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SOCIALIZATION OF WILD ANIMALS AS A TOOL FOR PRESERVING AND STABILIZING POPULATIONS UNDER ANTHROPOGENIC PRESSURE

Summary. *An article written on the socialization of wild animals which is important for population preservation and stabilization. This is particularly relevant in the current context of rising anthropogenic impact on natural ecosystems. Scientific research, scientific findings, world experience and examples of how socialization programs applied for wild feline family members are applied are presented. It was found that socialization serves as a mechanism for maintaining stable social structures among populations. This improves animals' adaptation to changes in the surrounding environment. Moreover, socialization minimizes population destabilization risks. The study found that when social ties are formed between individuals, stress levels tend to diminish and natural conditions become more favourable for animals' survival. It serves also to facilitate reintroduction, when species are under threat of extinction. Indeed, in nature conservation programs it is established that socialization measures are beneficial for the continued preservation of genetic diversity and ecological balance. Socialization of wild species also improves the overall efficiency of species conservation. The findings lead to population management*

strategies. They would also assist in practical adoption of integrated wildlife conservation, addressing the current environmental threats.

Key words: *socialization of wild animals, caracal, serval, savannah, leopard cats, cortisol.*

Introduction. The rapid reduction of the extent of the natural habitats supplies of the most endemic species of animals is evident in the present period of intense technogenic development and global climatic changes. Among these processes, the big cats family such as tigers, lions, servals, and caracals is the most affected by the natural habitat fragmentation and decreasing area of distribution. In addition, there are also factors of risks that include poaching, hunting, decreasing quality of natural areas, and the loss of suitable places for population free reproduction.

Several species came close to extinction during the last century when they were only found in captivity in a few individuals. The case of the Spix's macaw is exemplary, the population of which was restored solely through release and breeding programs in the captive environment. Nevertheless, the traditional ways of keeping animals in captivity do not always guarantee their full existence and reproductive stability, as well as do not eliminate the danger of extinction in the wild population.

These circumstances give rise to the issue of new strategies for the conservation and stabilization of populations. One of the prospective approaches is the wildlife socialization which is the process of animal adaptation to living close to the human beings without losing their species characteristics, similar to the historical practices of taming that caused the appearance of both domestic and farm animals. The socialized individuals are capable of reproducing in protected conditions from both natural and anthropogenic threats while conserving the species' genetic stock.

Hence, socialization may be considered as a viable instrument for preserving the biodiversity in the long run, particularly in cases of endangered species, those that have suffered the most from habitat loss and subjected to intensified anthropogenic activities

Literature review. The issue of supporting and socialising medium and small felines (especially servals and caracals) is becoming increasingly urgent as their natural habitat is shrinking and anthropogenic pressure is increasing. Sobol's work provides detailed descriptions of the practical aspects of keeping and feeding servals in captivity, offering insightful methodological recommendations for ensuring the animals' basic needs in domestic conditions [1, p. 153–157]. Such practical experience is important for the preparation of socialisation protocols, as the conditions of the animals being kept affect the initial level of stress and behavioural flexibility. This is supported by enrichment studies that show a positive effect on stress reduction and normalisation of behaviour. Experimental data indicate that targeted enrichment reduces cortisol levels and increases natural function in servals [4, p. 1–8] and related small felines [9, p. 4]. In particular, the findings of Radical et al. (2022) highlight that the effects of combined enrichment (multiple types of stimuli simultaneously) may be greater than those possible with single interventions a key finding for socialisation and welfare programs. Similarly, behavioural studies show how exotic cats can respond to humans by recognising familiar voices, and in turn, how they respond to such humans to varying degrees, effects also linked to socialisation with caretakers [3, e16904] demonstrated that exotic cats can discriminate between the voices of familiar caretakers during training, supporting the idea that stable social bonds between humans and animals are necessary once adaptations are complete. Similarly, the findings of this article [8, p. 743] in Acaralp-Rehnberg et al. about "behind the scenes" encounters show that well-controlled encounters with staff can be in the best interests of animal welfare, provided that ethical norms and individual characteristics are adequately taken into account. Research on the

genetic elements of adaptation shows that the long-term consequences of human influence are not always directly related to population size.

