Methodologies for differentiating between wild and captive-bred CITES-listed snakes

Synopsis
(full report annexed)

IUCN SSC Boa and Python Specialist Group (BPSG)

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1.0 Importance and CITES context

The international trade in snakes, including their parts and derivatives, is a multi million dollar industry. Snakes are often sourced from the wild, but are increasingly being sourced from captive breeding facilities that produce many thousands of individuals to meet demands for pets, medicines, leather goods and food. These trades are often critically important for the livelihoods of many people participating in them, and captive breeding has been promoted because it may reduce harvesting pressure on wild populations. However, there are also concerns that some captive breeding facilities are being used to launder wild-caught specimens and trade them as though they were captive-bred. When this occurs it can continue to place pressure on wild stocks through unregulated harvesting and can undermine mechanisms designed to ensure sustainable and legal trade.

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) regulates trade in wild and captive-bred snakes listed in the CITES Appendices. Parties to CITES have acknowledged that illegal harvest and trade of wild snakes through captive breeding facilities undermines the rules of the Convention and may result in trade becoming detrimental to wild populations if left unchecked (Article IV). In compliance with Decision 16.102 of the Sixteenth Meeting of the Conference of the Parties (Bangkok, 2013), the CITES Secretariat has commissioned a study on:

"Methodologies to differentiate between wild and captive-bred CITES-listed snakes in trade, including parts and derivatives, ensuring that the work is carried out in line with

recommendations of the Standing Committee concerning source."
http://www.cites.org/eng/dec/valid16/16_102-108.php

This report aims to identify and describe these methods in detail. It also aims to acknowledge their potential limitations, examples of their use and score their applicability to snakes (and their parts and derivatives) in trade. Information on each method was gathered through consultation with relevant experts, scientists and CITES Management Authority staff. Parties are encouraged to also review other outputs that may provide useful guidance for differentiating wild from captive-bred snakes. E.g., http://www.cites.org/sites/default/files/eng/com/ac/27/E-AC27-Inf-17_0.pdf

2.0 Captive breeding scenarios for snakes

Captive breeding of CITES-listed snakes is becoming more common in many parts of the world, to supply both domestic and international markets. The situations in which captive breeding occurs are highly variable, and are influenced by the country of origin, the species of snake being bred, and the type of trade they are being bred for. For example, Indonesia has a small number of large and highly sophisticated commercial snake-breeding facilities producing snakes for the pet trade. By contrast, Viet Nam has hundreds of small household-sized satellite farms raising snakes for the skin and meat trades.

The methods used to differentiate between wild and captive-bred snakes will therefore be case specific. For example, some methods will be pertinent and reliable for application to snakes being bred in small numbers for pets, but become ineffective and costly when snakes are bred in the thousands for their meat or skins. Understanding the different scenarios in which snakes are being bred is important when deciding on the most appropriate method.

3.0 What is an ideal method for differentiating between wild and captive-bred snakes?

When evaluating methodologies to differentiate between wild and captive-bred snakes, there are a number of important attributes that must be taken into consideration. Some of these relate to the types of trade and breeding scenarios in the country of interest, and others relate to the logistical difficulty of implementation and reliability of the method. The most important attributes include (1) the time to implement, (2) the cost of the method, (3) its suitability for large and small numbers of snakes and for (4) live individuals and parts and derivatives, (5) its labor intensity, and (6) its reliability. An ideal method should first and foremost be reliable, but should strike a balance between it logistical feasibility and its costs.

4.0 What is the aim of this guide and how should it be used?

This guide aims to provide exporting and importing Parties with information on methods that can be used to differentiate between wild and captive-bred snakes and their parts and derivatives in trade. In this summary, information is provided to guide Parties in the selection of methods that are most appropriate for these needs. Conclusions about reliability and costs are provided for whichever Party implements the method (e.g., exporting or importing). A more detailed examination and justification of the use of each method for differentiating between wild and captive-bred snakes is provided in the Annex to this summary.

5.0 Available methodologies to differentiate between wild and captive-bred snakes

This section summarises available methodologies that can be used to differentiate between wild and captive-bred snakes. Some of the methodologies are more reliable than others, while some are only suitable for specific situations. It is the prerogative of each Party to evaluate and determine which methodology is most reliable, suitable and cost-effective for their trade situation.

