis*	s
N/A	*Rhamphicarpa montana*	bl, fl, l
Natal rhus	*Rhus natalensis*	fr
N/A	*Salvadora persica*	fr, l
Weeping boer-bean	*Schotia brachypetala*	l, n
Marula	*Sclerocarya birrea*	b, fr
Cat-thorn	*Scutia myrtina*	fr
N/A	*Sporobolus consimilis*	fr
N/A	*Sporobolus kentrophyllus*	c
Black monkey orange	*Strychnos madagascariensis*	fr
Lowveld cluster-leaf	*Terminalia prunioides*	s
Horse puslanes	*Trianthema ceratosepala*	fr, l
Calthrop	*Tribulus terrestris*	bl, fr, l
Buffalo thorn	*Ziziphus mucronata*	fr

*b = bark, bl = blossoms, c = corms fr = fruit, fl = flowers, g = gum, l = leaves, n = nectar, p = pods, r = roots, s = seeds, t =thorns, ys = young shoots. Modified from Alberts *et al.* (2016, 2020) with additional compilation of Hamilton *et al.* (1987); Whiten *et al.* (1991); personal observations at Riverside.

Pre-release assessment

A troop would be considered fit for release once proper troop formation has been observed; a formed troop is identified with activity budgets similar to wild conspecifics, an

Figure 3. Riverside's sustainably grown supplemental food for the animals. Photograph by Rachel Fuller.

established hierarchy, frequent copulation, and the arrival of the first offspring within that family/troop. The babies are the catalyst for the bonding of both family and troop members (as seen at Riverside). All animals to be released are processed with a protocol similar to individuals leaving quarantine (see *Conspecific Resocialization* section). Each troop member's individual record should be at hand when doing the final pre-release processing. A final medical assessment should be conducted by a veterinarian or a similarly qualified individual on all troop members being considered for release (Baker 2002; Guy and Curnoe 2013; as employed at Riverside). In the final medical assessment, the individuals should undergo a generic physical exam to identify any minor new abnormalities (for example, no mortally wounding injuries) and to collect data for the individual's records (for example, body measurements, weight, physical development; as employed at Riverside). The medical assessment should include a screening for common diseases (Guy and Curnoe 2013); since captive individuals are more susceptible to pathogens that their species usually does not come into contact with (Cunningham 1996; Guy and Curnoe 2013) and share certain pathogens with humans (see *Arrival* section). It is of the utmost importance that animals prepared for release are deemed healthy upon completion of the physical exam, otherwise pathogens and ectoparasite-causing diseases could kill the released individuals due to stress, and they can potentially spread pathogens to wild conspecifics, other wildlife, and local human populations (Heuschele 1991; Viggers *et al.* 1993; Baker 2002; Guy and Curnoe 2013).

To avoid the risk of disease transmission, human contact should be minimal throughout the rehabilitation stages. Centers should quarantine new arrivals (see *Arrival* section), clinical examinations should be conducted by a veterinarian or similarly qualified individual when a baboon shows signs of illness or injury, and baboons should undergo routine fecal examinations for parasite eggs and larvae (Viggers *et al.* 1993; Guy and Curnoe 2013; as employed by Riverside). Additional veterinary exams should be conducted in an on-site animal clinic (as employed at Riverside, see Fig. 1b), or another local veterinarian clinic. Hematology and serum biochemistry (blood) profile values should be collected for comparisons with normal blood values of wild conspecifics (Melton and Melton 1982; Viggers *et al.* 1993; Guy and Curnoe 2013) but this is only recommended if the collection method is not stressful, or if less invasive methods can be used. Guy and Curnoe (2013) recommend testing bodily fluids for infectious diseases, microbial cultures to identify disease, and to vaccinate for some common diseases if necessary (Viggers *et al.* 1993). Whenever animals die at rehabilitation centers or post-release (see *Post Release* section), a necropsy should be performed (Guy and Curnoe 2013, as employed at Riverside). Determining the cause of death could help reduce preventable deaths of future captive animals and better the practices at the center. An example of preventable spread of disease and death is tuberculosis, which can be transmitted between humans, domestic animals, and baboons (Parsons *et al.* 1993; Drewe *et al.* 2012; Guy and Curnoe 2013).

