Assessment of Python Breeding Farms Supplying the International High-end Leather Industry

Daniel J. D. Natusch and Jessica A. Lyons

IUCN/SSC Boa and Python Specialist Group

Occasional Paper of the IUCN Species Survival Commission No. 50

A REPORT UNDER THE 'PYTHON CONSERVATION PARTNERSHIP' PROGRAMME OF RESEARCH

Assessment of Python Breeding Farms Supplying the International High-end Leather Industry

Species Survival Commission

Boa & Python Specialist Group

KERING

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Cover photo: Staff feed and clean pythons at a farm in An Giang Province, Viet Nam, by Daniel J. D. Natusch.

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ABBREVIATIONS, ACRONYMS AND DEFINITIONS

CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
g	Gram
FPD	Forest Protection Department (Viet Nam)
IUCN	International Union for Conservation of Nature
kg	Kilogram
m	Metre
MA	CITES Management Authority
MARD	Ministry of Agriculture and Rural Development (Viet Nam)
PFPD	Provincial Forest Protection Department (Viet Nam)
SA	CITES Scientific Authority
SSC	IUCN Species Survival Commission
SVL	Snout-vent length
TRAFFIC	The Wildlife Trade Monitoring Network
USD	United States Dollar
VND	Vietnamese Dong
WCS	Wildlife Conservation Society
Captive breeding	Legally acquired parent stock exchange gametes (egg and sperm) in a controlled environment, without reliance on wild populations. The parents must also be maintained without the introduction of specimens from the wild and must have produced offspring of at least second generation (F2) in a controlled environment or be managed in a manner that has been demonstrated to be capable of doing so
Closed-cycle python farm	The production of pythons within a controlled environment independent from introduction of specimens from the wild
Breeding stock	The ensemble of the animals used for reproduction in a captive-breeding operation. Under CITES the breeding stock must be established in a manner that is not detrimental to the survival of the species in the wild and in accordance with the provisions of CITES and relevant national laws
Farming	The process of raising wildlife within a controlled environment. In this report "farming" is synonymous with "captive breeding".
Hatchling	A newly or recently hatched snake
Raising stock	Pythons being raised for slaughter for skins
Ranching	Rearing in a controlled environment of animals taken as eggs or juveniles from the wild
Satellite farm	A small farm contracted to raise stock on behalf of a larger farm
Self sustaining farm	A farm whereby all python food is raised on-site and all live pythons remain on-site for the duration of their life

For CITES definitions see the CITES Glossary: http://www.cites.org/eng/resources/terms/glossary.php

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[1] The Python Conservation Partnership is a collaboration between Kering, the International Trade Centre (ITC) and the Boa and Python Specialist Group of the International Union for Conservation of Nature (IUCN SSC Boa & Python Specialist Group). See Executive Summary for greater detail.

EXECUTIVE SUMMARY

The "Assessment of Python Breeding Farms Supplying the International High-end Leather Industry" is the first report delivered under the Python Conservation Partnership. A collaboration between Kering, the International Trade Centre (ITC) and the Boa and Python Specialist Group of the International Union for Conservation of Nature, the Python Conservation Partnership was established in November 2013 with the aim of contributing to the improved sustainability of the python skin trade and to help facilitate industry-wide change. The Partnership's program of research is focusing on research and recommendations around improving sustainability, transparency, animal welfare and local livelihoods for the python skin trade.

The wild harvest of two species of Asian pythons (the Burmese Python *Python molurus bivittatus* and Reticulated Python *P. reticulatus*) has been ongoing for more than eight decades, and concerns have been raised about the conservation impacts of trade on wild populations and the potential issues related to illegal trade and animal welfare. In response, the high-end leather industry has expressed an interest in captive breeding production systems to ensure that international demand for python skins can be met in a way that is globally acceptable in terms of sustainability and animal welfare standards. However, conservationists and wildlife managers have queried the biological and economic feasibility of breeding pythons for skins, casting doubts about the applicability of this system.