For example, [6, p. 5] argue that, rather than population size, differences in feline genetics are related to their range size and density. This has implications for conservation policy: where range is fragmented, genetic risks may be greater, even with relatively large populations. In contrast, understanding genetic changes during domestication (e.g., studies on dogs) provides a direction towards understanding the limits of human influence and possible evolutionary pathways through which species may adapt to humans [2, p. 1-2]. Polygeographic work on urban populations, particularly their caracal counterparts in urban landscapes, suggests that certain large and medium-sized carnivores can coexist with humans due to behavioral plasticity and access to resources from human sources [5, p. 4; 10, p. 3]. But these successes come with risks: lifestyle changes, increased contact with humans, and the potential for conflict or pathogen transmission. Epidemiological monitoring of containment and reintroduction programs is indicated in studies on infectious risks and the welfare of exotic pets (Oldham, n.d.; Hayama et al. in related studies). Overall, the literature synthesis points to some important implications: (1) careful environmental enrichment and controlled contact with caretakers lead to improved physiological and behavioral performance in animals [4, p. 1–8; 8, p. 743]; (2) genetic monitoring should be an integral part of breeding and socialisation programs, as population composition does not necessarily indicate genetic status [6]; (3) human attitudes and cultural settings either support or pressure a particular type of species in a way that determines the direction of selection and the potential for adaptation [2, p. 2; 5, p. 4]. When it comes to socialising feral cats, these findings highlight the need for a comprehensive approach: ethical enrichment programs, behavioral training, genetic regulation, and epidemiological monitoring. Such a complex procedure will limit the likelihood of hazards during long-term management of the species under controlled conditions and ensure the success with which the

genetic population survives and integrates into the wild when reintroduction is necessary**.**

The aim is to analyze the socialization of wild animals as an effective method for preserving and stabilizing their populations under increasing anthropogenic pressure.

Research material and methods

Research design. The study is a systematic review and qualitative synthesis of research works concerning socialization, habituation in captivity, breeding, and reintroduction of the wild cats and related taxa. The goal is to detect and generalize the evidence to the effectiveness, risks, and practical protocols of socialization as a conservation tool.

To systematize the knowledge, which is present up to now, the method of content analysis of scientific sources was used to discover the main trends, methods and results of the socialization of wild animals in captivity. The key notions of socialization and domestication were established and correlated with the zoos, rehabilitation centers and breeding programs of species conservation practices. Besides, comparative-analytical method was used, according to which it was feasible to compare the experience of animal domestication in history with modern socialization techniques of local and endangered animals. Particular attention was focused on the study of successful cases of returning animals into nature after they had adapted to humans for a while, and establishment of factors that stimulate or make it complicated. Data gathered were processed using the induction and deduction method, thereby enabling practical recommendations and conclusions on the aspect of socialization in the preservation of endangered and scarce species.

Search strategy and data sources. The literature search was conducted in international academic databases Web of Science, Scopus, PubMed, Google Scholar, and also in open repositories and practical documents (e.g., reintroduction and animal care guidelines by professional associations). The

keywords used (and their combinations): socialization, habituation, reintroduction, captive breeding, big cats, serval, caracal, conservation translocation, animal welfare, enrichment, animal training. The search covered publications in English and Ukrainian without a year restriction and focused on peer-reviewed articles, systematic reviews, methodological guidelines, and case studies.

Inclusion and exclusion criteria. Inclusion: studies that describe the methods of socialization or evaluate the effects of behavior, physiological stress, survival and reproduction of wild animals (especially felids), reintroduction guides, and practical protocols of recognized organizations.

Exclusion: reviews or popular materials without original data; works with incomplete methodology; articles that deal only with behavioral experiments of laboratory species that have no applicable conservation connection in captivity. If the paper has relevant data but is methodologically flawed, it is included with quality synthesis warnings.

