Traceability in Crocodylian Conservation and Management

IUCN SSC Crocodile Specialist Group

IUCN SSC Species Survival Commission Crocodile Specialist Group

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Why address traceability in crocodylians?

CHAPTER 1

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1.1 Introduction

Crocodylians comprise some 28 extant species and subspecies of crocodiles, alligators, caimans and gharials, distributed across 99 countries. Diverse approaches to their conservation and management, tailored to local needs and contexts, are now being implemented around the world, with sustainable use and trade integrated into programs for commercially valuable species.

It is within this commercial context that the issue of traceability has been steadily attracting attention (CITES 2018). The technologies being developed to track, trace and account for many products in trade are evolving rapidly (see Chapter 3 - Natusch 2021). They are being applied within different parts of supply chains for crocodylians, but it is often not clear whether increased traceability aimed at improving business efficiency and compliance with corporate social responsibilities at one end of supply chains, will always benefit conservation and livelihoods of local people at the other end of supply chains (CSG 2021).

Within the zoo community, a remarkable commitment to traceability is implicit within the management procedures and studbooks used to track production of endangered species through captive breeding (EAZA 2013). Some elements of studbook traceability systems have been voluntarily adopted by some commercial crocodylian farms, to meet their specific production objectives, but the standard zoo approach has limited application to the large-scale commercial production of skins, with the rapid turnover of tens of thousands of individuals.

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The Crocodile Specialist Group (CSG) of the Species Survival Commission (SSC), within the International Union for Conservation of Nature (IUCN), has an inherent interest in better understanding the strengths and weaknesses of traceability technologies with regard to crocodylian conservation. Since its formation in 1969, the primary focus of the CSG has been to improve the conservation of wild crocodylian populations and their habitats, and to increase the benefits that they provide to local people living with recovered wild crocodylian populations. CSG members (now 700+ in 70 countries) are actively involved in most conservation and management programs for crocodylians. They are increasingly being called upon to advise on traceability issues, which was the reason the current review was undertaken.

1.2 The changing focus of CSG involvement in crocodylian management

The original global conservation need for crocodylians, particularly in the 1960s and 1970s, was to rebuild depleted wild populations. It remains a priority with some species in some countries. Population recovery was initially achieved through protecting wild populations, and restricting commercial use and trade (Bustard 1971). But by the 1980s, protection had resulted in some wild populations of some species recovering rapidly, causing increased rates of human-crocodile conflict. This created a new challenge for the CSG, because incentives for local people to tolerate abundant wild crocodylians were needed. Various ecological benefits were proposed, but few had any real basis in science (Somaweera *et al.* 2020) or were considered compelling evidence by local people, who knew first-hand that the wetland habitats remained intact with or without crocodylians. In contrast, the ability to harvest and sell eggs, juveniles or skins, for direct commercial benefit, was an effective incentive. For the CSG, this meant on the one hand promoting the rebuilding of depleted populations, but on the other, acknowledging population recovery when it occurred, and supporting sustainable use of the recovered populations, because it could incentivise ongoing conservation.

Prior to the 1970s, crocodylian skins were harvested from the wild, with limited if any regulation. These harvests were sometimes legal and sometimes illegal under national legislation. The unregulated use of crocodylians for skins was consistent with the general "social license" of the day in developed countries, which at that time saw crocodylians mainly as pest species. The harvests caused obvious and serious declines in the abundance of wild crocodylians, and steadily reduced the supply of skins to the international market. Crocodylian farming contributed little to world trade in skins in the 1960s (Youngprapakorn *et al.* 1971; MacGregor 2002).

The declining status of wild crocodylians attracted more and more attention in the 1960s, when the IUCN's "Red List" initiative started to link increasing risks of biological extinction, with declining abundance, caused by unregulated harvests for international trade. The crocodylian skin trade became a poignant case history when the text of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) was being developed. The text was agreed in 1973, and CITES came into force in 1975, with all crocodylian species listed on its Appendices. This was largely due to action by the CSG (Jelden 2004).

CITES was incredibly effective, and unregulated trade from declining populations ceased in many countries as they became members of CITES. But as wild crocodylian populations recovered in some of those countries, legal, regulated trade, based on a new commitment to wildlife management programs, replaced the historical, unregulated harvests. The transition from unregulated to regulated use and trade, occurred faster and more effectively in some countries than in others, for various reasons. The precautionary traceability measures implicit within CITES, and the general conditions aimed at constraining illegal trade, needed to be an integral part of all programs of regulated use. Once approved by the Parties to CITES, the management programs needed to be retained in order for trade to continue.

Trade in crocodylian skins is now mostly legal and well-regulated, and the conservation significance of illegal activities, considered biologically significant in a depleted population, are mostly minor in recovered and healthy populations. CITES infractions are often not "illegal trade" *per se*, but rather procedural difficulties encountered in navigating the tiers of protocols, checks and balances required for legal trade from recovered populations (Natusch *et al.* 2021). In a recent review of CITES infractions with crocodylian products in the USA, there was a higher rate of infractions amongst imports by researchers and government institutions, than by established commercial companies (Natusch *et al.* 2021). Illegal international trade in crocodylian skins still exists, and the CSG acts against it when appropriate. However, low level illegal harvests are by and large within biologically sustainable levels, and are rarely considered biologically significant to the conservation of the wild populations.

A fundamental CITES traceability system for crocodylians is embedded within CITES protocols and resolutions, particularly the universal tagging system for crocodylian skins, which has worked well (CITES 2010). Trade in some other reptile species, particularly snakes and lizards, was not prioritised by the Parties to CITES to the same extent as crocodylians, partly because there was no evidence for population declines, despite wild harvesting and

Landowners involved in the collection of saltwater crocodile eggs in the Sepik River, Papua New Guinea

trade for 80+ years. Whereas historical harvests of wild crocodylians were demonstrably unsustainable, with both wild populations and the numbers of skins in trade declining, this was not the case for lizards and snakes. The real abundance in the wild of the main species of lizards and snakes in trade is technically difficult to quantify, by the sorts of standard biological survey techniques used for crocodylians. But this does not constitute a reason to reject the obvious - that the uses and trade are and have been demonstrably sustainable over long periods of time. The population dynamics underpinning the ability of some reptile populations to sustain harvests is imprecisely known (Webb *et al.* 2011; Bird *et al.* 2013). It partly reflects the fact that herpetology has tended to be pursued as a zoological science, without reference to the principles and practices of wildlife management (Scott and Seigel 1991), which are fundamental to understanding how uses are sustained (Webb *et al.* 2004; Webb 2015).

Today, there are many examples of conservation and livelihood benefits being achieved from management programs that allow the sustainable use of wild crocodylian eggs and/or juveniles, and sometimes adults (Hutton and Webb 2003; Jenkins *et al.* 2006; CSG 2021). They are programs in which conserving the wild populations and natural wetlands are incentivised in a variety of ways by the ability of local people to engage in sustainable trade and receive economic benefits for doing so (CITES 2004).

Crocodylian farms and ranches are a critical, in-country, intermediate step, in most of these programs. The transformation of an egg or juvenile from the wild, to a high-quality skin for the export market, is technologically challenging. It often involves significant investment in infrastructure and research. Many CSG members have been involved directly and indirectly in farm-based enterprises, particularly the research involved. Farming through closed-cycle captive breeding (versus farming that raises animals collected as wild eggs or juveniles) is sometimes integrated into ranching farms, to counter "bad" seasons for wild egg production. However, closed-cycle captive breeding is the only form of legal production permitted in some countries. This is in part a legacy of it being the only method of production recommended in the early 1970s, when the conservation goal was to rebuild wild populations (Bustard 1971). The whole concept of sustainably managing recovered wild populations, at that time, was yet to be addressed seriously.

Despite the role trade had played in depleting wild populations in the past, it is now clear that it can play a positive role in generating benefits for people from recovered populations (CITES 2004). In crocodylian supply chains, the diversity of beneficiaries is extensive. It ranges from Indigenous peoples and local communities, to landowners generally, to crocodile and alligator farmers, tanners, manufacturers, retailers, to local and national Governments, and to international corporations ultimately retailing high-end products to consumers. All have a stake in conservation being successful. Linking conservation to rural economic development, in this way, epitomises the goals and spirit of the UN Sustainable Development Goals (United Nations 2021).

1.3 The traceability dilemma for the CSG

Not surprisingly, the CSG and its members have become reputable sources of technical information on most aspects of crocodylian biology, conservation and management. Over the last decade, they have been continually confronted with new suggested approaches to traceability, and asked to advise on conceptual and practical issues concerning traceability. Yet relatively few CSG members are truly expert in this specialised area.

Renewed CSG involvement in traceability issues started in 2010, when animal welfare concerns about the lizard and snake skin trade were raised publicly, and efforts were made to incorporate crocodylians in revised approaches for improved traceability of all reptiles (Webb *et al.* 2011). These concerns resurfaced in 2019, when to meet building opposition to trade in crocodylian products in California (USA), it was proposed that a single traceability system and set of technologies be adopted by all stakeholders, for all supply chains, for all crocodylian species in trade – to be implemented within a few months. This was a short-lived, knee-jerk, political reaction to a complex political problem, but it tested the CSG's ability to provide sound advice on traceability concepts, systems and technologies.

Likewise, since 2010 the CITES Standing Committee has been pressured to deal with increased suggestions about expanded traceability systems within CITES, from various Parties, stakeholders and entrepreneurs. It established a Working Group to investigate traceability, which led to the Parties to CITES adopting a definition that was more inclusive than exclusive of the diverse ways in which management and trade of CITES-listed species occurs today: *Traceability is the ability to access information on specimens and events in a CITES species supply chain* (CITES 2018).

Under this definition, all existing crocodylian programs involving research, conservation, management, production, trade, manufacture and retail, contain elements of traceability. The elements are the very processes of record-keeping, assessment and adaptation that have accompanied successful management. Even in species not being used commercially, tracking whether management goals are being achieved, and providing evidence-based mechanisms for adaptation where needed, depend on processes that can be broadly considered as traceability.

Commercial international trade in crocodylian skins and products is the main area where interest in improved traceability is being expressed by some stakeholders. At all stages, within all supply chains, new and innovative technologies for tracking and tracing are continually being adopted by different stakeholders, because they provide specific, tangible, cost-effective benefits to those involved. New technologies for more accurate tracking of wild crocodylian nests and eggs collected by Indigenous

peoples in Brazil (Weber and Girardi 2018) is but one example in one stage of one supply chain.

The allure of standardised and integrated traceability systems, along and between complete supply chains, involving all stakeholders, in all stages, is increasingly appearing technically possible (see Chapter 3 - Natusch 2021). The concern of the CSG is whether such approaches with crocodylians will benefit some stakeholders at the expense of others. Local people at the primary harvest level are the most vulnerable, because some have very limited access to refined technology, yet this is where incentives to conserve are arguably the most important, and it is where the livelihoods of people are most in need of attention (CSG 2021). There are also practical problems along supply chains. Sustainability commitments by corporations to reduce waste means that offcuts and small pieces of skin are exported by weight, and fully utilised in labour-intensive ways to make small or patchwork products. The skins used are legal, but identifying each individual piece of skin in each product is impractical, costly and has no conservation value.

A further need for caution concerns the ongoing development of new traceability products, marketed as solutions to potential and perceived problems, without their strengths and weaknesses having been tested. Applying new technologies is an integral part of economic development, but caution is needed to ensure that traceability technologies are not used purely as a competitive marketing tool. Introducing new technologies at one point in a crocodylian supply chain, without ensuring the ability to apply those new technologies at other parts of the supply chain, or in competitive supply chains.

Against these concerns, within the luxury and high-fashion product industries, corporations are implementing sophisticated traceability systems as part of their commitment to sustainable development and sustainable sourcing (LVMH 2019; Kering 2021). These industries are the economic drivers of most crocodylian management programs in the field (e.g., Jenkins et al. 2006; Hutton and Webb 2003; LDWF 2019; Webb 2021). If they fail, due to perceived traceability shortcomings, so do benefits to conservation and the livelihoods of Indigenous peoples and local communities (CSG 2021). At the final retail stage in crocodylian supply chains, the traceability requirements extend beyond the CITES mandate to achieve legal trade - biological and ecological sustainability. Consumers want assurances about a range of other social issues, in which traceability is implicated: animal welfare, working conditions, worker housing arrangements, pay, gender equity and similar, valid, humanitarian concerns.

The CSG is not concerned about the uptake of traceability systems within crocodylian supply chains, but it is concerned that it does not erode the conservation and livelihoods outcomes, especially for Indigenous peoples and local communities (CSG 2021).

1.4 The current review

Recognising these difficulties, the CSG Executive Committee agreed to review traceability, as it applied to crocodylians at this point in time. The main goal was to provide CSG members and others interested in the issue, with a snapshot of key points.

Within the CSG, Dr. Daniel (Dan) Natusch, who is also Chair of the IUCN SSC Snake Specialist Group, was one of the few CSG members who had been working actively with traceability systems in reptile management and trade. He led IUCN's involvement in the CITES Traceability Working Group and has been actively involved in several programs where traceability issues and technologies have been successfully integrated into management - Reticulated Pythons (*Python reticulatus*) and Asian Water Monitors (*Varanus salvator*) (Kasterine *et al.* 2012; Natusch *et al.* 2016, 2019; Khadiejah *et al.* 2020). He has experience implementing systems in the field, facilitating uptake by end users, and using the results to objectively establish non-detriment. Dan kindly agreed to prepare an overview report - a rapid assessment - for the CSG Executive Committee to consider in their deliberations. Various CSG members contributed to his review, in different ways, and his informative report (Chapter 3 - Natusch 2021) provides many of the insights the CSG required and more. We are most grateful for his contribution.