5.1 General health, appearance and behavior of individuals

In particular, wild snakes of many species are often poorly adapted to captive conditions and become easily stressed if proper captive care is not provided. This can result in a number of symptoms such as failure to accept food, unusual passivity or torpor, emaciation and lesions on the gums and lips, among others. In addition, wild snakes often present scars and/or ectoparasites (e.g., ticks). These symptoms can be useful indicators of wild origin, with checks taking place in either the exporting or importing Party. However, this method is not an unequivocal means of differentiating between wild and captive-bred snakes and does not have forensic application. For example, poor housing conditions (e.g., males kept with males in the same enclosure may fight during breeding season and therefore exhibit scaring), inadequate heating and cooling (e.g., snakes may become sick and exhibit respiratory disease) and poor hygiene (e.g., snakes may spend many months in water and contract skin infections – scale rot, etc.) can result in each of the behavioral and health symptoms listed. This method is only applicable for live snakes and may be difficult to implement for large shipments. It is thus most suitable for the trade in snakes for pets. It is not possible to use this method for snake parts and derivatives. The only cost associated with the method is the time required by staff from either the exporting or importing Party to inspect animals, and it would be a useful indicator for determining which facilities require additional monitoring to ensure their declared sources of snakes legitimate.

5.2 Physical, thermal and chemical branding

Physical, thermal and chemical branding consists of physically marking the skin of a snake using a suitable tool or chemical substance. The premise is that the brand heals to become a scar, which can be used to uniquely identify an individual snake. By applying a brand to snakes born in captive breeding facilities and recording their identity in a database, authorities can trace an individual throughout its life to verify that it has indeed been bred and raised in captivity. Snakes bred for skins may be branded on the head or tail, which are discarded from the exported skin and thus the brand does not reduce product value. This method will be most suitable for snakes kept in small numbers within a few facilities, and is only suitable for exporting Parties because of the need to check facility stock against a database. Even with several fail-safes in place (e.g., branding snakes as soon as they are born at a facility), there is still scope for circumvention of this method (e.g., branding wild-caught snakes). Because of this, this method cannot be used to unequivocally differentiate between wild and captive-bred snakes. Logistic impediments also diminish the suitability of this method; costs will by high in terms of man-power, time and money needed to brand and record all snakes within a database, especially for Parties that have many facilities housing several different species in large numbers. Finally, this method may not be accepted by facility owners that require their snakes to be unmarked before export (unblemished skins or pets destined for high end markets).

5.3 Passive Integrated Transponder (PIT) tags

A PIT tag is a small electronic microchip encased in biocompatible glass that can be inserted under the skin or within the body cavity of snakes. They serve as a permanent coded marker that is as reliable as a fingerprint for identification of an individual snake using an alphanumeric code. PIT tags are commonly used in ecological studies to identify individual snakes. They offer an improved method of marking compared to branding or scarring and the use of alphanumeric codes means greater numbers of individuals can be identified. Using PIT tags, relevant authorities can uniquely mark and identify captive-bred snakes kept in breeding facilities. Snakes without PIT tags can be assumed to be of wild origin and allow relevant authorities to determine which individual snakes have left the facility (by recording remaining tags). However, PIT tags are not a foolproof means of differentiating source and require intensive monitoring to be effective (because wild snakes can also be tagged). Because they are injected underneath the skin, or within the body cavity, they are not suitable for determining the source of skins or other parts and derivatives (gall bladders, fat, meat). The overall cost and manpower needed to manage captive populations precludes the use of PIT tags in situations where farms are producing thousands of new snakes each year. By contrast, for species that are coveted as pets, and

are kept in small numbers, application of PIT tags may be a simple and effective means of identifying specimens and monitoring captive breeding facilities.

5.4 Eggshells

For snake species that lay a clutch of eggs, eggs can be used to verify provenance of captive individuals. Because a single egg corresponds to a single snake, the premise of this method is that if the animal has been bred in captivity there should be an associated eggshell to prove it. Instead of discarding the eggshells of captive-bred snakes, facilities could provide an eggshell for each individual snake that is to be exported. These eggshells can be matched to the number of snakes to be exported to form a type of "quota", limiting the number of snakes to the number of eggshells. These eggshells can be monitored by authorities within the exporting country or, additionally, exported together with the snakes. The unique size and shape of snake eggs allows authorities to sample the visually most "out of place" eggshells to ensure they originate from the species concerned. This method could be used as an initial step in monitoring and enforcement to identify which facilities are providing fallacious breeding records. The costs of the method are low, and would only require the time taken by staff to count the eggs. It would be most applicable to situations where facilities are mis-declaring the source of all snakes being exported, because simply the requirement to keep eggshells could not be satisfied.