Under the Python Conservation Partnership, the IUCN/SSC Boa and Python Specialist Group (BPSG) aimed to screen and assess facilities presently farming *P. m. bivittatus* and *P. reticulatus* for their skins within closed-cycle breeding facilities. Information within this resulting report was obtained by consulting national CITES Management Authorities, farming associations, python keepers and breeders, python farmers, fashion houses and tanneries, and relevant scientific experts. Data gathered were augmented by visits to 39 small to large python captive breeding farms in China, Thailand and Viet Nam that are currently producing pythons for the global skin trade.

The present report provides information on how pythons are farmed in Asia, farming's impact on local livelihoods and the relative contribution of captive python skins to the total trade. In addition, recommendations are offered on the prospects of using both a ranching approach to supply python skins for trade and a closed-cycle captive breeding approach to meet current and future demands for python skins. These recommendations have been developed with the aim of providing guidance for the industry and conservation policy on future monitoring of the trade in captive-bred python skins.

Commercial captive breeding farms for python skins are currently located in China, Thailand and Viet Nam. Wild harvest of *P. reticulatus* still takes place in Indonesia and Malaysia, but in no other countries. *P. m. bivittatus* are not legally harvested from the wild anywhere within their range. Records from the CITES Trade Database indicate that, between 2005 and 2011, 99% of *P. m. bivittatus* and 24% of *P. reticulatus* skins originated from captive-bred stock. All exports of skins using a CITES source code "C" (meaning that the specimens are bred in captivity) originating from Cambodia, Indonesia, Lao People's Democratic Republic (PDR) and Malaysia should be treated with caution. In the case of Indonesia and Malaysia, national CITES authorities and trade associations deny that commercial captive breeding of pythons occurs in their country, while claims of captive breeding in Lao PDR remain unproven. Cambodia reportedly exported skins with source code C over a decade ago, in 2000, but there are no recent records of registered python farms in the country.

Two broad closed-cycle captive breeding systems for pythons are currently used: (1) self-contained farming in Thailand, whereby all python food is raised on-site and live pythons remain on-site for the duration of their life; and (2) satellite farming in China and Viet Nam, whereby a small number of large farms produce many hatchlings that are given or sold to a large number of small "satellite farms" for raising. After approximately one-year satellite farms then sell adult pythons back to the large farms for slaughter and/or export.

Several uncertainties in production figures for farmed pythons remain. For example, despite large exports of python skins from Lao PDR with a CITES source code C, this study found no evidence that python farming is currently taking place. Another issue is that the locations, sizes and registration status of many satellite farms in Viet Nam remain unknown, making it difficult to verify Vietnamese annual production figures for captive-bred pythons. As a result, it is important that all farms in Viet Nam be registered and a verifiable and regularly validated reporting system be implemented in order for the fashion industry to commit to Viet Nam as a source country for python skins.

Key results of this report include that farming pythons may assist the conservation of the two species considered in this study only if it: (1) reduces unsustainable wild harvests, and (2) does not encourage illegal laundering of wild-caught pythons through farms. However, commercial production through closed-cycle captive breeding, completely disassociated from the wild, may create commercial incentives favouring extinction (and thus increase the value of captive stock) rather than favouring recovery of wild populations that could potentially compete in the market place with captive-bred stock. Thus, python farming may undermine conservation through sustainable use objectives because it provides little or no incentive for protection of wild pythons and their habitats.

The report also shows that python farming can provide a source of income for many people, and that satellite farming contributes to income generation for a larger number of small-scale farmers than self-contained farms. However, closed-cycle captive breeding of pythons in general generate benefits for a smaller number of people and communities than other python production systems (e.g., wild harvests), provided that the latter are sustainable.

Recommendations

General trade management:

(1) Python skin exports using a CITES source code "C" from countries other than China, Thailand and Viet Nam (e.g., Cambodia, Indonesia, Laos PDR and Malaysia) should be treated with caution until improved data on farms, management and monitoring systems are in place to verify captive production capacities.

(2) To facilitate control and monitoring by national and local authorities, python farmers breeding pythons in China, Thailand and Viet Nam should be encouraged to keep eggshells as evidence demonstrating their ability to breed. These can be collected and destroyed by enforcement officials each year to prevent re-use. Python farms in Lao PDR, and any future breeding operations in Cambodia, Indonesia and Malaysia, should be asked by national authorities to do the same.