His report was an important resource used by the CSG Executive Committee to identify key points about traceability, as they apply specifically to crocodylians at this point in time (Chapter 2 - Webb *et al.* 2021). Many issues discussed briefly are drawn directly from his report, to which readers are referred for more detail. Others are based on the first-hand experience of CSG members with crocodylian supply chains. The CSG is acutely aware that the pressure on high-end companies to shorten supply chains, and increase their controls on them (Morin 2019), is causing some successful management programs considerable hardship (CSG 2021). Thus, although exciting new opportunities will continue to become available through improved traceability technologies, due diligence is required to ensure conservation benefits and rural livelihoods are improved and not eroded, in line with the UN Sustainable Development Goals (United Nations 2021). We hope this review assists CSG members and others to appreciate further the concepts and practices of traceability as they apply to crocodylians.

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Key points about traceability in crocodylian conservation and management

CHAPTER 2

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2.1 Introduction

Traceability is a rapidly evolving field of endeavour, in theory, practice and technological development, which has wide application and potential within wildlife management programs involving consumptive use and trade. This includes crocodylians, hence this effort by the Crocodile Specialist Group (CSG) of the Species Survival Commission (SSC) of the International Union for Conservation of Nature (IUCN), to better understand current developments and their existing and potential applications to crocodylian conservation and management (Chapter 1 - Webb *et al.* 2021).

The CSG is indebted to Dr. Daniel (Dan) Natusch, for conducting a rapid review of traceability in reptile management and skin trade generally (Chapter 3 - Natusch 2021). It provides important insights into traceability systems and technologies, their strengths and weaknesses, costs and benefits, and their application to achieving management outcomes such as sustainable use, conservation, sustainable economic development, and where possible, improved livelihoods of Indigenous peoples and local communities.

With regard specifically to crocodylians, where our aim has been to update CSG members and provide guidance about traceability (Chapter 1 - Webb *et al.* 2021), a series of key points has been identified. These are drawn largely from Dan's report (Chapter 3 - Natusch 2021), but with insights, priorities and experience of various CSG members actively engaged in crocodylian conservation and management programs.

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2.2 Key points

1. The solutions to crocodylian conservation problems, including the application of improved traceability, need to be tailored to the local context and species' status, and where possible, to the known or suspected ability of wild populations to sustain specific types of harvest.

2. Commercial use and trade classically comprise a series of different stakeholders fulfilling different tasks, within different supply chains. Traceability systems and technologies have application to some of these tasks, and will continue to be implemented as stakeholders deem necessary, regardless of whether or not they are standardised and integrated within some larger, holistic, traceability system, across all supply chains. Key areas in which traceability is involved are:

a. *Compliance with CITES.* To ensure trade meets the CITES requirements for being legal, not detrimental to the survival of the species in the wild, and verifiable through a documentation trail. For this purpose, traceability has been defined by the Parties to CITES in broad terms: "*the ability to access information on specimens and events in a CITES species supply chain*". The development of electronic permitting within CITES is an example of improved traceability to meet treaty obligations (CITES 2021).

b. *Compliance with industry needs.* For a variety of practical business reasons, different harvesters, farms, tanneries and manufacturers have introduced different traceability systems to meet their needs, independent of CITES requirements.

c. *Compliance with industry Corporate Social Responsibility (CSR).* This is unstable over time – a moving target – as the commitments by industry to CSR are both dynamic and adaptable with various risks and uncertainties. The United Nations defines traceability generally for this purpose as: "*the ability to identify and trace the history, distribution, location and application of products, parts and materials to ensure the reliability of sustainability claims, in the areas of human rights, labour (including health and safety), and environment and anti-corruption*".

d. *Compliance with marketing expectations.* This is also unstable over time and prone to risk and uncertainty. For example, campaigns against trade in the media, despite often using misinformation to embellish the notion of animal welfare abuses (Natusch *et al.* 2021), may require consideration of issues not previously included in existing traceability systems. The trend is well recognised in the leather industry:

> *In recent years, the commitment to sustainable development of companies working in the tanning, footwear, leather goods and glove making industries have been the subject of criticism. Journalists, associations and social media have produced reports attacking the quality of products or companies, and have carried out media campaigns to alert public opinion to the problems they have identified ... they are part of a general trend in society which has intensified in the last five years, in favour of more sustainable development in consumer goods* (Morin 2019).

3. Increased traceability is required by the industry to meet changing consumer and investor attitudes, and adapted CSR sustainability obligations. This is impacting supply chains, local people, and conservation programs with sustainable wild harvests in remote areas (CSG 2021).

4. There are positive and negative consequences of changing traceability commitments in crocodylian conservation and management programs:

a. As a mechanism for countering criticisms by opponents to the use and trade in animals, corporations are being advised to improve traceability, shorten supply chains, and exert more control along supply chains, to reduce the risk of being unfairly criticised (Morin 2019). As industry success underpins conservation success in sustainable use programs, such actions need support. But low-technology supply chain stakeholders, such as harvesters, may end up being excluded from supply chains.

b. Developing traceability systems requires that attention be given to components of a supply chain that can be improved. However, the more commitments made, the greater the risk of non-compliance for opponents to trade.

c. Traceability improvements that are cosmetic and only address problems of consumer perception, do not necessarily improve reptile conservation, animal welfare or livelihoods. For example, the exclusion of wild-harvested skins, nominally on skin quality grounds, but also because the process of harvesting is misinterpreted as being cruel, can remove the incentives to conserve wild populations.

d. The more steps in a traceability system, the more avenues for non-compliance that are created.

e. Programs that comply with CITES and are legal, non-detrimental and verifiable, and which are already generating significant conservation and livelihood advantages, are vulnerable to failure if criteria beyond the remit of CITES, are used to effectively exclude CITES-compliant products from the marketplace.

5. Traceability systems can contribute to confirming the origin and legal sourcing of materials, and can strengthen the credibility of certification systems in the marketplace. They can help prevent, but cannot overcome, false declarations, laundering of illegally sourced materials, and smuggling. Traceability is a tracking process - a conduit for verification – a methodological process that makes no claim to the legality or sustainability credentials of a skin. That is, if not managed carefully and diligently, it could be equally open to abuse.

6. For a full traceability system to be incorporated into a new program (Chapter 3 - Natusch 2021), or introduced into an existing program, ideal components of that program should include (see also Rosser and Haywood 2002):

a. Clearly defined assumptions and expectations.

b. Adequate institutional frameworks.

c. Appropriate marking systems, matched to the needs and capacity of different producers.

d. Data management systems to ensure the traceability system is sufficient for the purpose but does not exceed the needs or resources of all actors.

e. A variety of compliance and enforcement measures.

f. Dedicated funding.

g. Downstream stakeholders should develop sustainable sourcing agendas that benefit upstream stakeholders.

h. Policy and legal approaches that seek to promote legal trade.

i. Capacity building and ongoing professional development to enhance effectiveness.

j. An adaptive rather than highly prescriptive management approach.

7. The main functions of improved traceability systems within national management programs, are potentially:

a. *Improved regulatory compliance.* For example, to assist verification of legal acquisition;

b. *Increased management documentation and statistics.* For example, to assist non-detriment and sustainability assessments, where truly independent methods for monitoring wild populations are not available, cost-effective nor sensitive enough. They can provide additional indices to test conclusions drawn from independent monitoring programs where they exist; and,

c. *Certification.* For example, to assist verification of sustainability, animal welfare, and various humanitarian standards and codes.

8. Traceability Systems fundamentally have three key components, which need to be recorded separately in an Information Management System (IMS):

a. *Unique Identification* (UI) describes the product (e.g., whole skin, batch of skins) and supply chain source (e.g., farm, processing facility). Numerous coding systems have been developed to supply the market with unique identifiers.

b. *Critical Tracking Events* (CTEs) define the transfers of materials that trigger data recording. Optimal traceability aims to identify the beginning-to-end path of a product throughout its supply chain. Examples of important CTEs in the reptile skin trade may include transfer of skins from hunters to regional collectors, from farms to processing and tanning, export and import. The length of the supply chain covered by a traceability system is called its *depth*.

c. *Key Data Elements* (KDEs) are recorded at each CTE. KDEs will differ along the supply chain as the product is transformed and different information becomes relevant. For example, KDEs for live reptiles received at a processing facility may include hunter's name and harvest location, while a tannery may be interested in the processing facility name and CITES permits. The amount of information recorded at each KDE is called the *breadth* of a traceability system.

9. The IMS with details on UI, CTE and KDE need to be securely stored, and be widely accessible in the interests of transparency.

10. Marking should remain a cornerstone of crocodylian skin traceability systems, as it is today. Effective marking systems should aim to be:

a. Low cost, simple and effective;

b. Pragmatic and business friendly;

c. Durable and tamper-proof;

d. Capable of capturing electronic data in real time and linking to existing databases; and,

e. Able to identify differences in source and capacity, when required (e.g., captive-raised versus wild-harvested in some contexts).

11. There are a variety of different marking methods for crocodylian skins, with advantages and disadvantages:

a. *Plastic tags*, which can include barcoding and digital collection of tag information. The two main types of plastic tags are button and loop styles.

b. *Radio Frequency Identification (RFID) tags*, also called Passive Integrated Transponder (PIT) tags, that emit tag numbers via a radio frequency and also permit digital collection of information.

c. *Physical marking methods* involve altering the skin to create a unique mark. Marks act in a similar way to tags, except that the 'tag number' is permanently attached to the skin. However, they do not permit automated or digital collection of information.

d. *Analytical and molecular methods*, including DNA, stable isotopes, elemental markers, microbiological barcodes and fatty acid profiles.

e. *Biometric imaging*, which relies on the unique scale and colour patterns of individual reptile skins, much like a human fingerprint.

12. Physical, analytical, molecular, and biometric imaging methods of marking all have potential in the future, but are logistically challenged at present, and confer few advantages to conservation over plastic or RFID tagging systems. Importantly, several of the above methods offer 'proof of provenance' (e.g., various molecular methods) but not 'traceability' *per se*. This distinction is important when designing and implementing appropriate systems.

13. With regard to the specific recommendations in Chapter 3 (Natusch 2021):

a. The exotic skin industry, which includes crocodylians, needs to maintain and in some cases re-establish credibility in the face of mounting opposition campaigns by animal activists. Where claims are based on spurious grounds, which is often, the CSG should actively intervene with evidence-based clarification.

b. In the eyes of consumers, provenance based on the latest and most advanced technologies is often synonymous with legitimacy and credibility, irrespective of real-world utility. The CSG should strive to better understand the allure of technology, the difference between real and cosmetic solutions, and actively intervene with evidence-based clarification where appropriate.

c. Understanding the nuances of traceability is becoming increasingly important for all stakeholders in the exotic skin industry. As a trusted figurehead for crocodylians, the CSG is in a unique situation to play an increasing role in educating its members and other stakeholders.

d. Specific actions the CSG will consider, budget permitting, are:

   i. The establishment of a Traceability Task Force under the direction of the CSG Executive Committee, to address traceability issues, better understand industry perspectives, and better understand the consequences of traceability on existing and new conservation-management programs.
   ii. Conduct a series of virtual workshops to exchange traceability information and concerns with stakeholders and CSG members interested in traceability issues, to develop a better understanding of public expectations and interest in sustainability, animal welfare and foci of traceability systems.
   iii. Investigate the degree to which traceability systems meet and/or surpass the existing requirements for ensuring trade is legal, non-detrimental and verifiable under CITES, and ensure through IUCN that crocodylian case histories and perspectives are represented within CITES deliberations about traceability.
   iv. Investigate the precision, depth and breadth of traceability systems proposed for crocodylians from time to time.
   v. Encourage CSG members to report on traceability issues in the CSG Newsletter, particularly on new and existing traceability technologies that provide real-time open access, novel tagging technologies, smart phone application, and the increasing options for publicly accessible online dashboards and databases.

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Traceability considerations for crocodylian and other reptile skins.

A rapid assessment for the IUCN SSC Crocodile Specialist Group

CHAPTER 3

Dr. Daniel Natusch

About the author

Dr. Daniel Natusch is a conservation scientist and exotic skin trade expert. He has been involved with wildlife traceability projects since 2010 and has developed traceability systems in several reptile skin supply chains. He has been an active member of the CITES Working Group on Traceability, is the Scientific Director of the Southeast Asian Reptile Conservation Alliance (SARCA), and has undertaken research into novel methods for verifying the provenance of reptile skins. Daniel is Chair of the IUCN SSC Snake Specialist Group, and a member of the IUCN SSC Crocodile Specialist Group (CSG) and several other IUCN SSC Specialist Groups.

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Executive summary

1. There is mounting pressure to improve the transparency of the exotic leather industry. This pressure is fuelled largely by public perception, which itself is driven by uninformed campaigns against the use of reptiles, rather than by genuine knowledge of issues and impacts of the trade.

2. The improvement of reptile skin traceability systems has been proposed as one way to increase transparency and provide stakeholders and the public with the sustainability, legality, and animal welfare assurances they require for peace of mind.

3. However, in some cases, traceability improvements only address problems of public perception, rather than actually improve reptile conservation or animal welfare. If implemented for the wrong reasons, or if the increased requirements are unachievable for some actors, traceability may even hinder conservation efforts and adversely impact on local livelihoods.

4. It is critical, therefore, that conservation professionals, trade organizations, and regulatory bodies, keep abreast of traceability developments so they can offer informed advice about the application and usefulness of wildlife trade traceability systems.

5. I was asked to provide a rapid assessment of traceability consideration for crocodiles and other reptiles for the IUCN SSC Crocodile Specialist Group (CSG). The report is not meant to be comprehensive, but offers an update of traceability developments for reptile skins, identifies some of the most widely used technologies available, and discusses their application to broader CITES and wildlife trade issues.