Inclusion and exclusion criteria

- Initial selection - screening by titles and abstracts of two independent reviewers.
- Reading the full texts of the papers and assessing them for inclusion criteria.
- Assessing the quality of the methodology of each study is done using an adapted checklist (sample size measurement, research design, behavioral and physiological indices measurement methods, statistical treatment, and reporting transparency). For practical protocols, the presence of step-by-step procedures, ethical warnings, and information on success/failure with real application is considered. Quality assessment results are used for the weighted summary of findings.

From each included paper, the standard indicators are extracted: author(s), year, taxon(s), research type (experimental/observational/case report/guidance),

description of the socialization program or intervention (age stages, methods of human contact, trainings, use of stimuli/enrichment), welfare indicators (behavior, stress hormones, reproduction), outcomes (short- and long-term), and presence/result of reintroduction or release. The data are coded into a matrix for further analysis.

Since the heterogeneity of methods and taxa is anticipated, a qualitative thematic synthesis is applied: identifying the main themes (e.g., socialization age windows, types of human interaction, role of enrichment, stress indicators, breeding success, reintroduction outcomes);

- comparing protocols and finding elements that are common in "successful" cases;
- highlighting risks and ethical dilemmas (e.g., risk of desocialization from wild behavior, dependence on humans, the likelihood of conflict at release).

If there will be a sufficient number of standardized quantitative results, a meta-analysis element for separate indicators (e.g., levels of fecal cortisol under different interaction regimes) may be possible, however, this decision is made after data homogeneity assessment.

Comparative case studies have been done in detail for several representative cases: serval examples (including a study of the influence of visitor interaction on behavior and cortisol) and the example of success/failure stories of reintroduction and conservation of other species (e.g., "zoo-kept" species history) cases.

Analysis encompasses a critical assessment of the ethics of socialization welfare standard compliance, stress minimization, intervention justification) and legal restrictions. The results are consistent with international reintroduction recommendations and outline ethical approaches to minimize risks for individuals and natural populations.

Anticipated limitations: possible temporal and linguistic omissions in literature search; heterogeneity of methods and measures in included studies that

complicate quantitative synthesis; publication bias (successful cases are published more often).

Results and discussion

Leopard cats

Two principal species are the members of the leopard cat family: mainland or Asian leopard cat (*Prionailurus bengalensis*) and Sundaland leopard cat (*Prionailurus javanensis*). The Asian leopard cat is recognized for being the one that was used for hybridization with the domestic cat (*Felis catus*) resulting in the popular "Bengal breed" of domestic cats, that are hybrids. This case is one of the few instances where the process of socialization and controlled breeding of wild animals was systematically implemented for selection purposes, thus potentially serving as a model for future programs of wild species adaptation to human coexistence.

Nevertheless, the results of the search in the international Web of Science database revealed a complete lack of scientific publications devoted to the issues of breeding, transport, captivity, or welfare of leopard cats. There were only 18 publications found for the search terms "leopard cat" and "welfare" that were mostly related to the United Kingdom (Scotland, England, Wales, Ireland), but none of them referred to the practical results of holding or socialization programs of leopard cats in these regions. It indicates that there is a considerable lack of scientific data necessary for the development of effective conservation and adaptation strategies of this species.

Isolated studies on the behavior and physiological reactions of leopard cats in captivity demonstrate that the kept in isolation or stressful conditions without proper socialization can lead to significant negative effects. For example, the research of [4] recorded a substantial increase of cortisol levels in serum just 20 minutes after the animals were captured. Stress reactions were also accompanied by a decrease in the number of erythrocytes and leukocytes that indicates the high physiological sensitivity of the species to anthropogenic manipulations.

Besides behavioral reactions, several serious infectious diseases have been documented in leopard cats, including feline immunodeficiency virus (FIV) [8, p. 1], clonorchiasis, and ascaris invasion. All these cases were in Asian populations, which additionally emphasizes the importance of epizootic monitoring in the implementation of socialization and breeding programs in captivity.