(3) It is important that python farming is part of a holistic approach to sustainable trade, which may include management and sourcing from wild harvest systems that promote *in situ* species conservation.

Captive breeding in Viet Nam:

(4) The Vietnamese CITES Management Authority and Provincial Forest Protection Departments should work together to provide verifiable data relating to the number of pythons capable of being legally, sustainably and humanely bred in captivity in Viet Nam to promote transparency and trust within international markets.

(5) Provincial Forest Protection Departments should endeavour to conduct inventories and register all households and satellite farms raising pythons for the skin trade.

(6) The Vietnamese CITES Management Authority should consider making it mandatory for python skin export companies and large farms to provide them with records of all satellite farms supplying them with pythons, and the number of pythons sourced from each, thus enhancing monitoring and traceability.

(7) When available, these data should be routinely analysed by the Vietnamese CITES Management Authority and reported to the CITES Secretariat in order to provide further verification of their captive-breeding capacity.

Captive breeding in China and Thailand

(8) There is higher transparency in the Chinese and Thai python farming systems than in Viet Nam because there are only single companies producing pythons for the skin trade. Strict controls should be maintained in China and Thailand if more/larger farms become established in these countries.

Future research:

(9) Field surveys should be considered in Viet Nam, and neighbouring countries (Cambodia, China, Lao PDR, Thailand), to determine if wild collection of pythons is still occurring, and if so, at what scale and impact to local populations.

(10) Southeast Asian CITES Management Authorities, together with industry and other relevant stakeholders, should research the use of techniques (e.g., stable isotopes) to unequivocally differentiate between the skins of captive-bred and wild-caught pythons.

Farming improvements:

(11) China, Thailand and Viet Nam should consider the recommendations from the study on humane killing of reptiles and employ appropriate slaughter methods that ensure brain destruction.

(12) Industry in Europe and python range States should consider promoting a certification system for farms, linked to a central administration point (e.g., a website), that provides stakeholders with confidence that they are sourcing python skins from verified sustainable, legal and humane sources.

1.0. INTRODUCTION

1.1. Background

Human beings have farmed animals for millennia, resulting in the domestication of many species still commonly found in captivity today. More recently, however, there has been an increase in the production of wild animals to supply growing market demands for meat, skins, pets and medicines (WCS, 2008; Brooks et al., 2010; Noguiera and Nogueira-Filho, 2011). Wildlife farming provides income for many people globally and has been promoted in regions where the environment is less suitable for more traditional farming practices and species. From an economic perspective, wildlife farming provides greater stability, control and predictability than harvesting animals from the wild, and can enhance uniformity in some products (e.g., reptile skins). Wildlife farming has also been promoted to aid in wild species conservation because of a supposed reduction in the demand for wild-caught individuals (Jori, 1995; Noguiera and Nogueira-Filho, 2011). However, concern has been raised within the conservation community that, in the absence of strong regulatory measures, wildlife farming may result in increased demand that must be met by sustained wild collection, and farms may act as loopholes through which illegally collected wildlife can be traded without detection (Bulte and Damania, 2005; Lyons and Natusch, 2011). Most importantly, because many of the wild species currently being farmed commercially are relatively poorly known biologically (e.g., sizes at maturation, growth rates), it is difficult to monitor and assess the activities of farmers and determine whether such farms are indeed closed-cycle production systems.

Asia's large pythons, the Reticulated Python (*Python reticulatus*[2]) and the Burmese Python (*Python molurus bivittatus*[1]), have been harvested from the wild for their skins for almost eight decades (Groombridge and Luxmoore, 1991; Webb et al., 2000; Kasterine et al., 2012). Both species are widely distributed within Asia and are relatively common within their range (Groombridge and Luxmoore, 1991; Shine et al., 1999). They are among the world's largest snakes, and their generalist ecological attributes (dietary and habitat requirements) and life history traits (high reproductive outputs) have helped sustain their harvest (Shine et al., 1999; Auliya, 2006; Kasterine et al., 2012). Python skins are traded primarily to meet demands from the fashion industry to make luxury leather products, but also for traditional Chinese musical instruments (*Erhu*; Kasterine et al., 2012). Within the last two decades, growing demand for skins from the fashion industry has seen the scale of trade in python skins increase significantly, and over the last decade nearly half a million skins of *P. m. bivittatus* and *P. reticulatus* have been exported from Asian countries each year (Auliya 2011; Caldwell, 2011; Kasterine, et al. 2012).