Figure 4. Volunteer researcher conducting a pre-release assessment. a: "Flona-salemi", semi-wild enclosure; b: Transfer cage, used for conspecific resocialization. Photograph by Rachel Fuller.

In addition to a medical exam, results of each individual's behavioral assessment are another factor that influences release. Minimal atypical behaviors should be noted, and the individual should exhibit species-specific normal behaviors and an activity budget comparable to that of wild conspecifics. Regular behavioral monitoring should be conducted to inform the type of rehabilitation needed, and the readiness of an individual for release (Fig. 4). Significant deviation from wild conspecific activity budgets and frequent atypical behavioral occurrences could also indicate the need for modification in the rehabilitation methods (for example, increase enrichment, have more of a natural environment, and promote natural behaviors). Individuals that have very similar behavior and activity budgets to wild conspecifics, do not seek out human contact, and have minimal atypical behavior and are more likely to survive release (Grueson 2007; Guy and Curnoe 2013; Mathews *et al.* 2005). Behavioral observations should be conducted and recorded daily to monitor troop dynamics and development, as well as any possible stereotypical behavior that has developed in captivity that could influence their releasability (Guy and Curnoe 2013; as employed at Riverside).

Release site selection

IUCN has outlined factors that indicate a suitable release site (Baker 2002). A site is deemed feasible to use as a release location based on the availability and seasonality of water and natural food resources, and protection status of the site (for example, a national park, game reserve or private land). If the release site meets these criteria, then the next step is to evaluate if the site is appropriate for the troop. The presence or absence of wild conspecifics and potential human influence and disturbance (for example, road development or hunting) need to be determined. A release site

should also be able to sustain the released individuals (i.e., the habitat does not reach or surpass carrying capacity), help minimize edge effects, and should have no unnaturally high numbers of predators (Dodd and Seigel 1991; Baker 2002; Guy and Curnoe 2013; Guy *et al.* 2013). To this end, a standing crop index template can be used for determining food availability and variety, medicinal flora, and sustainable water source(s) (as employed at Riverside). Due attention should also be given to the average height of large trees in order for the animals to have safe and secure roosting sites.

Species should be released within their historic home range if possible (Baker 2002). Chacma baboons inhabit woodlands, savannas, shrub lands, grasslands, coastal, and rocky areas (i.e., inland cliffs or mountain peaks) of southern Africa and are mainly distributed throughout South Africa, Angola, Zambia, and the Republic of Mozambique (Hoffmann and Hilton-Taylor 2008; Sithaldeen 2019). Although some chacma baboon populations are used to surviving days without water because they occupy arid and desert habitats, a lack of a permanent water source increases mortality (Dunbar 1988; Guy and Curnoe 2013). To avoid high mortality rates and reduce intertroop stress, it is recommended that the troop has access to a permanent water source at the release site and that the release occurs during the wet season, when water and food resources are more readily available (Wimberger *et al.* 2010; Guy *et al.* 2012; Guy and Curnoe 2013; as employed at Riverside).

As previously mentioned, baboons are opportunistic, and are considered pests and vermin because they can thrive in human-modified environments (Hill 2000; Pahad 2010; Hoffman and O'Rain 2012). This has led farmers and other local populations to retaliate, resulting in injury or death (Smit 2010). Baboons that live in close proximity to humans are also in danger of being hit by traffic and hunted for medicinal purposes (Alves *et al.* 2010; Smit 2010). These negative situations can be avoided by releasing the troop far from human settlements with plenty of natural food sources, along with providing supplementary food (usually used in soft releases; see section on *Release*) for an appropriate time after the release until individuals can find food on their own (Guy and Curnoe 2013; as employed at Riverside). With the proper rehabilitation practices prior to release, such as decreasing habituation and promoting natural behaviors, releasing should hopefully not take more than a few weeks for an entire troop (as employed at Riverside).