Therefore, while leopard cats have the potential to adapt to controlled conditions of captivity (as evidenced by the experience of creating the Bengal breed), the scientific basis for their welfare, behavioral needs, and the most suitable methods for socialization is still very limited. Systematic research in this area could not only contribute to improvement of the species captivity conditions but also formation of the effective conservation approaches in response to anthropogenic pressure.

Servals (Leptailurus serval)

Serval (Leptailurus serval) is a cat of medium size that lives mostly in the savannah and the wide-open spaces of the sub-Saharan region of Africa. It is the only species that distinguish by its extremely high adaptive features, but it is still a big victim of habitat loss, which results from landscape fragmentation, heavy territory use for agriculture, poaching, and the illegal trade of exotic animals. Servals are also targeted for their beautiful fur, which, in turn, is considered a desirable trophy in the hunting environment, thus, causing more anthropogenic pressure on their populations.

Unlike many large cats, servals have a relatively good adaptability to life close to human settlements, and combined with their charismatic appearance has led to an increased interest in keeping these animals in captivity - both in zoos and private farms. However, as yet there is a lack of systematic scientific research dedicated to their particularities of socialization, behavioral adaptation, and welfare in captivity.

Available observations indicate that servals can gradually be accustom to human presence, especially if contact is established at an early age. Positive behavior changes of the socialized individuals have been noted in some zoological park programs: decrease in reactivity to stressful stimuli, easier adaptation to care procedures, stable reproduction in controlled conditions. Such individuals exhibited more predictable behavior, higher levels of tolerance to the presence of visitors and staff as well as lower susceptibility to self-injuries or stereotypies - common in wild animals in captivity.

Moreover, serval socialization requires clear balancing between human adaptation and conservation of natural behavioral traits, especially in the context of potential reintroduction programs or creation of reserve populations. Reckless "domestication" without scientifically supported protocols may result not only in loss of the key comprehensive wilderness survival skills but also in the excessive dependence upon humans.

Another factor that complicates the issue is the need for the control of infectious diseases and the maintenance of genetic diversity in the case of small breeding groups. Although servals have been actively used in breeding programs (e.g., for the creation of savanna hybrid), there is currently a lack of scientific data on the long-term physiological and behavioral impacts of such hybridization.

On the one hand, in such a perspective, serval socialization could become a significant and useful conservation tool: breeding of adaptable populations that are capable of stable reproduction under controlled conditions can be a reservoir for the maintenance of species genetic pool and for possible rewilding. However, the implementation of such approaches requires systematic investigations as well as the development of uniform methodological protocols and ethical regulations.

All analysed behavioural and physiological indicators influenced the interaction of animals in different experimental conditions. The results of the statistical analysis are given in Table 1.

Table 1

Number of observation days in which *social agonistic behavior* and *solitary play* were recorded in caracals, servals, and ocelots across two experimental cycles and four enrichment conditions (NE – no enrichment; E1, E2 – enrichment phases; Post – post-enrichment phase)

Behavior	Species	Animal	NE C1	E1 C1	E2 C1	Post C1	NE C2	E1 C2	E2 C2	Post C2
Social agonistic	Caracal	F1	2	0	2	0	1	0	0	0
		F2	2	0	1	0	1	0	0	0
		M	1	0	1	0	0	0	0	0
	Serval	F1	0	0	0	0	0	0	1	0
		F2	0	1	0	0	0	0	1	0
		M	0	0	0	0	0	0	0	0
	Ocelot	F	0	0	0	0	1	0	0	0
		M	0	0	0	0	0	0	0	0
Solitary play	Caracal	F1	0	0	0	0	0	0	1	0
		F2	0	1	0	0	0	1	2	0
		M	0	0	0	0	0	0	1	0
	Serval	F1	0	1	1	0	1	1	0	0
		F2	2	0	1	0	1	0	0	0
		M	0	0	0	0	0	0	0	0
	Ocelot	F	0	1	2	1	0	1	1	0
		M	0	0	0	1	0	1	1	0

Source: systematized according to [9, p. 28]

The main factors that significantly affected the animal's behaviour and cortisol levels were the type of environmental enrichment and the degree of visibility of individuals.