To meet this growing demand, in a way that safeguards wild stocks, the international fashion industry has shown interest in sourcing python skins from captive breeding facilities. Several countries in Asia breed pythons for skins, but little information is available about this industry. It is the aim of the present report to examine the role of closed-cycle python production systems for *P. reticulatus* and *P. m. bivittatus* supplying the high-end leather industry. Specifically, the report summarises the activities of captive breeding farms and provides information about their location, contribution to the global trade in python skins, and contribution to the economic prospects of local people. Recommendations are provided with the aim of guiding industry and conservation policy on future monitoring of the trade in captive-bred python skins and the prospects for captive breeding operations meeting international demand for python skins (specific Terms of Reference are provided in Annex I).

[2]The Latin names used in the present report were chosen to reflect current usage by CITES. However, it should be noted that several authors regard *P. m. bivittatus* to be its own species (*P. bivittatus*; Jacobs et al. 2009), while others place *P. reticulatus* within its own genus (*Broghammerus reticulatus*; Rawlings et al. 2008).

1.2. Summary of methodology

1.2.1. CITES trade database

Trade data for *P. m. bivittatus* and *P. reticulatus* were obtained from the UNEP-WCMC CITES Trade Database (2014) for the years 2000 to 2011 (data from 2012 to 2014 are not yet available). The data included information on country of export, country of import, and the number of skins reported to be imported for commercial purposes from wild and captive-bred sources, allowing comparison between the two sources. Trade data for countries exporting captive-bred skins were also gathered directly from CITES Management Authorities. All data were compared to earlier trade reviews to assess consistency (Auliya, 2011; Caldwell, 2011; Kasterine et al., 2012).

1.2.2. Literature reviews, interviews and expert opinions

Data relating to the regulation and dynamics of python farming were gathered through searches of relevant reports, as well as interviews with source country CITES Management Authorities, snake breeders and professional herpetologists.

1.2.3. Targeted site visits

Surveys of 39 python farms and associated industries (tanneries) were conducted during six visits to the Vietnamese provinces of An Giang, Can Tho, Ca Mau and Ho Chi Minh City, the Thai province of Uttaradit and Hainan Island, China, between May 2012 and October 2013. These countries were chosen because they are known from CITES export data to be the only producers of captive-bred python skins. Within all countries surveyed, we visited farms from the provinces where the majority of python farming occurs, and aimed for a representative sample in terms of farm size and output. Semi-structured interviews were conducted with large-scale python farmers, satellite/household python farmers, tanners and exporters. Questions focused on methods of python breeding, production systems, slaughtering, and prices. Several of the major farms visited as part of the present study are listed in Annex II.

1.2.4. Survey representativeness

Viet Nam is the world's largest exporter of captive-bred python skins (CITES Trade Database 2014). Viet Nam has the largest number of farms and exporters, and breeding of pythons for skins has been taking place for more than two decades. By contrast, in China and Thailand there are only single companies producing pythons for skins. Because of this, the present report focuses heavily on python farming in Viet Nam, which is reflected within the analyses and conclusions.

1.2.5. A note on the data source

Data gathered from python farmers themselves is perhaps the most important information source for this study. However, given the rumours of potentially illicit activity within python farming systems in Asia it is important to provide justification for their validity. Their use herein is justified because the information, figures and values provided during interviews were not contradictory when crosschecked. Data provided also exhibited enough variance to exclude prearranged figures among the farmers. Given the timing of the six visits and geographic spread of farms inspected the authors are confident that data gathered are independent and useful for the purpose of this study.