5.5 Breeding non-natural morphs

All species of snakes exhibit a finite range of natural phenotypes. Because colour and pattern mutations in wild snake populations are extremely rare, the captive propagation of specimens exhibiting colours and patterns not displayed by wild conspecifics can therefore be used to distinguish between wild and captive-bred snakes. Replacement of all existing stock within captive breeding facilities with non-natural morphs would allow relevant authorities to inspect snakes to ensure that no natural morphs, that potentially represent wild-caught individuals, are present. Visually differentiating wild from captive animals using this method will be extremely rapid and straightforward given the obvious differences in pattern and coloration. Breeding and trading non-natural morphs of snakes that exhibit unusual coloration and pattern is a simple and cost-effective means of ensuring that those individuals were born in captivity. It is 100% reliable and the only cost is that of staff time to visually inspect facilities or shipments in either the exporting or importing Party, respectively. This method, however, does not have applicability for many parts and derivatives (e.g., meat, fat, gall bladders), unless the snake producing those parts has been visually sighted and verified to be captive-bred before it is killed. A disadvantage of this method is the time it will take captive breeding facilities to replace their existing captive stock with snakes exhibiting non-natural forms.

5.6 Presence of gastrointestinal parasites

Many gastrointestinal parasites have complicated life cycles that require several hosts. Their indirect mode of reproduction means that certain life stages of parasites are unable to infect their host without transmission first to one or several different hosts. Because captive snakes should technically have spent their entire lives in captivity, the probability that they will become infected with certain parasites is extremely low. We should expect, therefore, that the parasite loads of free ranging wild snakes would be much greater than captive-bred snakes (see study completed as part of this work in the **Annex** to this document). Of particular forensic application is the presence of parasites in snakes that require infection through an intermediate host (e.g., a snail or other invertebrate). It should not be possible for captive-bred snakes to acquire these parasites, indicating a wild origin for snakes presenting these infections. Provided a sufficient image database of parasite faunas present in wild snakes is available then examination of scat samples can be compared to determine the likelihood of captive origin. This method has been shown to be effective for several species of CITES-listed snakes being traded internationally. It is most applicable to live snakes, which can be tested by either the exporting or importing Party, but less applicable for parts and derivatives (unless the live snake producing the parts is tested at the breeding facility in the exporting Party before it is killed). This method requires outsourcing to a laboratory (for microscopy) and cannot be conducted on site.

5.7 DNA, Genotyping and Parentage Assignment

All animals inherit their genetic makeup (DNA sequences of their genomes) from their parents. Some parts of the genome vary substantially between individuals and can be used to establish the genetic relationships among individuals within a single population, including determining an individual's parents. Offspring share a higher proportion of their genomes with their parents than they do with unrelated individuals in the same population. Thus if a substantial part of the highly variable genome is examined, we can establish if juvenile snakes are indeed the offspring of breeding stock in snake farms. This approach has been successfully used for forensic purposes in a variety of domestic and wild species. In this instance it is most suitable for facilities producing small numbers of snakes. Despite its reliability for differentiating wild from captive-bred animals, countries where many farms are breeding and trading thousands of snakes will find the cost and logistical challenges of sampling and analysis too great to effectively implement this method.

5.8 Stable isotopes

Isotopes are different forms of the same element with greater or fewer numbers of neutrons than their sister forms. For example, Carbon 12 (^{12}C), ^{13}C and ^{14}C are all isotopes of the element carbon. These distinctive isotopes occur at different ratios within all materials and this property can be utilised to differentiate between wild and captive-bred snakes. This succeeds because stable isotopes are propagated from one organism to another through food assimilation and growth. For example, herbivores acquire an isotopic value from the plants they eat and this value is reflected up the food chain as predators consume herbivores. For example, a wild snake may feed on a variety of prey such as lizards, birds and small mammals, while a captive snake is usually fed on a single food source (e.g., laboratory rats). Because these food items differ in their isotope ratios, measurement of these ratios can elucidate the source of the snake of interest. For this method to be implemented, tissue must be collected and analysed from *known* wild and captive snakes. Once a database of wild and captive isotope ratios has been established, samples of unknown origin can be compared. The use of stable isotope analysis has considerable potential for accurately determining the source of wild and captive-bred snakes and has been successfully used for similar applications to other wildlife species. In the vast majority of cases the reliability of this method is high and can be used by either exporting or importing Parties to unequivocally detect instances of mis-declaration. However, the cost of sampling may be prohibitive. A specific isotopes laboratory must conduct analyses and the cost of each sample can be high.

6.0 Summary and Conclusion

The suitability of all source differentiation methods is represented in **Figure 1**. The breeding of non-natural morphs appears to be the most reliable and cost and effort effective method for differentiating between both small and large numbers of snakes. However, this method is more limited in its applicability to parts and derivatives where examination of skins is not available (meat, gall bladders and fat). For forensic application, stable isotope methodologies offer a reliable means of differentiating between wild and captive-bred snakes in all forms (live animals and their parts and derivatives). However, isotope analyses can be costly for large numbers of snakes and require some time to implement.