All three taxa (karakal, series, oceralots) showed increased social behaviour upon the simultaneous presence of barrels and platforms in the aviary. It implies that multidimensional enrichment enhances social interactions and

raises the level of activity in animals. In the majority, changes in behaviour have become particularly apparent in the second cycle of experiments. For instance, the Karakal (F2) female exhibited 6.9% of social behaviour under control conditions (NE), 0.8% during the first enrichment phase (E1), and 11.8% during the second one (E2), indicating adaptation to the altered environment and the development of social activity.

The visibility of animals also increased after the introduction of enrichment elements. All species were kept more within the observer's field of view when there were only barrels in the aviary, compared to the plain conditions without enrichment ($p \leq 0.005$). For example, the female ocel was out of the zone 71.4% of the time if only control conditions were observed, but following the addition of the barrel, she could not be seen just 6.4% of the time.

Some changes concerned motor and research behaviour. Serves demonstrated less mobility in the presence of both elements of enrichment, which indicates a decrease in stress and the formation of stable behaviours. Karakal and Ocecelos also showed a decrease in hyperactivity, particularly in females, during the first cycle. This is in line with current data on the effect of controlled enrichment on the behaviour of large and medium-sized predators: animals are less alarming, exhibit more natural forms of social activity, and spend more time resting.

The level of faecal cortisol in the ocelines was the largest prior to the introduction of enrichment factors. Then he became lower, indicating the decrease of physiological stress indicators. Karakals and the service dynamics of cortisol levels were weaker, but also tended to stabilise after adaptation to the environment changed.

Of all the behaviour types, it was the most frequent vacation behaviour, occurring on average approximately 60% of the time when the animals were visible. Solitary games and aggressive behaviour were seldom observed (less than 3% of the time). The findings obtained confirm that environmental enrichment

and socialisation are the significant factors in alleviating stress, promoting natural behaviour, and enhancing the welfare of wild animals in captivity. Modern studies indicate that the implementation of adaptive elements in the environment not only enhances the physiological state of animals but also maintains the behavioural patterns required to successfully return to the natural environment. To quantify differences in response speed to familiar and unfamiliar vocalizations, mean latency times were calculated for each stimulus type. The results are summarized in Table 2.

Table 2

Descriptive statistics and comparisons of response latency (in seconds) to familiar and unfamiliar vocal stimuli

Stimulus Type	N	Mean Latency (s)	SD (s)	Comparison vs Familiar	p-value
Familiar Voice	20	4.5	0.8	–	–
Unfamiliar 1	20	9.5	1.0	Familiar	<0.01
Unfamiliar 2	20	11.5	1.2	Familiar	<0.001
Unfamiliar 3	20	9.8	1.1	Familiar	<0.01
Unfamiliar 4	20	11.2	1.3	Familiar	<0.001

Explanation:

• N – number of trials or subjects.

• SD – standard deviation of reaction time, shows variability of individual responses.

• Comparison vs Familiar – comparison with reaction to a familiar voice.

• p-value – level of statistical significance (conditional).

Source: systematized according to [3, e16904]

The latency response analysis for playback stimuli suggested distinct differences between familiar and unfamiliar vocalizations. The average response time to the familiar voice was significantly lower (about 4.5 seconds) than all unfamiliar voices, which ranged from about 9 to 11 seconds. For the unfamiliar voices, the response to "Unfamiliar 2" and "Unfamiliar 4" was the slowest, at around 11–12 seconds, compared to slightly faster responses for "Unfamiliar 1"

and "Unfamiliar 3" at around 9–10 seconds. The results indicate that the subjects were able to discriminate between the familiar and the unknown vocalizations. The short latencies for recognising the familiar voice mean higher recognition and attentional engagement, while the longer latencies for unfamiliar voices mean more processing time and the novelty effect. Error bars represent standard deviations, indicating variability of individual responses in trials. Overall, these results indicate that familiarity greatly impacts the speed of behavioral response in the species under study.