1.3. The role of CITES

The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) came into force on 1 July 1975 with the aim of preventing overexploitation of species by trade. Those species that are threatened with extinction, and may be affected by trade, are listed within CITES Appendix I. Appendix II includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival. Several reptilian groups (boas pythons, monitor lizards, crocodilians) are included within the CITES appendices because of high levels of international trade, and the difficulties involved in customs officers identifying the skins and other products of different species. Today, all but one species of python are listed in CITES Appendix II[3], which requires countries that are signatory to CITES (referred to as Parties) ensure that any trade in these species will not be detrimental to wild populations (under Article IV of the CITES Convention), is legal, and traceable through a system of permits and certificates.

Because they are both listed within CITES Appendix II, International trade in *P. reticulatus* and *P. m. bivittatus* requires a CITES export permit issued by the exporting Party. In many cases, a corresponding CITES import permit is also required, although this is not mandatory under CITES for species in Appendix II. Each Party must designate one or more Management Authorities responsible for issuing permits. Parties are required to report all imports and (re-) exports of CITES listed species to the CITES Secretariat, and this information is made available to the public online through the CITES Trade Database, which is operated by the United Nations Environment Programme-World Conservation Monitoring Centre (UNEP-WCMC). Parties are also required to identify a CITES Scientific Authority, who are charged with ensuring that each trade transaction for an Appendix II species is not detrimental to the survival of the species in the wild.

1.4. The scale of the python skin trade and its source

Pythons used for the international skin trade are supplied through both intensive and extensive management systems. Intensive management systems use a high degree of human intervention and husbandry under controlled conditions, while extensive management systems depend upon the continued harvest of individuals from the wild with less emphasis on captive management (Wijnstekers, 2003; Thomson, 2008). The definitions for each production system of *P. reticulatus* and *P. m. bivittatus* are presented in Table 1.

Table 1. Production systems used for sourcing *P. reticulatus* and *P. m. bivittatus*.

Production system	Production type	Definition
Closed-cycle captive breeding (CITES source code "C")	Intensive	Adults exchange gametes (egg and sperm) in a controlled environment. There is no reliance on, or input from, wild populations. The CITES definition of 'captive-bred' (CITES Resolution Conf. 10.16 (Rev.) on *Specimens of animal species bred in captivity*) states that specimens are born or otherwise produced in a controlled environment if: • Parents were in a controlled environment at the time of development of the offspring; • Breeding stock was established legally and in a manner approved by CITES. The breeding stock must also be maintained without the introduction of specimens from the wild and must have produced offspring of at least second generation (F2) in a controlled environment or be managed in a manner that has been demonstrated to be capable of doing so.
Ranching (CITES source code "R")	Semi-Intensive	Removal of eggs or juveniles from the wild to be raised in a controlled environment. Ranching may involve supplementary feeding, habitat manipulation, and veterinary treatment. Animals are raised to a required weight and/or size, and then exploited for use.
Wild harvest (CITES source code "W")	Extensive	Regular and programmed removal of individuals from the wild for either live export, or subsequent processing (without intensive management) to supply a commodity (e.g., skins).

[3] The only python species not included within CITES Appendix II is *Python molurus molurus*, which is currently included within Appendix I.

Gross annual direct imports of *P. reticulatus* skins from all sources are far greater than that of *P. m. bivittatus* (Fig. 1). However, the sources, in terms of exporting country and production system, vary greatly between the two species. Imports of *P. m. bivittatus* skins sourced from wild animals have ceased almost entirely, mainly due to concerns about declining populations and the increased production potential of captive propagation. The majority of *P. m. bivittatus* skins are now sourced from animals produced in captivity in Thailand and Viet Nam (Fig. 2). Conversely, skins of *P. reticulatus* are still largely taken from individuals sourced from the wild in Indonesia and Malaysia; however, they are increasingly being exported from neighbouring Viet Nam and Lao PDR as captive-bred (Fig. 2). There are very few python skins exported that are reportedly sourced from ranched animals (for further details of trade trends see Groombridge and Luxmoore, 1991; Auliya, 2011; Caldwell, 2011; Kasterine et al., 2012).