A summary of where each method can be applied (in the exporting or importing Party) and if it can be conducted on site (e.g., at the facility or at customs) is provided in **Table 1**. Although some methods possess attributes such as minimal cost and low labor intensity, when choosing a suitable method Parties need to focus on those that are most reliable for their situations. For example, trade in parts and derivatives will often require sophisticated forensic methods (e.g., stable isotopes) to overcome the homogeneity of the product (e.g., meat). Other trades, such as the trade in small numbers of snakes for

pets, may not require sophisticated methods to simply differentiate between small numbers of live snakes. In some cases it may be most beneficial to implement several methods in parallel.

Table 1. Summary of where each method can be implemented and if laboratory analysis is required.

Method	Exporting Party	Importing Party	Lab required
Health and appearance	Yes	Yes	No
External markers	Yes	No	No
PIT Tags	Yes	No	No
Eggshells	Yes	Maybe	No
Non-natural morphs	Yes	Yes	No
Parasites	Yes	Yes	Yes
DNA	Yes	No	Yes
Stable Isotopes	Yes	Yes	Yes

Implementation of methods should ideally be accompanied by a management plan, particularly with regard to dedicated funding. Although several techniques may be cost prohibitive for single facilities, establishment of nationally funded networks for inspection may allow more sophisticated techniques to be implemented. Additionally, small industry levies paid to regulatory bodies may allow spot-checks to be completed and may lead to establishment of more sophisticated certification systems for snake captive breeding facilities in general.

Although many of the methods presented herein will be useful for ensuring legal and sustainable trade in CITES-listed snakes, Parties should explore methods that are equivalent to (or lower than) the benefits of trade. Implementation of sophisticated methods may not be appropriate or economically viable for some corresponding trade situations and this should be reflected in the choice of method. Closely linking technical solutions to problems will help tease apart how these methods

can be most effectively used. Thus, regulatory bodies wishing to implement one or more of these methodologies should undertake pilot studies to determine the efficacy of the method for their trade situation.

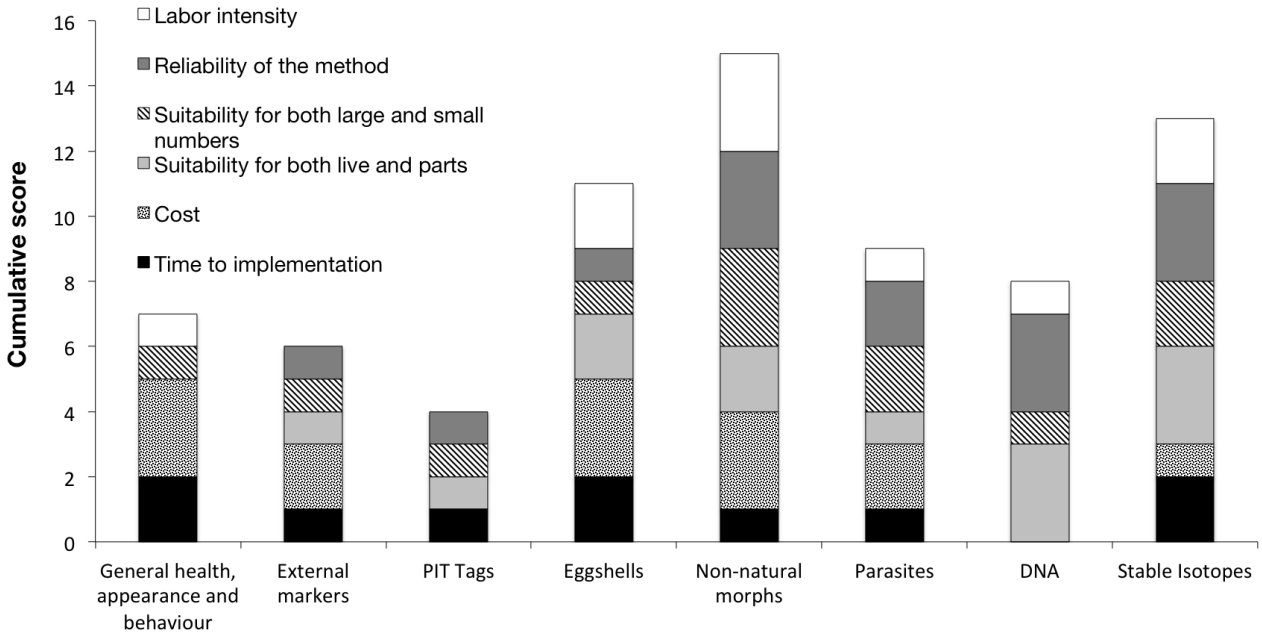

Fig. 1. A matrix of scores for attributes of each method used to differentiate between wild and captive-bred snakes. For each attribute, a score of 0 indicated that the method is poor, while a score of 3 indicates that it is very good (Scores assigned by the authors).