6. The objectives of the CITES traceability system are to substantiate the legality and sustainability claims of trade in CITES-listed species. A key element of traceability within the crocodylian skin trade is currently implemented through CITES Resolution Conf. 11.12 (Rev. CoP15) *Universal tagging system for the identification of crocodilian skins*. The traceability situation for snakes and lizards – CITES-listed or otherwise – is comparatively less developed.

7. A traceability system can contribute to confirming origin and legal sourcing, and can strengthen the credibility of the CITES certification system. It can help prevent, but cannot totally overcome, false declarations, laundering of wild skins, or smuggling. Traceability by itself makes no claim as to the legality or sustainability of a product. It is uniquely a tracking system that can support verification of such claims. Chain of custody is the record of the entities that have custody of a product as it moves through a supply chain.

Executive summary

8. The main functions of traceability in the reptile skin industry are:
   - Regulatory compliance (e.g., to assist legality);
   - Statistics (e.g., to assist sustainability); and
   - Certification (e.g., to assist verification).

9. Certification can be achieved via:
   - Individual Track and Trace – reptile skins retain their unique identity throughout the supply chain.
   - Skin Segregation – certified and non-certified reptile skins are identifiable, but not by the individual skin.
   - Mass Balance – Reptile skins from certified and non-certified sources are mixed. Buyers will not know if the skin they purchase is from a certified source – they will only know that a % of the skins entering the supply chain are certified.

10. Within the CITES traceability model, whole crocodylian skins are individually tagged before entering international trade, using uniquely numbered and non-reusable, tamper-proof tags. When whole skins are cut, the traceability of individual skins is often lost. However, skin pieces can be bagged, sealed, and the bag tagged with corresponding skin tags before entering international trade. The system is managed through a national registration and licencing process. It is simple, easy to implement and has a proven track record.

11. A tagging system similar to that used for crocodylians has been recommended for the python skin trade, where research is currently focused on developing an appropriate traceability system.

12. In some contexts, traceability in the reptile skin trade can be technically and logistically challenging. Supply chains often comprise disconnected entities. Tanning can be physically and chemically challenging for marking systems. Stockpiles can present problems unless inventories are maintained. Good governance and trustworthy stakeholders are sometimes lacking.

13. Traceability tools:
   - Tagging is most commonly used to mark reptile skins. There are two main types:
     - Plastic tags: include barcoding and digital collection of tag information. The two main types of plastic tags are button style and loop style.
     - Radio Frequency Identification (RFID) tags: emit tag numbers via a radio frequency and also permit digital collection of information.
   - Physical marking methods involve altering the skin to create a unique mark. Marks act in a similar way to tags, except that the 'tag number' is permanently attached to the skin but does not permit automated or digital collection of information.
   - Analytical and molecular methods include DNA, stable isotopes, elemental markers, microbiological barcodes and fatty acid profiles.

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- ***Biometric imaging*** relies on the unique scale and colour patterns of reptiles, much like a human fingerprint.
- ***Physical, analytical, molecular and biometric imaging*** methods of marking may have potential in the future, but all have logistical challenges at present and confer few advantages over plastic or RFID tagging systems.

14. **What is required to set up a traceability system?**
    - Adequate institutional frameworks are essential for effective traceability systems, and range, re-export, and importing States require a variety of compliance and enforcement measures.
    - Dedicated funding should be sought from the owners of commercial traceability systems.
    - Downstream stakeholders should develop sustainable sourcing agendas that benefit upstream stakeholders.
    - Policy approaches that seek to promote legal trade can be useful.
    - Capacity building and ongoing professional development enhance effectiveness.
    - An adaptive management approach is essential.
    - Traceability systems need to be tailored with clearly defined assumptions and expectations.
    - Time spent piloting different options may help to minimise teething problems. It is essential to identify the data management requirements and ensure the traceability system and available resources are suited to purpose.
    - It is ultimately Identity Preservation (IP) that helps determine the comparative value of a traceability system.

15. **Recommendations:**

The exotic skin industry needs to maintain and sometimes re-establish credibility in the face of mounting opposition from interest groups. A better understanding of their concerns, and improved information transfer to address them, are essential. In the eyes of consumers, provenance based on the latest and most advanced technologies is often synonymous with legitimacy and credibility irrespective of real world utility. Understanding the nuances of traceability is becoming increasingly important for all stakeholders in the exotic skin industry. As a trusted figurehead in synergising conservation and industry interests, the CSG could expand its long-standing commitment to traceability, and play a pivotal role in pursuing the following:

- A series of workshops to educate key stakeholders;
- Investigation of whether a universal traceability system, to augment the existing CITES process, can be developed;
- Investigating optimal precision, depth and breadth of traceability systems for crocodylians in a way that works for industry, conservation, and local people. This may include establishment of a traceability working group, or direct liaison with interested industry representatives willing to improve existing traceability systems;
- Investigation of new technologies that may be able to provide real-time, open access information on public interest issues, such as sustainability and animal welfare. Novel tagging technologies, smart phone applications, and publicly accessible online dashboards or databases are all possible options.

3.1
Why address traceability in crocodylians?

Luxury consumers, regulators and the general public are playing a pivotal role in reptile conservation programs incorporating sustainable use, and they are becoming increasingly concerned about environmental impacts and social injustices within the fashion industry (Garcia-Torres *et al.* 2019; Amed *et al.* 2019). Global challenges such as climate change, diminishing natural resources and societal inequalities are dominating the public debate. It is now widely accepted that the future successes of both natural and human systems are directly linked to consumer choices. This trend is growing and is forecast to accelerate in response to global change. The concept of sustainability has emerged as a primary response to global challenges (Garcia-Torres *et al.* 2019). It is a commonly accepted 'catch-all' phrase that encompasses the full suite of corporate social and environmental responsibilities. The ability of a product to meet the needs of the present without compromising the ability of future generations to meet their own needs (i.e., how sustainable a product is) is now an important consideration for both corporate decision-makers and consumers alike.

Provenance is a cornerstone of sustainable business strategies (Swaffield *et al.* 2019). Detailed knowledge of a product's life history contributes directly to perceptions of quality and desirability, and hence profitability. Traceability is one of the principal processes companies rely on to facilitate provenance. It permits the establishment and control of complex supply chains in accordance with customer expectations and company policies. It provides a link between source and end-user; a platform to furnish consumers with the information they require in order to understand the consequences of their actions, and thereby make informed choices. Without traceability, a fundamental disconnect develops between consumerism and sustainability, which can undermine conservation efforts.

The crocodylian skin trade has a commendable history in sustainability and traceability (MacGregor 2006). The concepts and systems behind the trade have been based on scientific integrity since the 1970s, and the industry has grown accordingly. Tried and tested crocodylian traceability systems are well established (Mundy and Sant 2015). However, in an era of heightened expectations and standards, consumer choices are increasingly correlated with the strength of systems in place for verifying provenance, especially for animal-based products. Proving ethical origin may suffice for baseline viability, but more sophisticated traceability systems increasingly confer significant commercial advantages, particularly for the younger generations (Amed *et al.* 2019).

Trade in most other reptile skins has not advanced in the same way as crocodylians, but it provides similar livelihood and conservation benefits. The snake and lizard skin trades are important in this report, both as a reference for what has been achieved with crocodylian skins, and as an alert to the dangers of assuming the "reptile skin trade" is a single entity with the same set of strengths and weaknesses. For example, legality issues in the python skin trade have only recently been addressed, and basic traceability systems have yet to be implemented in some snake and lizard skin supply chains (Ashley 2014; D. Natusch, unpubl. data 2020). The aim of this report is to help improve traceability standards throughout the exotic reptile skin trade by aligning the reader with current information, technology and best practices.

The specific objectives of this report are to:

- Define what traceability means in the context of the reptile skin trade
- Explain what traceability systems can and cannot achieve
- Provide an overview of traceability as a business function
- Explain why implementing traceability systems is technically and logistically challenging
- Provide an overview of the main traceability systems in the reptile skin trade
- Provide an overview of prerequisites and recommendations for setting up a traceability system

3.1.1 What is the source of information for this report?

This report is based on a literature review, personal experience and the experiences of other stakeholders in the reptile skin industry. Published sources of information reviewed for this report include: CITES documents, non-governmental organization (NGO), industry and other expert reports, meeting/workshop proceedings and peer reviewed articles.

3.1.2 What is traceability?

According to the United Nations (Norton *et al.* 2014), traceability in the context of sustainability is:
"the ability to identify and trace the history, distribution, location and application of products, parts and materials to ensure the reliability of sustainability claims, in the areas of human rights, labour (including health and safety), and environment and anti-corruption."

3.1.3 Traceability and CITES

CITES has adopted a non-binding working definition of traceability specifically for CITES-listed species, and therefore this applies explicitly to most reptile species traded primarily for their skins (CITES 2013):

"Traceability is the ability to access information on specimens and events in a CITES species supply chain." The definition elaborates further to accommodate the complexity and diversity of the wildlife trade:
"This information should be carried, on a case by case basis, from as close to the point of harvest as practicable and needed, to the point at which the information facilitates the verification of legal acquisition and non-detrimental findings and helps prevent laundering of illegal products."

The primary objective of the CITES traceability system is to substantiate legal acquisition, in compliance with CITES obligations. The traceability system implemented contributes to the domestic processes Parties are obligated to undertake to establish non-detriment prior to export, and on occasion to verify trade is taking place within sustainable limits to importing Parties.

CITES operates by way of a system of permits and certificates. With a CITES export permit, the exporting state declares that specimens were lawfully acquired (legality), and that trade is not detrimental to the survival of the species in the wild (sustainability). Parties are required to maintain records of international trade and submit annual trade reports to the CITES Secretariat. Traceability is a central and fundamental element of the CITES Convention.

In order to determine whether a specimen has been legally acquired, a national CITES Management Authority (MA) requires information about the origin of the specimen and any transformation (e.g., tanning) it may have undergone. An effective traceability system should therefore assist national CITES authorities in assessing whether trade is legal and within sustainable limits, on the basis of which an export permit for international trade will be issued or refused. Under the provisions of CITES (CITES 2013), traceability is maintained through:

- **Issuance of permits and certificates;**
- **Submission of permit and certificate data in annual reports;**
- **Identification and verification of transactions and specimens when entering/leaving countries (i.e., imports and exports);**
- **Collaboration between national CITES authorities and other relevant agencies; and**
- **Marking of certain specimens in trade (e.g., tagging in crocodylians).**

3.1.4 Reptiles and traceability

Crocodylian wild harvests, ranches and farms are typically operated by well-defined commercial entities within discrete geographical areas. Supply chains comprise limited numbers of producers, traders, processors and manufactures, and trade involves a relatively regulated and predictable number of high value specimens. The formal and well-structured context of the crocodylian skin trade, together with an established CITES track record, provides a sound basis for advancement of traceability systems, when and if needed.

All species of crocodylians are listed in either Appendix I or Appendix II of CITES. Some are recovered and no longer meet the listing criteria, but are retained on the appendices for a variety of reasons. The CITES system for the tagging of crocodylian skins was first introduced in 1992 and is currently implemented through CITES Resolution Conf. 11.12 (Rev. CoP15) *Universal tagging system for the identification of crocodylian skins* (Mundy and Sant 2015). The system applies mainly to raw, tanned and finished skins, but may also cover other skin by-products such as tail tips. By-products are typically bagged, labeled and tagged with a CITES skin tag attached to each package.

The trade in crocodylian skins pioneered the implementation of traceability for wildlife-derived products. Even if simplistic, the crocodylian system has remained reliable over many years. The traceability situation for snake and lizard skins is comparatively underdeveloped and less well structured (D. Natusch, unpubl. data 2020). Trade relies on comparatively low value and biologically similar species, many of which are commercially interchangeable. Many, but not all species are CITES-listed. Skins are derived from wild harvests and farms as both primary products and by-products of the meat and pharmaceutical industries. Supply chains can be fragmented, complex and dynamic, making the end-to-end traceability of these species considerably more challenging.

3.1.5 Why is there a need to understand traceability for reptiles?

The wildlife trade has come under increasing scrutiny in recent years (Roe *et al.* 2020). In particular, concerns have been raised over the impacts of illegal trade on biodiversity conservation and animal welfare. More recently the trade has also been linked to public health concerns, including COVID-19. The commodification of wildlife is sometimes an emotive and divisive subject, attracting considerable media attention. Over the last two years, public pressure to end the trade in wildlife has resulted in several luxury fashion brands abandoning exotic skins altogether (D. Natusch, unpubl. data 2020).

In response, the luxury industry has sought to ensure exemplary standards in the legal, sustainable and ethical sourcing of raw materials (Garcia-Torres *et al.* 2019). Improved traceability systems have been promoted as a means of verifying the highest standards in ethical and sustainable sourcing; new ways to control supply chains in ways increasingly linked to marketing and the customer interface (Amed *et al.* 2019).

3.1.6 Principles to underpin development of traceability for reptiles

Today, the vast majority of the reptile skin trade is legal and sustainable. Most wild populations are healthy and stable (and in some cases, increasing). The reptile skin trade often creates incentives (both commercial and non-commercial) for the protection of species and their habitats. Given the complexity of biodiversity conservation issues in human landscapes, the benefits provided by sustainable use of reptiles are considered a major conservation success. Key to this success has been the empowerment of people living alongside wild (and often, dangerous) reptiles. These people, often living in remote areas where few livelihood alternatives are viable, have derived significant benefits from trade in reptiles. It is critical that traceability systems implemented for reptile skins are sympathetic to the context in which trade occurs, and do not inadvertently exclude these people. Doing so risks undermining the key foundations on which the benefits of trade for species conservation and rural development are balanced. As such, a core principle in the development of reptile traceability interventions is to ensure that systems and technologies are first and foremost commensurate with all small-scale upstream components, especially those that are least socioeconomically secure.