Habitat features that influence the likelihood of successful release correspond to the natural environment that chacma baboons occupy. The flora associated with natural food sources should be plentiful. If the release site is in a forested habitat, fruits will constitute a high portion of their diet and should adequately sustain them, while a release site in an open savanna habitat should have plenty of fruits, grass, roots, and other natural foods (Melnick and Pearl 1986; see Table 3). Preferably, the release site has cliffs or trees where the baboons can sleep during the night to avoid predators (Altmann 1980; Bidner *et al.* 2018). Studies have shown that protected areas such as national parks, game reserves, and private lands are associated with positive release outcomes (Guy and Curnoe 2013; Guy *et al.* 2013; Guy *et al.* unpubl. data; as employed at Riverside). Prior to release, communication should occur between those running the release project and the landowners, to establish an agreement and future cooperation when the release occurs and for post-release monitoring (Guy and Curnoe 2013; as employed at Riverside). Human settlements, potential human influence, and human disturbance are associated with poor-release outcomes, and locations with those issues should be avoided when choosing a release site (Baker 2002; Guy and Curnoe 2013; Guy *et al.* 2013; Guy *et al.* unpubl. data).

The release site size to released troop size ratio is another important factor to consider when preparing for release. The release site must be able to sustain the released troop (Baker 2002; Guy and Curnoe 2013), which can be a complex factor to assess considering the variation of troop size, home range, and day range seen in chacma baboons (see Tables 4a and 4b). Daily distance traveled (daily home range) can cover a large expanse of land, especially in bigger troops (Slater *et al.* 2018). However, if food resources are more readily available in a habitat, such as in a forest with high fruit counts during the wet season as opposed to a savanna, the baboon troop may not be required to travel as much. This in turn allows for a higher population density in a smaller home range. Troop home ranges are more likely to overlap when resources are low/less available (for example, in the dry season; Stone *et al.* 2012; Slater *et al.* 2018). Although overlaps occur naturally in the wild, releasing a troop within the core range of another troop is not recommended. Recommended home range size is 15.19 km², with a density of 1.8 individuals/km², and 2.0–3.0 km² for the daily distance travelled (Stone *et al.* 2012; Slater *et al.* 2018; see Tables 4a and 4b). The presence of wild conspecifics is one factor that determines the suitability of a potential release site (Baker 2002; Guy and Curnoe 2013; Guy *et al.* 2013). Wild conspecifics surviving in a habitat indicate that the habitat is suitable for the species. If possible, avoid too much overlap, if at all, since this can cause unnecessary stress and aggression. To ensure that the release site can support the addition of a self-sustaining population, the density of wild conspecifics prior to introduction should be lower than the environment's carrying capacity (Cowlishaw and Dunbar 2000; Baker 2002; Guy and Curnoe 2013).

The purpose of a release should be population restoration through reinforcement, as well as the welfare of the individuals being released. The goal of the release is to increase numbers and genetic viability (IUCN SSC 2013) of free-ranging baboons. Since gene flow predominantly depends on male troop emigration (Melnick and Pearl 1986; Smuts 1986), wild conspecifics should be nearby. When selecting a release site, other species need to be considered also for disease risks and competition. Chacma baboons occupy southern Africa along with many other primate species

(for example, vervet monkeys *Chlorocebus pygerythrus*; samango monkeys *Cercopithecus albogularis*; galagos, *Otolemur crassiscaudatus*, *Galago moholi*; IUCN 2020). These species' populations should also not be threatened in the habitat from the addition of the release baboon troop.

Release

A transportation plan from the rehabilitation site/center to the release site should be prepared that is of minimal stress and has a low risk of injury and illness for the individuals being transported (Baker 2002). The baboons should be in well-ventilated transport boxes with adequate water and food that is sufficient for the time in transit (Guy and Curnoe 2013; as employed at Riverside). To avoid illnesses or death caused by suffocation and overheating, transportation should occur in the early morning, late evening, or even at night (Baker 2002; Guy and Curnoe 2013; as employed at Riverside). All males considered subadult or adult (see Table 1a) are placed in separate transport boxes to avoid injury of other individuals as a result of stress (as employed at Riverside). Juveniles are boxed with one another for comfort (no more than two per box), and infants are transported with their mothers in separate boxes for each dyad (as employed at Riverside). Separating infants from their mothers or isolating young baboons (i.e., Juveniles-1, no less than 3.5 years of age; see Table 1a) from other troop members can be very traumatic to young baboons and can even lead to death. Frequent stops are recommended to check on the baboons and provide water if the troop is being transported long distances (Guy and Curnoe 2013). Experienced personnel involved in the rehabilitation project should accompany the troop, along with a veterinarian or similarly qualified individual if possible, in case of emergencies (Baker 2002; Guy and Curnoe 2013; as employed at Riverside).