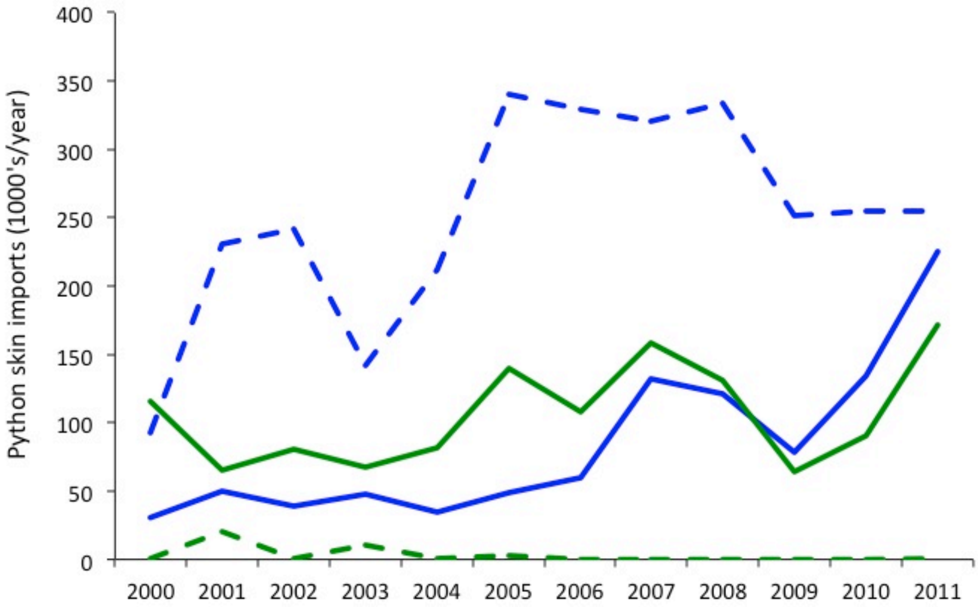

Fig. 1. Gross annual direct imports of *P. reticulatus* (blue) and *P. m. bivittatus* (green) skins reported to be from captive-bred (solid lines) and wild (dashed lines) sources between the years 2000 and 2011 (UNEP-WCMC CITES Trade Database, 2014). Note: Imports of skins sourced from ranched stocks are minimal and have been excluded here; see Section 6.3.).

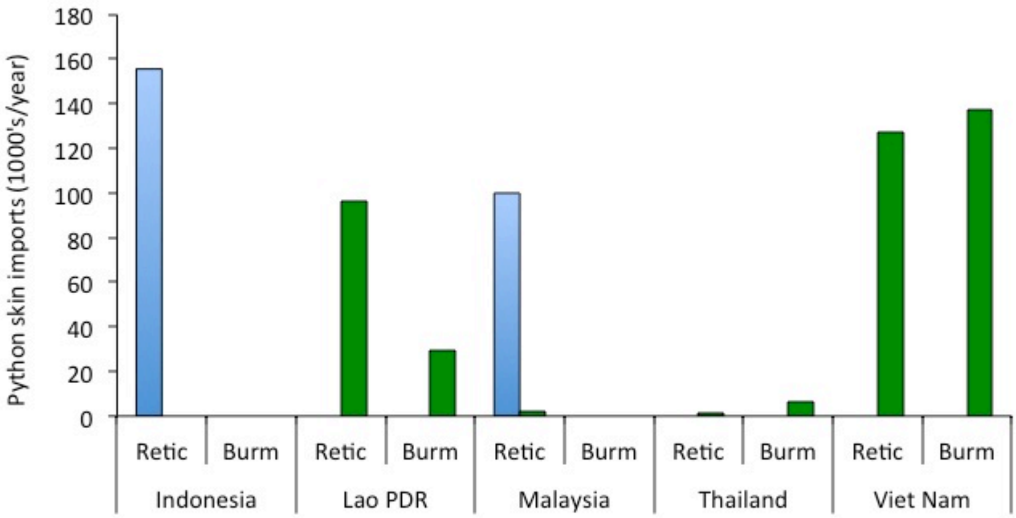

Fig. 2. Numbers of *P. reticulatus* (Retic) and *P. m. bivittatus* (Burm) imported using wild (blue columns) and captive-bred (green columns) source codes from key python producing range States in the year 2011 (UNEP-WCMC CITES Trade Database, 2014).