America alligator nest being collected as part of Louisiana's (USA) ranching program

3.2 Introduction to traceability systems relevant to the reptile skin trade

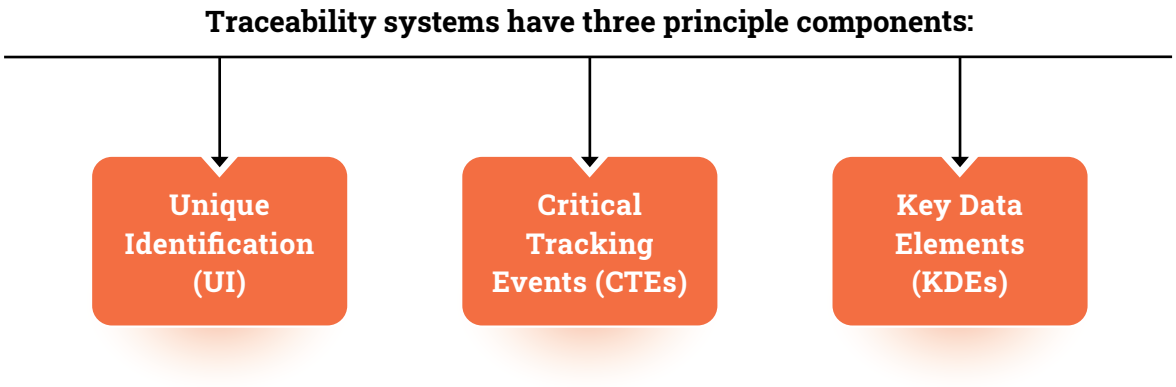


Fig. 1 Three critical components of traceability systems

3.2.0.1 What to trace: Unique Identification (UI)

Unique identification (UI) is a combination of the product (e.g., whole skin, batch of skins) and supply chain source (e.g., farm, processing facility). Numerous coding systems have been developed to supply the market with unique identifiers. Different unique identification systems may be used for a variety of traceable commodities. Unique Identifiers (e.g., a unique tag number on an individual skin) can be created and managed by the industry or user themselves, or through specific UI initiatives. For example, the Blue Number Initiative (Wozniak 2016) is one of the most widely used standardized unique identification systems. The Blue Number is a unique ID for any individual, entity or asset contributing to the food system. It includes a specific Global Location Number (GLN), which identifies an entity in any part of the supply chain. It provides the holder with a universal identifier in addition to other product specific information (see below). The Blue Number is issued online by GS1 (www.gs1.org).

Unique identification is provided in the form of alphanumeric codes, which can then be encoded into tags (physically etched or via RFID). In addition to the UI number, tags can include information specific to the reptile skin trade, such as:

- Range state
- Province
- Species
- Source code (e.g., captive bred, ranched or wild harvested)
- Year of harvest

How big or small the traceable units are define the *precision* of a traceability system. Traceability precision in the reptile skin trade most commonly involves the following units:

- Whole individual skins
- Pieces of individual skins (e.g., flanks, unique sectional cuts)
- Batches of skins
- Boxes of skin off-cuts and by-products

3.2.0.2 When to record: Critical Tracking Events (CTE)

Critical Tracking Events (CTEs) define the actions that trigger data recording. There are three main categories of CTEs per entity: Reception, Processing and Dispatch. Optimal traceability aims to identify the beginning-to-end path of a product throughout its supply chain. To achieve this goal, it is essential that key supply chain nodes record their actions and make the information available. Any traceability system has to be impervious to processing or transformation of a product (e.g., transformation from raw skin into leather) such that the individual commodity in question (or product unit) can be traced and tracked from its origins through the transformation process. For example, when a tanner buys raw skins from a processing facility, those skins must remain identifiable at the end of the tanning process so they can be tracked back to the processing facility from which they came. Examples of important CTEs in the reptile skin trade may include the hunter's, regional collectors, specific farms, carcass processing, tanning, export and import.

The length of the supply chain covered by a traceability system is called its *depth*. Knowing at which point in the supply chain to tag reptile skins depends on several factors, including logistics, cost, and the type of information stakeholders wish to trace (for various commercial and regulatory purposes). In some lizard and snake supply chains, individual hunters tag animals as soon as they are captured and the Unique Identifier follows the individual or its skin throughout the supply chain. Similarly, wild alligator (*Alligator mississippiensis*) hunters are required to tag individual animals as soon as they are killed. In these systems, key information on both hunting locations and hunter identity are known. In other systems, logistical and cost constraints may result in traceability beginning further down the supply chain. For example, many traceability systems begin once the skin is removed from the individual animal, which presents far fewer logistical obstacles compared to tagging by hunters, but which also results in the loss of harvest information.

Within CITES, traceability begins at the point of export when CITES permits are issued. Information on the geographic location of harvest, conditions of harvest, and data relevant to the species in question may be collected independently by national authorities, but is not linked to individual specimens through the CITES traceability system. It is this additional information that improved traceability systems carry that can provide further assurances of legality and sustainability. In addition, knowledge of the nodes in a supply chain through which a skin passes allows for problem identification and targeted interventions.

3.2.0.3 What to record: Key Data Elements (KDE)

A traceability system must define the Key Data Elements (KDEs) to be recorded at each of these CTEs. KDEs will differ along the supply chain as the product is transformed and different information becomes relevant. For example, KDEs for live reptiles received at a processing facility may include hunter's name and harvest location, while a tannery may be interested in the processing facility name and CITES permits. The amount of information recorded at each KDE is called the *breadth* of a traceability system. With an electronic database, this information can be synthesized and linked to the individual skin. There is significant power in a well-managed and sophisticated traceability system.

Table 1

Main components of traceability in the reptile skin trade (adapted from Lehr 2015)

Element of traceability	Unique identification	Key Data Elements	Critical Tracking Events
Examples	individual skins batches of skins boxes of skin pieces	hunter UI tag quantity date	delivery of live animals skinning tanning
Performance dimensions	*precision*	*breadth*	*depth*

Table 2

Example of Key Data Elements at Critical Tracking Events in the reptile skin trade

	Reception	Processing	Dispatch
Hunter/farm	species UI tagging egg source time/date welfare/condition	UI tagging pen number welfare/condition	UI tag logistics time/date welfare/condition
Processing facility	species hunter name time/date quantity source welfare/condition	UI tagging skin cut skin grade skin size	UI tag logistics exporter time/date
Tannery	species UI tag importer CITES permit time/date quantity	UI tag tanning skin grade skin size, color, finish	UI tag buyer logistics time/date

3.2.1 Information management

Traceability systems generate large volumes of data. Storage options include Individual Data Storage Systems and Cumulative Data Storage Systems.

3.2.1.1 Individual data storage systems

The Individual Data Storage approach requires that every supply chain node records its predecessor and successor. Thus nodes will be able to identify the supplier of an input and the customer for an output. Track and trace is made possible through many small traceability steps and collectively this forms a traceability system. The main advantages of this method are its simplicity and affordability. Every node is only responsible for its own data, and data storage can be done on paper as well as electronically, depending on the node itself. However, the system is not inherently compatible with automation or electronic information transfer and suffers from human error, slow processing speeds and diminished capacity for global data sharing or transparency. Today, individual data storage systems are unacceptable given the ease and affordability with which data can be gathered and shared.

A local Dusun man pins a reticulated python skin for drying in Sabah, Malaysian Borneo.

3.2.1.2 Cumulative data storage systems

There are two principle types of cumulative data storage systems – accumulative and centralized. Accumulative data storage systems are similar to individual data storage systems except the information from each node is collected and passed on down the supply chain, thereby resulting in the accumulation of traceability data at the end of the supply chain. This increases data consistency and utility, but there are added storage and administrative costs. Centralized data storage systems require all nodes in the supply chain to independently submit data to a centralized database.

CITES provides a working example of a rudimentary centralized data storage system for a short traceability chain. The system is short, because it covers only the export, re-export and import of the product, but does not extend further downstream or upstream. The CITES export permits record the origin country from which the reptile skins were first exported, as well as any intermediate re-exporting States. Each node in the supply chain is required to report these transactions to CITES, which makes the data available in a centralized database held by the World Conservation Monitoring Centre for the United Nations Environment Program (UNEP-WCMC; Mundy and Sant 2015). The reports from each node in the supply chain act as a form of cross-reference to ensure the validity of reported trade transactions. More sophisticated systems can extend further along the supply chain (e.g., from hunter to finished product).

Centralized databases allow for electronic automation and analysis, often in real time, and this can provide significant cost and time savings. Shipments are scanned at each point in the supply chain allowing for real-time tracking, similar to the highly sophisticated systems used by home delivery retailers (e.g., Amazon). However, they are costly to establish and maintain and they require a high degree of consensus. All nodes in the supply chain have to agree to a single shared system, which can present significant challenges in fragmented and disconnected industries, such as is often the case in the reptile skin trade.

Modern technology, such as smartphones and bespoke applications, may make central database systems more accessible and user-friendly in the future. For example, the Southeast Asian Reptile Conservation Alliance (SARCA) application is downloadable from the Google and Apple store onto both iOS and Android tablets and mobile phones. The Application is called ReptileTradeMonitor and has two main purposes: 1) To streamline self-reporting and allow instant online upload of key data collected by traders and trade monitoring officials (e.g., scientists), and (2) to ensure chain of custody (traceability) of skins along the supply chain.

All trade participants are registered to use the application by government staff, and allocated a unique identifier so data collected is linked to their permit and business registration numbers. Data are collected and uploaded in real-time to a central repository. The application and trader details are managed through an administrative platform accessible only by government staff. Plastic tags with barcodes and QR codes can be allocated to specimens at several points in the supply chain, depending how far users wish traceability to extend along their supply chain. Each node in the trade chain scans the unique code as it passes through their facility and the tag number is linked to all other information collected at other nodes to ensure chain of custody. At the same time, large amounts of important metadata are captured to help inform sustainability assessments. The tags are designed to withstand the tanning process, with the traceability system usually finishing when the skins are purchased and cut to manufacture products. The data from the tagging system can be downloaded in CSV file format and imported into a statistical analysis program for rapid analysis and reporting. Importantly, the information gathered allows government managers to crosscheck information to ensure compliance in real-time. At the time of writing, this system is in its pilot-testing phase.

3.2.2 Traceability vs verification vs chain of custody

The luxury fashion industry often uses the word “traceability” as if knowing where a reptile skin comes from solves the problems relating to legality and sustainability (D. Natusch, pers. obs. 2020). This is incorrect. Traceability is required in order to ensure legality and sustainability, but it doesn’t guarantee it. Traceability is a conduit for verification. Traceability by itself makes no claim as to the legality or sustainability state of a skin. In order to claim that a skin is from a sustainable and legal harvest, the claims have to be verified, even when those skins are traceable back to a specific farm or hunter (Fig. 1). In other words, traceability can carry information along a supply chain, including whether skins have originated from a verified source, but it doesn’t provide the verification itself. Theoretically, it is possible to have a perfectly functioning traceability system that links skins back to a source that is illegal, unsustainable and inhumane. As an example, using stable isotopes to ensure a crocodylian skin is sourced from a farm instead of from the wild is a form of verification. In contrast, a traceability system is the process by which the information on verification is passed along the supply chain. If stable isotopes are used to specify a particular farm (point A), and the skins could be tested at a later stage in the supply chain (point B), then this would be considered a form of traceability AND verification.

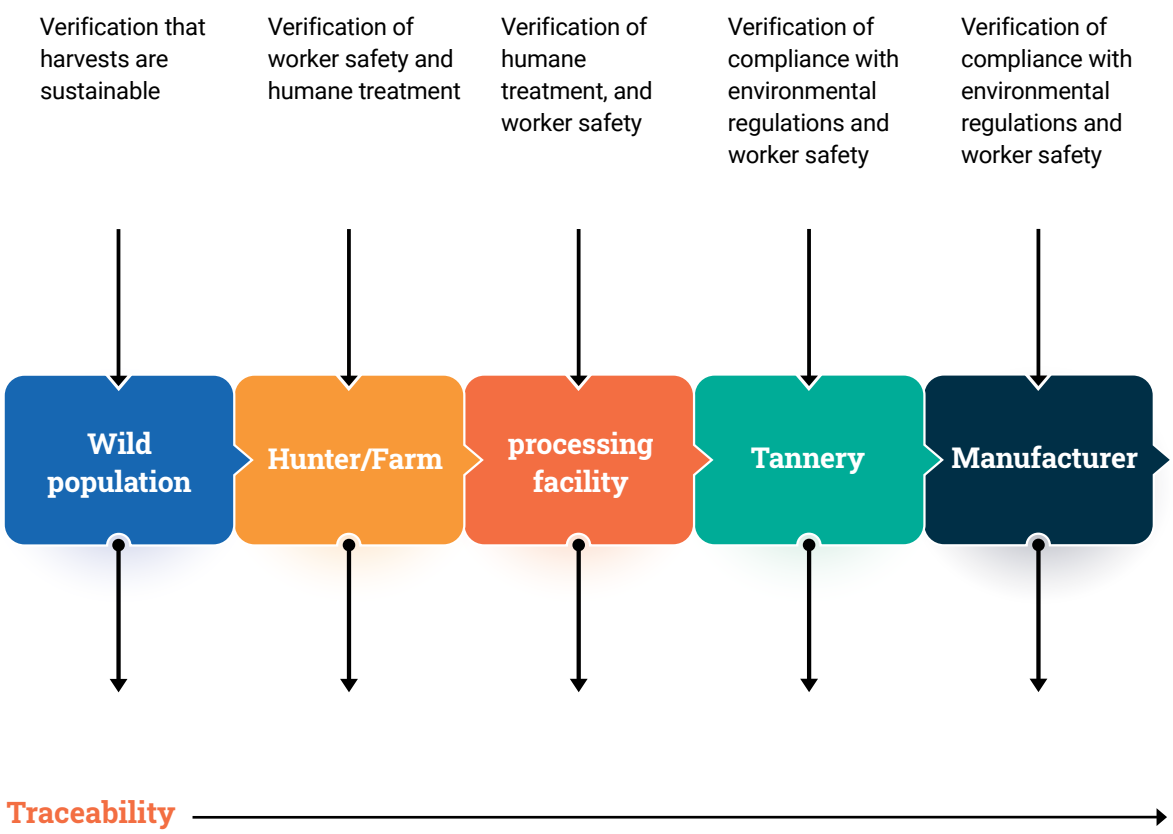


Fig. 2. Traceability does not provide verification. It carries information along the supply chain, and can communicate that reptile skins are derived from a verified source. Another process entirely is required to ensure the skins are indeed verified against whichever criteria are of interest.