A soft release method is preferred in rehabilitation projects because it allows the baboons to acclimatize to their new environment and familiarize themselves with the new surroundings while recovering from transport (Baker 2002; Guy and Curnoe 2013; as employed at Riverside). It is recommended that the troop stays in the release enclosure for two weeks at the release site, although more time might be required (Cheyne *et al.* 2012; Guy and Curnoe 2013; as employed at Riverside). To reduce stress at the release site, supplemental food should be provided to the troop during the acclimatization period as a means of ensuring that each baboon obtains adequate nutrition. Supplemental food should be comprised of natural food resources, preferably from the surrounding area (Baker 2002; Guy and Curnoe 2013; as employed at Riverside). Once the troop

Table 4a. Baboon group range. Modified from Melnick and Pearl (1986).

No. of groups	Group size mean (range)	Home range mean (ha)	Daily range mean (m)	Daily range length (m)	Population density (per km²)	Source
6	47.2 (30–77)	1,735 (1,295–2,331)	6,400	(3,219–9656)	4.0	Stolz & Saayman (1970)
3	45 (20–80)	1,100 (910–3370)	4,667	(1,609–8,047)	2.4	DeVore & Hall, (1965) Hall (1962)

Table 4b. Mean baboon group statistics. Data from Slater *et al.* (2018).

No. of groups (range)	Group size mean (±SD)	Estimated home range (km²) mean (±SD)	Daily home range mean (km²)	Annual home range size (km²)	Population density (per km²)	Source
21 (9–37)	18.3 (±6.8 SD)	10.2 (±2.3 SD)	3.37 (±0.73 SD) (n = 25)	10.35	1.8 (±0.4 SD)	Marais *et al.* 2006)
10 (18–70)	38 (±19.06 SD)	26.76 (±13.91 SD)	Wet season 26.54 (±12.76 SD) Dry season 26.72 (±13.91 SD)	n/a	3.57–4.06	Slater *et al.* (2018)
13	43.1 (±11.1 SD)	14.55	n/a	n/a	2.8	Henzi *et al.* (2011)
61	22.49	n/a	n/a	n/a	n/a	Henzi & Lycett (1995)
12	34 (±16 SD)	n/a	n/a	n/a	4.7 (±2.5)	Hoffman & O'Riain (2012)

has adjusted to the new location, or acclimatized (IUCN 2018), ideally the baboons will be resourceful enough to not require supplemental food, but it is recommended to provide food for a period up to a two-months if required (Baker 2002; Guy and Curnoe 2013). The supplemental food can be gradually reduced so that the baboons will be more encouraged to forage on natural foods that are not supplied by humans. Once the troop is out of the release enclosure, tracking for post-release monitoring should begin (as employed at Riverside; see Fig. 5).

Post-release assessment

Post release monitoring is vital because the data collected determines the success of the release and provides insightful information for future release projects. For tracking, following troop movements, evidence of troop presence (for example, tracks), and personal recognition of individuals (as employed at Riverside) can be used, although these methods may not always be feasible. Radio and GPS collars are recommended since they are regularly used on wild baboon populations without ill effect (Alberts *et al.* 2016; Farine *et al.* 2017; Fehlmann *et al.* 2017). However, it should be noted that collars and the process leading up to attaching collars can have detrimental consequences on the animal(s) (Isbell *et al.* 2019), and further studies must be conducted on this subject. Collars provide substantial information, such as home range and habitat use based on an individual's movements. Collars last for up to two years and can aid in locating individuals when they cannot be seen. Collars should be sufficiently tight so that they cannot be pulled over the head by baboons or caught in vegetation, but they should be comfortably loose enough that they do not choke the individual or irritate the skin (Fehlmann *et al.* 2017). Only adult baboons (females: >5 years, males: >9 years; see Table 1a) should have collars around their necks since younger individuals are still growing (Farine *et al.* 2017). Adult females with signs of pregnancy should also not be collared due to the sedation required for putting it on. All individuals large enough to be collared should have one in order to limit the number of missing individuals, and to collect as much data as possible (Guy and Curnoe 2013).