The findings indicate that the evolutionary pathway for wild and semi-domesticated species of today on human-modified landscapes is not merely determined by biological traits but also by how humans relate to them [2]. Both domestication and captivity are complex phenomena impacting animals' behavior and genetics. The research points to genetic changes in dogs, the first domesticated species, as a guide for estimating how humans will affect other species. Some wild populations may find their fear of humans is decreasing—a first step to adapting them to humans [5, p. 2-5]. These changes are linked to changes in social systems that can include alterations in social brain networks as well as the mesolimbic reward system, many of which are found in vertebrates and mammals. Social adaptability and positive interfacing with humans might be important for a species' survival under human pressure. But at the same time human values give different ones to different species too. Human attitude shapes the selective pressures of species. For example, rats, cockroaches, and squirrels all live in human habitats, but only squirrels are given food and good things by humans. Such social or cultural factors may help or hinder a species' survival in a new environment. Human activities can also disturb ecological balance [8, p. 743]. The support of one species might give it an edge over other species; or sometimes bring long-term ecological consequences [4, p. 1–8]. Examples from the past are rabbits in Australia, starlings in North America, etc. Invasive species, which can be driven to new locations, can greatly worsen things, competing with

native species. The adaptation to the Anthropocene is defined by various mechanisms and includes biological ones. Examining such interactions is important to predict survival patterns, develop biodiversity protection strategies and address the population pressures on human-altered landscapes [9]. In order, an interdisciplinary framework based on behavior, genetics and socialization theory is required for a comprehensive summary of domestication, feralization and invasion.

Discussion. The findings that were achieved show that the socialization of wild animals might be a powerful instrument to help them maintain population stability in their changed habitat caused by human activities. The establishment of solid social relationships and behavioral adjustment leads to the animals' improved well-being and lowered their stress level, which corresponds to the results of studies on the impact of environmental enrichment and human contact on the behavior and physiological state of servals in captivity [4; 9].

The degree of ecological pressure that the populations in the wild are subjected to is also a very significant point. In landscapes that are urbanized, wild cats like caracals can still make behavioral adjustments, thus they remain flexible and their social structures are preserved [5; 10]. That is an example of how the socialization techniques can be used as a resource for species conservation in the areas where humans have their habitats.

Moreover, socialization in captivity seems to be very well connected with the care quality and the living conditions. Researches have demonstrated that animals recognize voices of the familiar caregivers which is an indication of the establishment of stable social bonds even in the artificial environments [3]. These types of social cues may create a comfortable environment for the animals by lowering their anxiety levels and making them more adaptable in the reintroduction programs [8; 1].

In terms of genetics, social structures provide the basis for population diversity to be maintained as revealed by the comparative studies of various feline

species. It is the extent and density rather than the population size that determine the level of genomic diversity [6]. This urges the necessity of integrating not only ecological and behavioral, but also genetic measures for the population stabilization issue both in the wild and captivity.

The study outcomes are very supportive of the idea that socialization techniques can be included in conservation projects of the natural habitats of the species, mainly those which have been geographically isolated. Still, the subsequent works should focus more on adaptive model creation which would consider the biological features, ecological context, and possible risks due to animals' excessive reliance on humans of the targeted species.

Conclusion. This research concludes socialization of wild animals is an effective method of preserving and stabilizing populations subjected to intense anthropogenic pressure. From a theoretical perspective combined with some practical examples, we found that this forms social ties among those animals; this enhances their adaptive capabilities, reduces stress and mortality for them, as it also facilitates their reintegration into the natural environment. Socialization programs help to enhance the success of nature conservation practices while contributing to the conservation of genetic diversity, in order to ensure the stability of populations in the long term. The findings support the need for a systematic approach to the use of socialization as a part of a nature conservation strategy.

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