Chain of custody refers to all steps in a supply chain that take possession of the skins, including farmers, hunters, middlemen, processing facilities, transporters, tanneries, exporters, importers, manufacturers, wholesalers, retailers, and sometimes end users. It provides a record of the sequence of entities that have custody of skins and transformed products as they move through the supply chain. Tracking information generated by chain of custody allows traceability systems to follow the trail of skins along the supply chain back to their origin.

3.2.3 Main functions of traceability in the reptile skin industry

3.2.3.1 Regulatory compliance

Traceability in the reptile skin trade originated as a means of ensuring claims of legality. For example, context-specific traceability systems can link a skin to its origin and thereby verify whether it was derived from a legal source.

3.2.3.2 Sustainability

Another objective of traceability in the reptile skin trade is to help protect the resource from overexploitation by linking traceability systems to information on the state and wellbeing of the resource. Traceability systems can be synergized with population monitoring and management activities carried out by third party agencies. The ability to capture 'big data' from strategic linkages can reveal patterns in population trends vs trade volumes and thereby contribute directly towards CITES non-detriment findings (NDFs). Bespoke software applications, smartphone technology, and centralized data storage systems hold considerable potential for allowing data from traceability systems to be used rapidly to undertake such assessments.

3.2.3.3 Certification

Traceability is often used as a tool to verify the source and provenance of a product. For example, a certification scheme may ensure biological and environmental sustainability, staff working conditions and animal welfare in upstream entities within reptile skin supply chains. However, to ensure that a particular item is derived from a certified source, a traceability system is often required. Types of certification include:

3.2.3.3.1 Individual Track and Trace (Hard Identity Preservation)

Individual Track and Trace, sometimes referred to as "hard identity preservation", ensures that a certified product retains its unique identity throughout a traceability system. It allows a certified product, be it a skin or manufactured product, to be uniquely traced through the supply chain from source (e.g., certified alligator farm) to end point (e.g., use of a certification claim by a tannery selling whole skins). The certified skin must be uniquely identifiable. Skins can be physically mixed with other certified or non-certified skins at any point along the supply chain, but only if their unique identity is retained by use of a tag or alternative identification method. The current crocodylian skin tagging system is an example of hard identity preservation traceability, because the unique identity of individual skins is retained by the application of a unique tag (Fig. 2).

3.2.3.3.2 Product Segregation (Soft Identity Preservation)

Product segregation relies on physically separating certified and non-certified skins throughout the supply chain. This approach ensures that the skins derived from certified sources (e.g., tanneries segregating skins according to origin from certified or non-certified crocodile farms) preserve that identity throughout the remainder of the supply chain. The system permits the mixing of certified skins from a variety of sources, each certified to the same standards, but does not maintain visibility of which skin came from which farm (Fig. 2).

3.2.3.3.3 Mass Balance

The Mass Balance approach allows for mixing of certified and non-certified commodities. CTEs record the proportion of certified and noncertified product entering the operation as KDEs, allowing the nodes to calculate the percentage of certified output. For example, a tannery would be able to make the claim that a certain percentage of its crocodile skins are derived from certified sources. This system is best suited to high volume/low-value commodities and holds minimal potential for whole reptile skins. However, mass balance may have useful applications for off-cuts and by-products (e.g., tails, feet and teeth, Fig. 2).

Example of an advanced certification system for reptile leather products.

In Germany, the reptile leather industry has developed their own tagging systems for finished CITES-listed reptile products. These voluntary certification schemes are primarily used for the domestic market and to assist consumers in their decision making. One example is the "Artenschutzfahne" or "Conservation tag" of the German-based International Reptile Association (IRV). The IRV Conservation tag is a certification system for finished reptile leather products. The tag is a voluntary scheme but it is recognised by the German CITES Authorities as proof of legal origin. The tag is used only for those products that originate from raw materials that were obtained and traded in accordance with the provisions of CITES and the EU Wildlife Trade Regulations, and only products for which the original CITES documents are available can be tagged. The tag uses a combination of letters and numbers that provide information about the country of origin, the species, the CITES permit number and year of issuance. The information is managed through a computerised database that ensures an easy and secure way to track the individual product to the origin of the raw material and to assist the authorities in controlling the trade in these products. More information is available here: https://ec.europa.eu/environment/cites/info_marking_en.htm

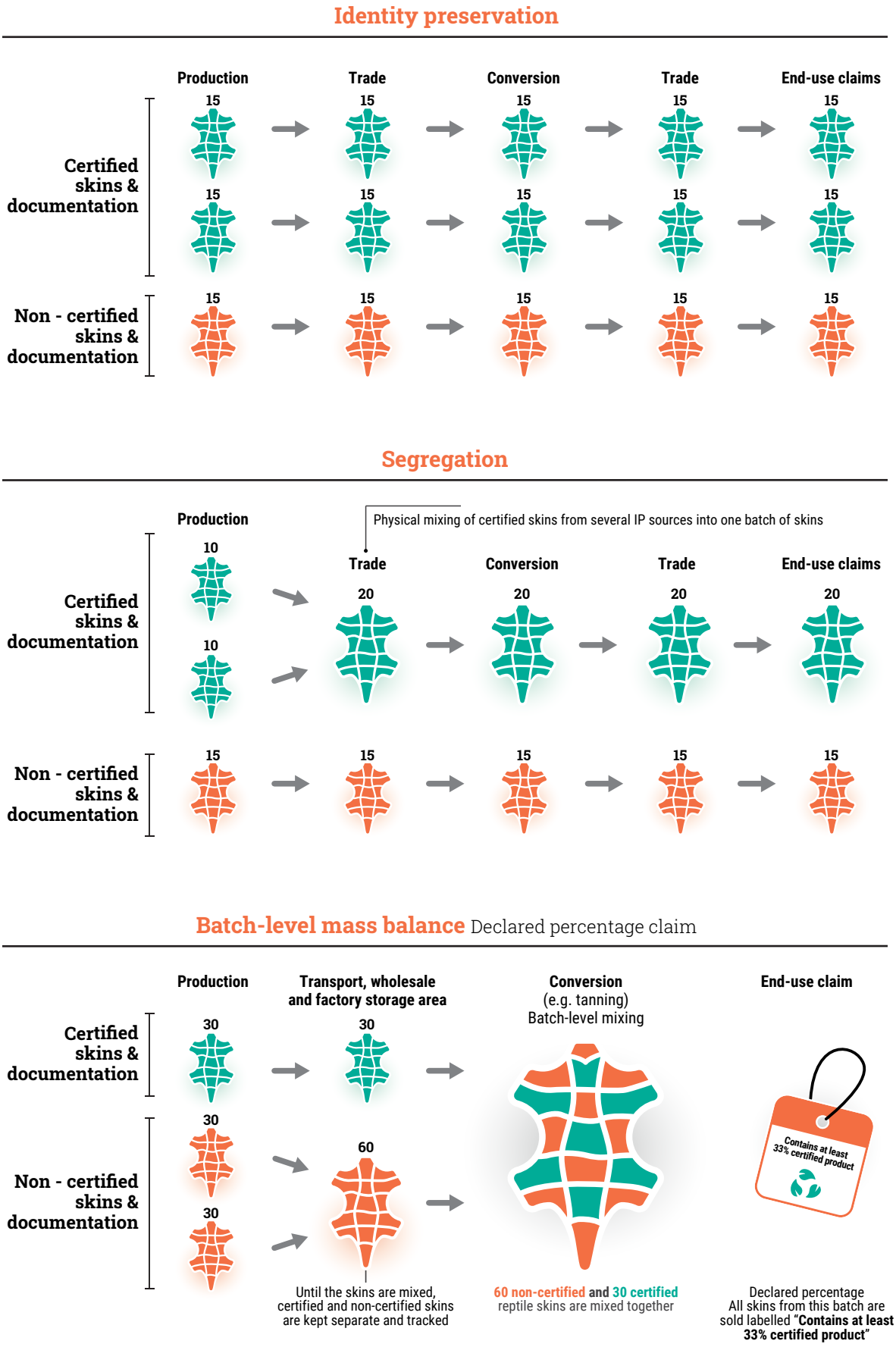


Fig. 3. Different types of traceability systems linked to product certification.

3.3 Traceability of crocodylian skins

The introduction of individual tagging for crocodylian skins by CITES was largely motivated by the need to track imports and exports through the often complex trade routes for raw and tanned skins (Mundy and Sant 2015). Thus it was largely about ensuring compliance with CITES. However, the tagging system benefited industry and management in various other ways. Hence recovered and abundant crocodylians are retained in CITES, and traded with CITES protocols, because the system has broad utility beyond the CITES mandate to ensure non-detriment. The CITES crocodylian tagging system enables hard identity preservation for each skin up to manufacturing, and potentially allows end-to-end traceability (e.g., alligator farm to luxury retail outlet).

Raw, tanned and/or finished crocodylian skins are tagged individually before entering international trade from their countries of origin, using non-reusable tags. The tags include:

- The ISO code for the country of origin;
- UI number;
- A species code;
- The year of skin production or harvest.

Tags also:

- Have a self-locking mechanism that is tamper proof;
- Are resistant to the physical and chemical stresses of processing;
- Include alphanumeric information, which may include barcoding.

Smaller by-products (e.g., feet, back straps) are exported in transparent, sealed containers, marked with a non-reusable label detailing tag information along with a description of contents and count or total weight. Re-exports require original tags intact, or a "re-export tag". Re-export tags should meet the aforementioned requirements, except that country of origin, standard species code and years of skin production and/or harvest need not be included.

Parties are also recommended to implement a management and tracing system. As part of the management system, Parties must follow these standards:

- Tag manufacturers must be approved by CITES
- Import, export and re-export data must be recorded and made available to CITES
- Sample of tags/labels used on containers must be made available to CITES

In order to manage the tagging process, CITES recommends a system of national registration and/or licensing for producers, tanners, importers and exporters. Specifics vary between countries (commonly referred to as stricter domestic measures), but most, if not all, achieve a functional and satisfactory level of compliance in terms of ensuring legality and sustainability. Most importing countries now include stricter domestic measures designed to match exports with imports.

Fig. 4. A CITES-approved tag applied on the tail of a newly harvested wild alligator in Louisiana, USA

3.3.1 Strengths

- Evidence of legal source
- Universal standard
- Flexible implementation
- Verifiable record of trade volumes (e.g., cross-checking import vs export statistics)
- Compatible with automated and digital information systems
- Tagging systems covers all important supply chain nodes
- Tagging system covers by-products

3.3.2 Limitations

- Administrative and financial costs;
- Tags are vulnerable to fraud (e.g., tampering, counterfeits, reuse);
- Laundering of illegal wild harvests pre-tagging;
- Inconsistencies between countries (e.g., stricter domestic measures);
- Technicalities and interpretation by national authorities; and,
- Difficulties tagging smaller products derived from tagged skins.

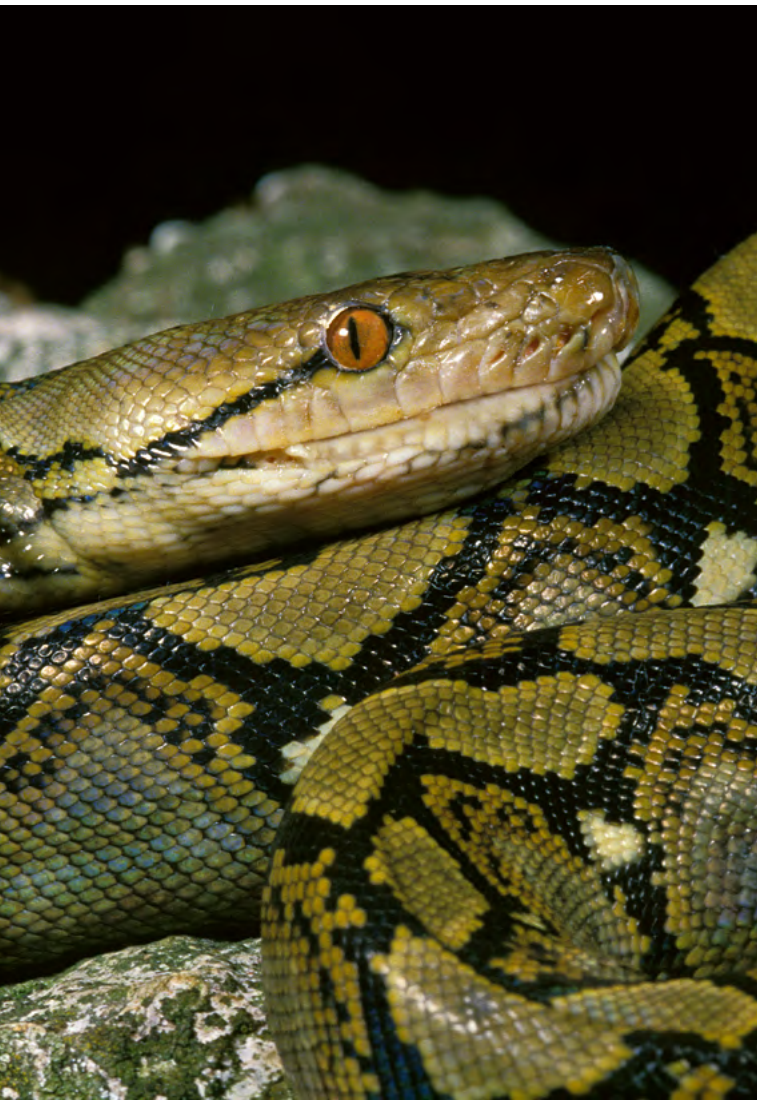
The crocodylian tagging system is technologically simple, but has still faced implementation challenges. For example, traceability was and is expensive for producers and regulatory authorities to introduce, operate, and manage at all steps in the supply chain, nationally and internationally. However, most stakeholders now consider the benefits outweigh the costs. The system has a proven track record for all traded species. It affords stakeholders a high degree of flexibility and adaptability, and in this sense is well placed to meet emerging traceability challenges and opportunities. However, the system does incorporate a considerable volume of technical information and fundamentally relies on self-reporting. In this regard, good governance is essential, as is adequate training of administrative and enforcement personnel.