2.0. WHERE ARE PYTHON FARMS LOCATED?

This section summarises where python farms are currently located and provides context about the levels and source of python skins originating from Asia (Table 2).

Table 2. Summary of Range States, status and trade for *P. m. bivittatus* and *P. reticulatus* in Asia.

Country	Species range	Wild status	Wild harvest	Captive breeding
Cambodia	*P. reticulatus* and *P. m. bivittatus*	Unknown for both species	Unknown (illegal)	Limited exports of *P. m. bivittatus* with a captive-bred source code
China	*P. m. bivittatus* only	Depleted	Unknown (illegal)	Captive breeding of *P. m. bivittatus* for domestic use
Indonesia	*P. reticulatus* and *P. m. bivittatus*	Stable for *P. reticulatus*; unknown for *P. m. bivittatus*	Yes for *P. reticulatus* (legally); unknown for *P. m. bivittatus*	Limited captive breeding of *P. m. bivittatus* for pets
Lao PDR	*P. reticulatus* and *P. m. bivittatus*	Unknown for both species	Unknown (illegal)	Exports of skins from captive-bred individuals of both species
Malaysia	*P. reticulatus* only	Stable	Yes (legally)	Limited exports of skins from captive-bred individuals of both species
Thailand	*P. reticulatus* and *P. m. bivittatus*	Stable for both species	Unknown (illegal)	Exports of skins from captive-bred individuals of both species
Viet Nam	*P. reticulatus* and *P. m. bivittatus*	Both species depleted	Unknown (illegal)	Exports of skins from captive-bred individuals of both species

All information on the status and trade of *P. reticulatus* and *P. m. bivittatus* is taken from the IUCN Red List (2014), the UNEP-WCMC CITES Trade Database (2014), the Vietnamese Red Data Book – Part 1 – Animals (2007) and Kasterine et al., (2012).

2.1. Cambodia

In the year 2000, Cambodia reported exporting 2,000 *P. m. bivittatus* skins under a captive-bred CITES source code (CITES Trade Database, 2014). Python farmers in both Thailand and Viet Nam stated that there are no python farms in Cambodia; however, the Cambodian CITES Management Authority was unable to confirm or refute this.

2.2. China

There is currently a single company commercially breeding pythons in China: Dosho Python, located in Hainan province. The company specialises in breeding *P. m. bivittatus* and currently has a stock of 70,000 individuals. Dosho operates several large facilities with a total breeding stock of 4,000 mature pythons. In 2013, the farm produced 45,000 hatchlings. These are distributed among 640 smaller farms (still part of Dosho Python) on Hainan Island that are contracted to raise the young snakes. When grown, the smaller farms are paid for raising the pythons based on the mass of each individual. Pythons are reared for sale into the Chinese leather market and for the Chinese Musical Instrument (*Erhu*) market. All transactions made by the farm have to be approved by the State Forestry Administration, which also monitors and certifies the facility and governs the use of a tagging system for the regulation of trade. Dosho Python Company has placed considerable emphasis on research and development. Researchers from Hainan University have established the Hainan Python Institute, which conducts research on the influence of management practices on the physiology of pythons with the aid of Dosho.

2.3. Indonesia

P. m. bivittatus are fully protected in Indonesia and cannot be harvested from the wild. *P. reticulatus* are not protected and Indonesia presently has an annual harvest quota of 157,500 individuals, the majority of which are exported as skins. Despite this, Indonesia still has a healthy wild population of this species. Information provided by the Indonesian CITES Management Authority states that there are no farms in Indonesia commercially breeding pythons for skins. The President of the Indonesian Reptile and Amphibian Trade Association (IRATA) also confirmed this, and stated that although farming pythons for skins in Indonesia may be technically feasible, it was found not to be economically viable (G. Saputra, in litt, 2012).