The released troop should be monitored for at least one year to record data encompassing the natural occurrences a chacma baboon troop experiences annually (i.e., season and resource availability change, troop migration, male emigration, new wild male immigration, breeding, predation) (Beck *et al.* 2007; Guy and Curnoe 2013; as employed at Riverside). Data on predator densities should also be collected because it can increase the accuracy in tallying baboon deaths due to predation and in assessing the effectiveness of predator awareness behavior training (i.e., group attack or running into trees; see section on *Housing and release preparation*). Natural predators of baboons are crocodiles, leopards, hyenas, lions, cheetahs, and in some cases, immigrating adult male baboons (infanticide). Since human activity is one of the most common causes of baboon mortality (see section on *Release site selection*), any noticed human activity around or at the release site should be recorded, especially when it impacts the troop. Population demographics (i.e., total numbers within a troop over time, sex ratios, adult/juvenile/infant ratios, population changes within the troop, and a continuing assessment of threats) of the troop should be recorded and compared to data collected from existing wild conspecifics (Fischer and Lindenmayer 2000; Guy and Curnoe 2013; see Table 2). Wild conspecifics in the same habitat can easily be used for comparisons because they are influenced by the same factors.

Conclusion

Baboons in a released troop and their future offspring are more likely to survive when released in accordance with carefully considered criteria (see sections on *Pre-release assessment* and *Release site selection*). Nevertheless, one issue sometimes causes strife between and within rehabilitation centers and sanctuaries: all released individuals will eventually die, whether they are in a zoo or sanctuary (Kleiman 1996) or after a release. A rehabilitation and release project should not be deemed a success or failure by simply tallying the deaths of the originally introduced individuals; but rather be measured by the criteria listed in the Post-release section, as well as the number, genetic variation, and species-specific behaviors of the descendants of the originally released troop members should be used as indicators of release outcome.

Population sizes of common animals such as baboons are dwindling (Ebua *et al.* 2017; IUCN 2020), and conservation strategies are vital to the survival and maintenance of biodiversity. Recent studies have determined that 60% of primate species are threatened with extinction, and 75% have declining populations (Estrada *et al.* 2017, 2019; IUCN 2020). Rehabilitation projects and population restoration through reinforcement are, therefore, important

Figure 5. 2018 Baboon release. Baboon troop leaving temporary enclosure set up at release site. Photograph is a frame from a video posted on the Riverside Facebook page <https://www.facebook.com/groups/10315717899/>.

methods that can be used to combat the loss of biodiversity. Although rehabilitation and reinforcement projects are increasing, there is a general deficit of species-specific guidelines in the scientific literature (Fischer and Lindenmayer 2000; Cheyne 2004; Guy *et al.* 2014, 2012; Wimberger *et al.* 2010), including guidelines for chacma baboons. Programs that intend to release animals should have access to guidelines to aid in the development of methods that optimize chances for success. If rehabilitation methods and release outcomes are published, regardless of a positive or negative outcome, rehabilitation and reinforcement can become an effective aid to conservation as practices improve (GFAS 2013; Guy *et al.* 2013). The guidelines provided here are meant to be a "best practice" model for chacma baboons. It is recommended that species-specific guidelines are developed for each primate taxon considered for release, as well as incorporating additional material to existing guidelines in order to optimize successful releases (Guy and Curnoe 2013). Since these guidelines are constructed to reflect the practices of centers that have successful releases, but are not accredited by GFAS or PASA, this can also be used for those that do not qualify to become accredited or cannot afford the fees.

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