Of note, is that at the time of introduction crocodylian skins were highly-valued and the costs associated with tagging were considered minor relative to profit margins. Over the years, this situation has changed as the value of many crocodylian skins has declined precipitously, to near or below production costs. Hence the tagging of skins and management of the traceability system becomes an increasingly significant component of an increasingly cheaper product. The exact impacts of this on the industry and the functioning of the traceability system are not yet known.

Fig. 5 CITES-approved tags on tanned and finished crocodylian skins

3.4 Traceability of pythons

Efforts to develop a traceability system for python skins began in 2013 (Ashley 2014) after videos from Indonesian processing facilities raised concerns over animal welfare standards. Progress involved baseline work to strengthen regulatory frameworks and improve traceability standards, and this prompted the establishment of a Traceability Working Group within CITES. Discussions surrounding the most appropriate traceability tools and applications are ongoing and continue to draw on the experiences of other traceability systems (e.g., Ashley 2016; Jouffrey and Batt 2017). A CITES Resolution on Snakes (Resolution Conf. 17.12), in conjunction with a study undertaken by UNCTAD and CITES (Ashley 2014), includes the following recommendations concerning traceability:



- Traceability systems for python skins should follow a hard identity preservation model (e.g., tagging);
- Stockpiles require inventorying and tagging;
- Traceability systems should generate funding to support ongoing conservation and management activities;
- The CITES tagging system developed for crocodylians (Resolution Conf. 11.12) provides a suitable base model;
- Marking should include the following as a minimum:
  - Species;
  - Country of origin (where relevant regional code);
  - Year of harvest or production;
  - Unique serial number; and
  - Source code (wild, ranched or captive-bred).
- Point of first tagging should be mindful of resource availability and logistical constraints of Range States.
- Verification of legality is reasonably feasible upstream of the tanning process provided there is honest reporting at processing facilities. Thereafter, tanning of python skins typically necessitates the removal of tags (i.e., 'rolling' to flatten scales and achieve a smooth finish), thus increasing the fraud risk and making verification more difficult. Here, a "two-tiered" tagging approach may be employed to bridge the tanning transformation via a re-tagging process.

- Marking systems should be pragmatic, business-friendly and have real-time electronic capacity.
- The production and distribution of tags should be standardized to limit fraud.
- Range State issuing authorities should allocate tags to licensed and regulated facilities. Issuing authorities should maintain a tag database detailing transactions.
- Traceability systems should link with Range State management and monitoring activities and CITES permitting process. Information should be digitized, standardized and automated.

Despite these recommendations, and the time elapsed since they were made, traceability of python skins has not moved forward in the way it did for crocodylians. Reluctance from regional actors, combined with concerns about illegal skins entering a processing facility before they can be tagged, have hindered implementation. For example, until recently, illegal trade in skins between processing facilities was prevalent. Initiating a traceability system further downstream (e.g., at the processing facility, once the skin is removed from the snake, or at the tannery) may have resulted in authorities inadvertently allowing illegal skins to enter the legal supply chain. In this case, illegal trade represented a critical barrier to the implementation of traceability systems. It is only through the creation of incentive structures, such as raising quotas, removing bans, and introducing skin size limits that the legal trade has been able to reach a point whereby effective traceability systems can be implemented (D. Natusch, unpubl. data 2020). This has allowed traceability systems to be implemented in some python skin supply chains, where those systems are operating smoothly and providing added assurances to buyers.

Reticulated python (*Malayopython reticulatus*) skins rolled for temporary storage after they have been air-dried in Central Kalimantan, Indonesia.

3.5 What can a traceability system achieve?

A traceability system in the reptile skin trade can contribute to confirming origin and legal sourcing, provide data to assist sustainability analyses, and can strengthen the credibility of the CITES certification system. However, to be successful, traceability systems still rely on the integrity of stakeholders. In the absence of trustworthy reporting, traceability is valueless. In fact, if illegal trade exists within the structures of a functional traceability system, traceability can be counterproductive. In grey markets, where skins are clandestinely laundered into legal supply chains, traceability can provide insights into illegal activities. This can also be used in law enforcement as it points towards products with questionable sourcing. For example, lawmakers could define different customs standards depending on whether the product is traceable or not, thereby ensuring that investment in traceability is supported by regulations. In black markets, where both the customers and producers are aware of illegally sourced skins, traceability can support law enforcement, as a lack of traceability can highlight products of questionable origin. Furthermore, if traceability were mandatory for a product category, a lack of, or forged traceability, will give law enforcement officers a legal basis for confiscation of questionable products. Hence, traceability can function as a gatekeeper and deny illegally sourced products market entry, or at least increase the risk of participating in black markets. Having said this, if both sellers and buyers agree on illegal transactions, traceability is not likely to be effective. A summary of what traceability systems can, and cannot, achieve is presented in Table 3.

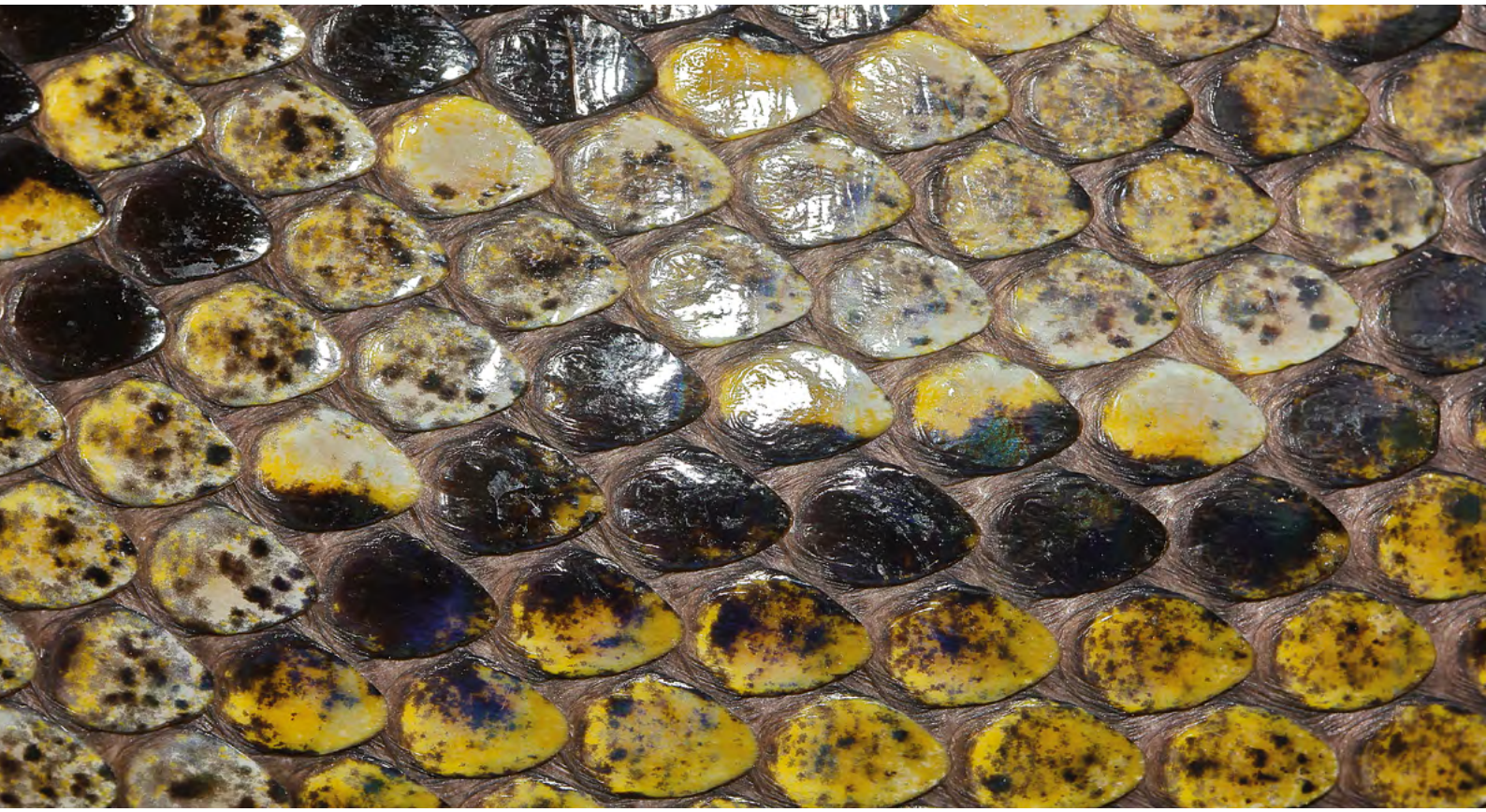


Table 3
Comparison of what traceability systems can and cannot achieve for reptile skin trade and conservation management

Possible benefits	Possible negatives
Confirmation of origin	Cannot completely prevent illegal trade
Confidence in legal acquisition	Can be used to launder illegal goods
Improve credibility of existing systems (e.g., CITES permits)	Can be costly to implement
Link products to verified/certified sources and practices	May exclude supply chain actors who cannot comply (e.g., small-scale businesses or remote communities)
Can link and offer visibility of supply chain entities	May jeopardize conservation outcomes based on sustainable use if market exclusion of key stakeholders occurs
Can facilitate circular economies (e.g., financial inclusion models) through identification of product and financial flows	
Can help to pinpoint areas of the supply chain in need of improvement	
Can identify defects or hazards within the supply chain (e.g., food safety for recall purposes)	
Can improve transparency, brand integrity and consumer confidence	
Can produce statistics for sustainability and non-detriment finding purposes	
Can calculate environmental, economic, and social impact along supply chains	

3.6 Why is establishing a traceability system challenging in some contexts?

Supply chains in the reptile skin industry often comprise numerous informal and disconnected upstream components. For example, wild harvests in particular may rely on large numbers of opportunistic harvesters and complex networks of collectors, dealers, middlemen, and processing facilities, many of whom deal in both live animals and raw skins with no formal contractual arrangements.

It is very difficult to bring traceability systems to these small-scale stakeholders, in remote settings, where access to basic services, technologies and education are lacking. There is also often reluctance from exporters to disclose their skin suppliers to trade participants further down the supply chain for fear of being eliminated or made redundant within the value chain.

The tanning process is physically and chemically arduous (Ashely 2016). In some cases it may present technical challenges for marking systems. Tags can be destroyed or removed, and the chemical and morphological characteristics of the skins may change (Webb *et al.* 2012). Mitigating these issues requires the design and testing of specific tag types and technologies. Re-tagging also presents opportunities for human error or deliberate non-compliance, and adds to the administrative costs of traceability systems, especially in Range States where value-adding is an important component of sustainable use programs.

Raw and crust tanned skins store well and significant stockpiles of skins exist in some Range States. Unless bookkeeping and inventory systems are rigorous, these stockpiles present opportunities for illegal skins to enter legal supply chains undetected, and thus undermine traceability systems. Inventorying and tagging of stockpiled skins before implementation of a traceability system can help to mitigate this problem (Ashley 2014).

3.7 Traceability tools for reptile skins

3.7.1 Marking

Marking has been a cornerstone of reptile skin traceability systems. It has proved highly successful with crocodylians and anacondas and has been recommended as a principal traceability tool in the python skin trade. **To be successful, marking should be:**

- √ **Low cost**
- √ **Simple and effective**
- √ **Pragmatic and business friendly**
- √ **Hardwearing**
- √ **Tamper proof**
- √ **Have real-time electronic capabilities**
- √ **Account for differences between wild harvests and captivity**
- √ **Ideally link with existing databases, such as:**

  Population monitoring
  CITES
  National registry and permitting
  National checking and inspection points

3.7.1.1 Tags

3.7.1.1.1. Plastic tags

Loop and button style tags are some of the tag types currently in use for tracing reptile skins (Fig. 6 & 7). Costs typically range from US$0.3 to US$0.7 depending on quality and economies of scale pricing (Ashley 2016). Tags can include a digital interface such as one or two-dimensional barcoding (e.g., QR codes) to allow for digital collection of tag information. Barcoding enables compatibility between database systems. Most barcodes are now readable via smartphones and compatible hardware and/or software applications. Plastic tags can be vulnerable to the tanning process, although new technologies such as nylon and laser-etching are increasingly negating this issue.

Button style: Currently successfully used for tagging yellow anacondas and caimans in Latin America. Based on the required information (see above) a button diameter of 5 cm is recommended. Button style tags are suitable for barcoding.

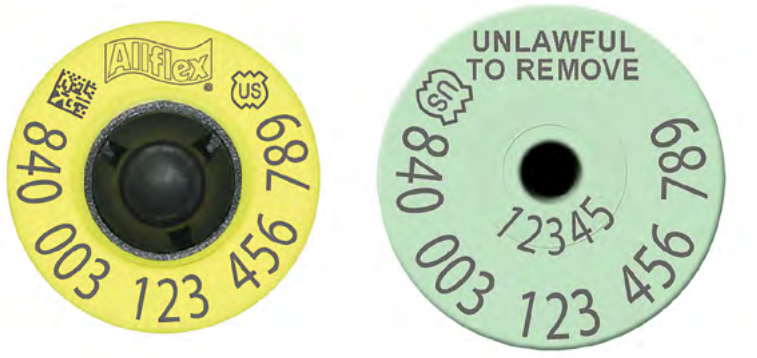


Fig. 6
Button style tags come in numerous shapes and designs and can include tag information as well as RFID technology.

Loop style: Widely used to tag crocodylian skins. Can be prone to snagging in the tanning process so not recommended for fragile skins. An important feature of loop style tags is the interlocking mechanism designed to be tamper proof.

Fig. 7
Loop tags come in multiple designs, with different tag manufacturers offering different model, plastic types, and data etching with properties to suit most purposes.

3.7.1.1.2 Radio-frequency identification (RFID) tag

RFID technology is widely used in supply chains and is successfully used to trace the skins of some reptile species (Mundy and Sant 2015; Fig. 8). They are a common alternative to barcoding. RFID tags emit unique tag numbers via a radio-frequency, which can be recorded and linked to other electronic databases. Many RFID tags are resistant to tanning and finishing processes, including destructive mechanical processes such as "rolling" or "plating" for millennium finish. They can be attached to a peripheral part of the skin (e.g., adhesive systems, stapling gun) and read via a standard RFID reader or smartphones equipped with reader software and hardware technology.

Fig. 8
RFID tags come in a variety of shapes and sizes. They can be rigid or flexible, big or small, and many can withstand the tanning process (including potentially destructive mechanical processes such as millennium finishing).

3.7.1.1.3 Barcoded tags vs RFID tags

Plastic tags and RFID tags are functionally very similar but there are some important differences:

- Barcoded tags are typically less expensive;
- RFID tags require special hardware (scanners), while barcodes can be read via downloadable smartphone software applications;
- Barcodes are designed to be scanned one at a time whereas many RFID tags can be scanned simultaneously, which improves processing and recording times;
- Barcodes require that the scanner maintain a line-of-sight with each tag, while RFID is a "near field" technology – so the scanner only needs to be in range with the tag to read it. This can allow a user to scan batches of skins and obtain all RFID tag numbers in a matter of seconds. Use of barcodes necessitates shipments to be unpacked and tags to be scanned individually.

For application to the reptile skin trade, the necessity to individually inspect and grade skins at multiple points in the supply chain renders the advantages of RFID tags somewhat obsolete.

3.7.1.2 Physical marking methods

Physical marking methods involve altering the skin to create a unique mark. Marks act in the same way as a tag, except that the 'tag number' is permanently attached to the skin. Examples include scute clipping on crocodylians and ventral scale clipping on snakes. Although these systems may be applicable in the farm context, they are less useful for wild harvested specimens, are intensive to implement and offer little if any benefits over conventional tags.

Skin scarring methods are sometimes used to prevent laundering of wild individuals into captive production systems. This is a form of verification rather than strict traceability, and is best used to verify the production system rather than as a traceability tool.

Skinning patterns can also be used to determine source. Skins can be cut according to a unique pattern to aid in verification and traceability. This technique has been used to address the problem of illegal stockpiling of skins by the Yellow Anaconda Management Programme in Argentina (Natusch *et al.* 2015). Here, anacondas are skinned differently in alternate years and seasons to help differentiate between harvest seasons and harvest years.

A physical marking method for Caiman in Colombia. Tail scutes are cut in young captive-bred animals. These cuts heal over time to form distinctive scars that can be used to ensure the specimen has grown in captivity and was not sourced from the wild.

3.7.2 Chemical and molecular methods

Chemical and molecular traceability and verification methods require analysis of the unique properties of reptile skins, and include the following:

- *DNA (genotyping)* involves determining differences in the genetic make-up of an individual by examining the individual's DNA sequence using biological assays, and comparing these to reference samples. Analysis of skin samples allows inference to be made about the parent or source population. DNA techniques have been successfully used with raw reptile skins to verify source (Lyons *et al.* 2015).

- *Stable isotopes:* Animals absorb the unevenly distributed isotopes (H, O, N, S, C, etc.) in nature and incorporate them into their structure. Laboratory analysis can reveal the relative abundance of these isotopes and thus make inferences about environmental origin. Stable isotope analysis has been successfully used on raw reptile skins to verify source (Natusch *et al.* 2017).

- *Elemental markers:* Similar to stable isotopes, elemental markers rely on ratios of absorbed elements such as heavy metals to make inferences about environmental origin. Elemental markers have proven successful with raw reptile skins in verifying source (Natusch *et al.* 2017)

- *Microbiological barcodes:* The genetic profile of bacterial communities associated with an individual can be used to determine the origin of that specimen. This method has proved successful with fish but not with reptiles (Cohen *et al.* 2013).

- *Fatty acid profiles:* The profile of fatty acids has been successfully employed to distinguish wild fish from cultured conspecifics (Cohen *et al.* 2013). Farmed reptiles commonly have uniform diets and significantly higher lipid content compared to wild conspecifics and therefore are likely to have different fatty acid profiles (D. Natusch, upubl. data 2020). This method has not been tested on reptiles.

These technologies all rely on tissue samples from skins to identify unique properties of an animal or site from which it came to verify provenance. For example, fatty acid profiles, elemental markers, stable isotopes, and microbiological markers can theoretically be used to verify whether a reptile is derived from a particular farm, because the unique characteristics of that farm (temperature, water, food inputs) result in a unique biochemical "fingerprint" or "signature" within the skin of the animal. In addition, farms can create farm-specific signatures by introducing artificial markers (e.g., glycine) to feedstock (Natusch *et al.* 2017). With the exception of genotyping, these methods are typically not sensitive enough to allow identification of individual specimens within a particular farm.

It is important to note that these methods themselves are not a traceability system. Although they can link skins to the point of origin, they do not allow the carriage of other information that might accompany the skin, and do not allow identification of the supply chain nodes the skin passes through from the beginning of a supply chain to the end. Hence, these methods would need to be employed at each point within the supply chain, at considerable cost, or be accompanied by a complementary method (like a tag) to ensure chain of custody (the latter of which would result in significant redundancy). Finally, the chemical processes involved in tanning reptile skins alters the DNA, fatty acid, and microbiological profiles of the skins, preventing the carriage of information beyond this point in the supply chain. Although early evidence suggests that it may be possible to identify skins after this transformation process using stable isotope and elemental markers (D. Natusch, unpubl. data 2020), further research and development is needed to conclude the efficacy of these methods. All else being equal, the considerable logistical impediments and financial costs associated with these techniques confer few advantages over simple tagging systems.

3.7.3 Biometric imaging

Biometric imaging relies on exploiting the unique scale and colour patterns of reptiles, much like a human fingerprint, to verify the provenance of skins (Ashley 2014; RESP 2016). The concept relies on precision scanning entire skins as the first step in the traceability system, and therefore incurs considerable logistical and financial costs for small-scale stakeholders in Range States. Similar to analytical and molecular methods, scanning of skins would need to occur at each point in the supply chain through which a skin passes in order to verify chain of custody. Although available technology is constantly improving, it is not currently feasible to preserve 100% identity of unique skins from the raw through to the tanning stage using biometric imaging.

The unique pattern on the skin of a blood python (*Python brongersmai*) in North Sumatra, Indonesia, may allow unique identification - like a fingerprint. More testing is needed to confirm the efficacy of biometric imaging as a traceability tool.

3.8 What policy structures are required to establish a good traceability system?

Adequate management, scientific, and enforcement are essential to well-functioning traceability systems. Traceability systems require strong institutional frameworks and a variety of compliance measures to compliment a tagging protocol.

Institutional frameworks can be supported by revenues generated through legal trade (e.g., tag fees). Dedicated funding can be used to support research, management, enforcement, compliance, trade monitoring and conservation education, as well as local communities.

Many reptile skin supply chains are characterized by significant socio-economic differentials between up and downstream components. High-end retailers, manufactures and tanners in the downstream component should develop a sustainable sourcing agenda that seeks to optimise equity and benefits for upstream stakeholders and *in-situ* biodiversity conservation.

Policy approaches that seek to undermine the incentive structures of illegal trade and promote legal trade are useful (Hutton and Webb 2003). For example, policy initiatives designed to support the legal trade in python skins from Malaysia have indirectly undermined illegal trade while simultaneously creating a robust framework for traceability systems. Several simple yet effective traceability systems are now successfully operational– not because they "outsmarted" any illegal traders that were operating, but because there was no longer an incentive to circumvent relevant legislation.

Capacity building and ongoing professional development can enhance the effectiveness and value of a traceability system, particularly in those parts of supply chains where formal education standards are limited. Animal welfare and ecological principles such as maximum sustainable yield require a high level of ongoing professional development.

An adaptive management approach is essential. Traceability systems within the reptile skin trade need to reflect the hyper-diversity and dynamics of supply chains. Development and implementation may require a multi-staged process with frequent reassessment. Wild harvest quotas are likely to fluctuate unpredictably with natural cycles, and real-time monitoring and analysis of population trends often require management adjustments. The capabilities of tools and technologies are rapidly advancing, bringing new opportunities for traceability.

3.9 What are the components of a good traceability system?

3.9.1 Basic elements

Traceability components that require consideration include:

- *Participation of all stakeholders,* particularly the most vulnerable groups in upstream components;
- *Rule of Law.* Impartial legal systems and enforcement authorities immune to corruption;
- *Transparency.* The general public must have access to information and understand the decision making processes within the industry;
- *Responsiveness.* Supporting institutions such as CITES and government authorities need to respond rapidly to stakeholder concerns;
- *Consensus oriented.* An agenda that seeks to mediate between all stakeholders with due respect for the different cultural, social and economic contexts of the trade;
- *Equity and inclusiveness,* ensuring all stakeholders feel empowered by the reptile skin industry and have the ability to maintain or improve their wellbeing;
- *Accountability.* Stakeholders need to be accountable to the public and to one another. This includes government agencies, the private sector and local communities. Honesty and trust are important.

3.9.2 Tailoring traceability to reality

Consumers of reptile skin products mostly live in technologically advanced environments, and assume the high standards of governance they are used to can and should be applied to the fashion industry and its supply chains - an assumption that high end manufacturers are incentivized to comply with. But the supply chain parameters in the reptile skin trade are remarkably diverse. For example, despite similar geographies and harvest histories, issues facing supply chains for saltwater crocodiles (*Crocodylus porosus)* in Australia, Indonesia, and Papua New Guinea are vastly different. Issues involved with monitor lizards are very different to those facing supply chains for pythons. Traceability systems need to be tailored accordingly, rather than assuming that any one approach constitutes a "silver bullet" that can be applied universally. Nuanced planning, as opposed to generic application, is essential. Defining the desired resolution and reconciling expectations with real-world constraints (what is required vs what is achievable) will be the only foundation for traceability that is truly equitable.

This does not imply that bespoke traceability systems (e.g., custom made smartphone applications to record and manage a company's supply chain transactions) are required in all scenarios, or that bespoke solutions cannot feed into universal systems or centralized databases. Simple, standardized tagging technologies can work equally well in all contexts. Indeed, specific traceability technologies will rarely be the limiting factor in the success of a traceability system. It is usually governance structures and the incentives (or disincentives) that traceability systems create that act as limiting factors,

3.9.3 Identification of appropriate tools

Time spent piloting different technologies, in different contexts, may help to minimise teething problems and enable effective optimization. Tag designs, materials and technologies, and how these interact with the different processes in a supply chain (e.g., tanning, grading, transporting) require testing. For example, loop or button-style tags may work well for country to country trade traceability, but cannot withstand some processes within the tanning process. Loop-style tags may be effective for crocodylians, but their tendency to snag during tanning may be catastrophic for less robust skins such as monitor lizards or water snakes.

3.9.4 Data management

Data management systems need to be tailored according to the needs and available resources of the traceability system. The crocodylian skin industry is already well aligned under the CITES traceability system and successfully exploits a centralized data storage system. The issue of data ownership – who has access to and owns the data generated by traceability systems – is an important consideration and will vary depending on the purpose for which the traceability system was implemented. For example, what will the system be used for, by whom, and who pays? Traceability systems implemented by national governments are often used for compliance and to assist CITES non-detriment findings. In this instance, the national authority may keep data. In contrast, industry traceability systems may make some information public (e.g., country of origin or farm location), but keep commercially sensitive information (e.g., business names and relationships between different actors in the supply chain) confidential. To prevent issues arising between stakeholders, data ownership issues should be agreed before traceability systems are implemented.

3.9.5 Real-time information access

Customers of animal-derived luxury goods and the authorities that regulate trade demand a high degree of transparency about the sourcing and production of those goods. Traceability systems that can capture key information from the supply chain, upload information wirelessly to an internet server, and allow real-time access by trade participants, authorities, and the public, is a key advantage of any system. The ability to monitor the movement of goods and analyse their associated metadata (e.g., information useful for CITES non-detriment findings) can also improve enforcement response times and help to identify issues in a timely manner.

Papuan women with crocodiles from the Sepik River in Papua New Guinea. Trade in crocodile skins and other products is a critical source of income for many indigenous people and provides incentives to value and conserve crocodiles and their habitats while maintaining their strong cultural and spiritual identity.

3.9.6 Identity Preservation (IP)

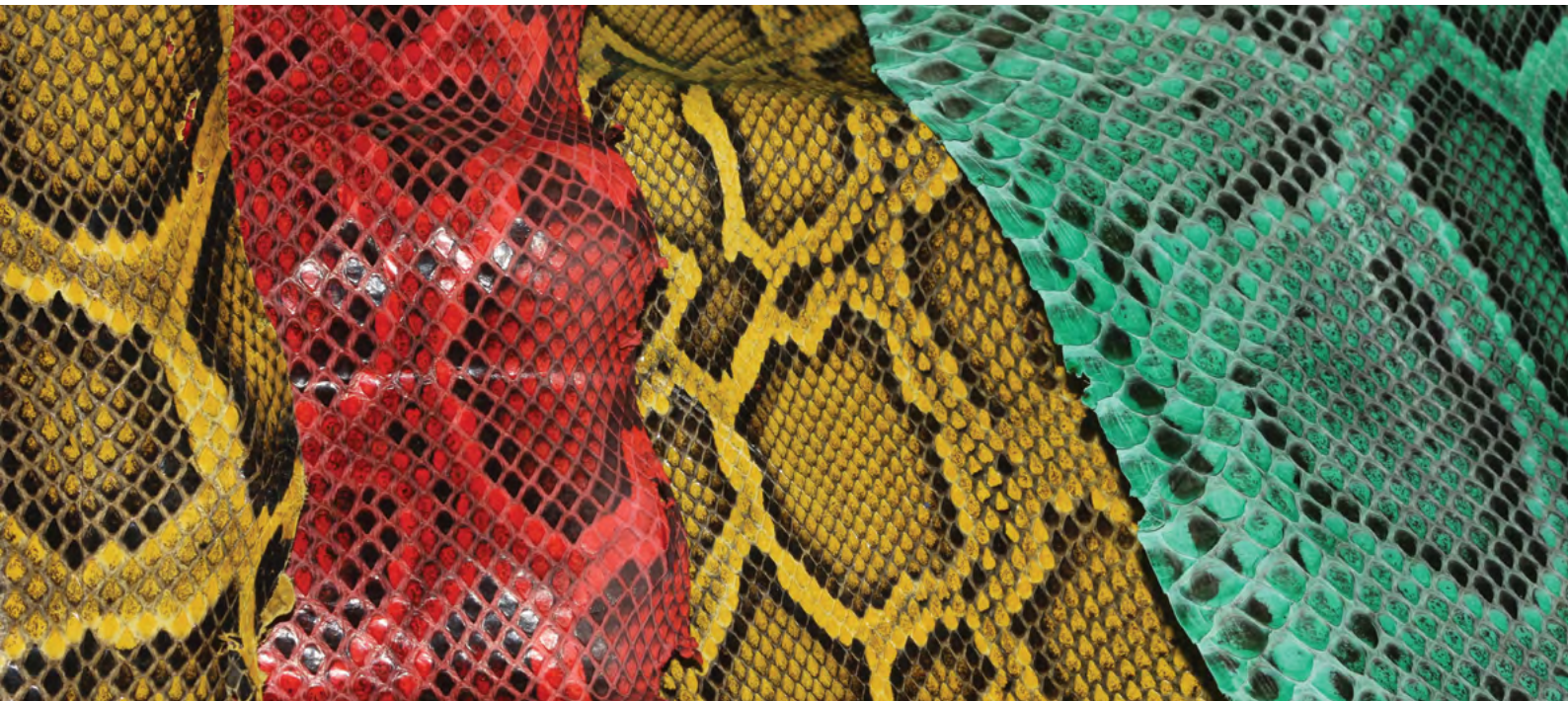
The combined precision, breadth and depth of a traceability system may be measured by the degree of Identity Preservation (IP) - how well a product's identity is maintained through the course of a supply chain. IP may begin at source and can be continued through to end market, but in the reptile skin trade it usually comprises smaller segments of supply chains. In the early stages of a supply chain, identity preservation for reptile skins is straightforward. For example, unique tags can be placed on crocodile skins at the production facility, which allow those skins to be identified as discrete units of known provenance at downstream nodes within the supply chain. However, after skins are cut, or when the tag is removed, hard identity preservation is lost. Soft identify preservation can be maintained by segregating skins of known sources within single facilities, but maintaining identity preservation beyond that point, without an alternative form of tagging or marking for individual skin pieces, can be challenging (but is not impossible with the advent of more versatile and affordable technology).

3.9.7 Dedicated funding

Dedicated funding must be built-in as a core element of any sustainable reptile skin traceability system. If a traceability system is State-run, then funds derived from levies of skin exports or permits can be used to sustain the traceability system. The Louisiana and Papua New Guinea crocodylian ranching programs are successful examples of this approach. Industry-run traceability systems can take a similar approach, whereby levies are taken from companies engaged in trade, based on revenues generated by skins or total skin volumes used. In other cases, individual companies may implement and fund their own traceability systems, to meet goals that go beyond those needed to establish legal trade in compliance with CITES. Where the commercial advantage to establishing their own company specific traceability systems is obvious, dedicated funding systems are less crucial – such systems are seen to provide a competitive edge over the competition and continue to be funded as a commercial imperative. In universal systems – often operated by national governments or governing bodies such as CITES – a robust system of dedicated funding is critical to the long-term success of any traceability system.

3.9.8 Positive incentives for implementation

The success of traceability systems depends on the determination of the Parties implementing them, and the degree to which compliance by stakeholders in the supply chain can be fostered. It is therefore important to consider measures that help to ensure the uptake of traceability systems by industry, without imposing a significant burden on the trade. For example, positive incentives for small-scale actors – who often bear a disproportionate portion of the responsibility for ensuring traceability systems are successful – can help to achieve this. Such incentives can take the form of positive discrimination or incentives for those properly implementing traceability systems for reptile skins. For hunters or processing facilities, this might include higher compensation for traceable skins, or tradable credits to support legal capture and trade within allocated quotas. Buyers – especially those removed from the originating source – can purchase credits to support sustainable reptile trade. Ideally, this would result in the ability to issue a marketing claim, for example, in the form of a logo or recognized statement (such as "Supporting sustainable reptile trade").



3.10 Sophisticated or simple systems?

The reptile skin trade is plagued by misinformation, with perception being as important as reality. Both skin buyers (e.g., brands) and their customers (e.g., the public) require assurances about the provenance of the raw materials within their product and even the conditions under which they were produced. In today's world, confidence in such assurances can be improved via the use of sophisticated technologies, which confer the perception of legitimacy and credibility for consumers (Jones *et al.* 2005). However, in reality, the functional benefits of such systems may be negligible.

For conservationists, the fear is that sophisticated technologies may not be accessible by some actors in the supply chain (e.g., rural or indigenous communities) and may thus undermine livelihoods and conservation outcomes linked to sustainable use (Opara and Mazaud 2001). Nevertheless, the perception of control can be generated by sophisticated traceability technologies, and their role in ameliorating concerns should not be underestimated. Considerations for comparison of simple vs sophisticated technologies are provided in Table 4.

Table 4

Comparison of simple versus sophisticated technologies for traceability in reptile skins

Sophisticated technology	Simple technology
Positives	
Can carry large amounts of information (metadata)	Lower cost
Handling can be easier with some technologies	Ongoing issues are likely to be lower
Often has improved counterfeiting and tamper free ability	More likely to be implementable by all user types
Negatives	
Higher cost	
May require ongoing troubleshooting with users	Often carries less information without another data basing system in place
Push-back from users if implementation is difficult or disrupts workflows	May be inadequate for complex supply chains with several nodes
Potential to exclude some user groups who are unable to implement	

3.11 Private or public traceability systems

Private or public interests can implement traceability systems. Private traceability systems typically have the goal of bringing traceability to only part of the trade (typically their own supply chain). In contrast, public interests such as trade associations, NGOs, local or national governments, or international bodies (e.g., CITES) may implement public or universal traceability systems, which typically capture the entire trade in the species or wildlife product of interest. Both systems have their advantages and disadvantages, which are summarised in Table 5.

Table 5
Comparison of private versus public traceability systems for reptile skins.

Private traceability systems	Public traceability systems
Positives	
Supply chain actors are typically already aligned on the need for traceability	Can result in lower costs per individual supply chain actor participating
Smaller scope of application can result in more rapid uptake	Increased confidence in the traceability system when implemented by third-party of trusted actors (e.g., regulators)
Imposes a lower absolute cost than public systems	Can be better linked to other important data collected (e.g., biological data for non-detriment findings)
May create a commercial advantage for private companies with traceability vs those that do not	Can typically extend further upstream within the supply chain because all specimens/skins are tagged and not just those destined for individual companies
	More likely to help address systemic or industry wide supply chain issues
	Less likely to discriminate poor or rural communities engaged in trade who otherwise could not compete with companies implementing private systems
Negatives	
Less trust in the overall system by stakeholders and consumers	Require greater resources to implement
Traceability is limited in depth due to the need to segregate skins based on quality/demand with actors/supply chain nodes that are not vertically integrated (i.e., independent) and an inability to grade skins from visual inspection of live animals	Can be challenging to ensure alignment on the specifics of the systems with all actors
If issues are systemic within the industry, traceability may mitigate risk within the private supply chain but do little to improve confidence in the industry more broadly	Costs of the traceability system may be borne by the state, local regulator, etc, rather than by the industry (although this can be dealt with via levies)
Potential to exclude some user groups who are unable to implement	

Conclusion and recommendations

The credibility of the reptile skin trade is increasingly being questioned in the public arena. This is largely a reflection of changing societal attitudes towards animal-based industries in general. There has been a failure of upstream stakeholders to adapt and reform their supply chains to address these changes, in part because they are unaware of events taking place at the far end of the supply chain, and because the perceptions of many luxury consumers do not make their way to many producer countries. Addressing this challenge requires investment in the essential soft assets that underpin the integrity of the industry - knowledge, education and outreach. With the benefit of hindsight, it is astounding that the direct and unequivocal link between purchasing many reptile skin products, and improving ecosystem services, wildlife conservation, and poverty alleviation, has failed to be effectively promoted in the public domain. Instead an atmosphere of indifference has prevailed. The intricacies of events at the consumer level are rarely explained at the producer level, but are felt when prices change and new conditions for purchase come into play. A lack of clarity and communication along supply chains has been exploited by anti-trade activists to undermine public sentiment towards exotic leathers and drive down market share.

To reverse this trend, the exotic skin industry has tended to narrow and consolidate its supply chains within technologically advanced assets. Vertical and horizontal integration has prevailed at the expense of more democratic, smaller-scale systems. Localized resource sovereignty has been lost. A shift towards closed-cycle production and a failure to embrace the nuances of wild harvests (e.g., variable skin quality and size) has adversely affected biodiversity and sustainability credentials, and has adversely affected local livelihoods. Reactionary policies and apologetic defence has dominated industry decision-making, rather than capitalization on unique pro-rural and pro-planet points of difference. In a landscape increasingly driven by corporate responsibility, the very justification for the industry has been undermined. There is a real danger of failing to comply with global biodiversity conventions and sustainable development goals. To stem the tide, the exotic leather industry needs to create culturally relevant content as part of its moral obligation to social and environmental responsibility, and adaptation to global challenges.

Traceability can assist with this. Provenance may not be essential for core business functions, but it is critical for aesthetics and brand imaging. Transparency and improved information transfer are essential. Sourcing and supply chains need to conform to recognisable and acceptable standards, and this must be done in a transparent and sincere manner. In many cases this exists, but the industry has largely failed to bring this information to the forefront. In this regard, more sophisticated traceability systems may be inevitable, and industry must not shy away from using those systems to tell its unique story.

Globalization of the reptile skin trade is a relatively new phenomenon, and many upstream components remain comparatively underdeveloped and unaware of the dynamic changes impacting the industry. The erudite fashion industry has often touted high-tech traceability systems as a potential remedial measure, with an increasing bias for fanciful technology (Amed *et al.* 2019). In reality, hi-tech systems are often more problematic, expensive, and seldom confer meaningful advantages in a real-world context. Nevertheless, it remains prudent to be mindful of the intangible value technology confers within the global agri-business arena. Provenance based on the latest and most advanced technologies is synonymous with legitimacy and credibility, and it is often rewarded accordingly by consumers and regulators alike, particularly in animal-based industries.

As a central figure in the exotic skin trade, the CSG has the opportunity to play a pivotal role in traceability discussions, aimed at finding systems that further help conservation. It can shed light on the broader issues of context and relevance within supply chains, and help build consensus for universal approaches. It can assist the industry to develop and improve a traceability system that adheres to the best available global standards and ensure benefits outweigh costs.

The CSG has worked consistently to unite all stakeholders so that conservation and livelihood benefits result. If a traceability system is deemed necessary by industry, and industry stakeholders are willing to synergise with CSG aims and objectives, then these remedial measures may not require much effort. The two entities are already well aligned on a functional level, and specific actions may be limited to:

A series of workshops to educate key stakeholders;

Investigation of whether a universal traceability system,
to augment the existing CITES process, can be developed;

Investigating optimal precision, depth and breadth of traceability systems for crocodylians
in a way that works for industry, conservation, and local people.
This may include establishment of a traceability working group, or direct liaison
with interested industry representatives willing to improve existing traceability systems;

Investigation of new technologies that may be able to provide real-time, open access,
information on public interest issues, such as sustainability and animal welfare.
Novel tagging technologies, smart phone applications, and publicly accessible online
dashboards or databases are all possible options.

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Traceability in Crocodylian Conservation and Management

IUCN SSC Crocodile Specialist Group

IUCN SSC Species Survival Commission Crocodile Specialist Group