2.4. Lao PDR

There is reportedly a single python farm in Lao PDR trading under the name Vannaseng Trading Company Ltd., located in Borikhamxay province. Prearranged visits by one of the authors and a team from the International Trade Centre and TRAFFIC Southeast Asia in April 2012 did not result in a visit to this farm. Despite the visit being prearranged, upon arrival both the farm owner and the Laotian CITES Management Authority were unable to facilitate access to the farm. Furthermore, discrepancies regarding the numbers and species of python being bred by this farm were highlighted during the CITES Asian Snake Trade Workshop in Guangzhou, China, in April 2011. For example, in 2011, Germany, Italy, Romania, and Spain reported importing 72,176 *P. reticulatus* skins originating as captive-bred from Lao PDR (many of these skins were re-exported from the Malaysian State of Sabah; Natusch, unpubl. data). This large number of skins appears to be greater than the expected output of a standard-large python farm and further investigation of this facility is necessary.

2.5. Malaysia

Only *P. reticulatus* occur naturally in Malaysia. They are harvested in large numbers from the wild and a quota is set at 162,000 individuals per year, the majority of which are exported as skins Despite this, wild populations of this species remain healthy. According to the Malaysian CITES Management Authority there are no commercial python breeding farms in Malaysia. Despite this, there have been numerous small shipments of *P. m. bivittatus* with Malaysian captive-bred origin permits. In addition, in 2010 Malaysia reported the direct export of 16,500 skins of captive-bred *P. reticulatus* (CITES Trade Database, 2014). Because of these discrepancies, all exports of skins from Malaysia with a captive-bred source code require verification, where possible. According to the Wildlife Department in the east Malaysian state of Sabah, a ranching program for *P. reticulatus* has been in operation since 2009 (see Section 6.3. for more detail).

2.6. Thailand

It is illegal to harvest both *P. reticulatus* and *P. m. bivittatus* from the wild under the Thai Wild Animal Reservation and Protection Act B.E. 2535 (1992). However, captive breeding of these species is permitted, and there is currently a single farm trading under the name Si Satchanalai Python Farm. The farm is located in Uttaradit province and breeds *P. reticulatus* and *P. m. bivittatus* for skin exports. Parent stocks were legally acquired from Thailand under the guidance of the Thai CITES Management Authority, and small numbers (ca. 5,000 per year) of pythons have been exported from this self-contained farm since 2000.

2.7. Viet Nam

Viet Nam is the world's largest exporter of captive-bred python skins (CITES Trade Database, 2014). Wild harvest of *P. m. bivittatus* and *P. reticulatus* was banned in 1998, and the species are now listed within Group IIB of endangered, rare and precious forest fauna, which are prohibited from exploitation or use for commercial purposes (Government Decree No. 32/2006/ND-CP of 30 March 2006).

According to the Vietnamese Red Data Book Part I – Animals (2007), Vietnamese populations of *P. reticulatus* and *P. m. bivittatus* are categorised as Critically Endangered. Their populations have decreased due to habitat degradation, hunting and illegal trade. However, these two species have been successfully bred in captivity since the early 1980s, largely in southern Viet Nam (Thomson, 2008; Vietnamese CITES Management Authority, pers. comm. 2012). In 2006 the Ministry of Agriculture and Rural Development of Viet Nam issued a national Technical Standard No. 14-TCN-2006 on breeding *P. reticulatus* and *P. m. bivittatus* (see Annex IV).

Farm registration and export management are regulated by Government Decree No. 82/2006/ND-CP of August 10, 2006, on management of export, import, re-export, transit, breeding and rearing of endangered species. All breeding farms must be registered to, and regularly supervised by, Provincial Forest Protection Departments (PFPD), which also verify the quantity and origin/source of specimens for each export application from farm owners. In addition to this, inter-provincial transportation of pythons requires transport permits issued by the PFPD at the origin and reported to/recorded by the PFPD at the final destination. Exporting and re-exporting specimens for commercial purposes also requires documentation that includes: (1) a proposal letter for permit and certificate granting that follows Appendix 1 of the Decree 82/2006/ND-CP, and (2) documents to prove that specimens have a legitimate origin as regulated in the current law.

The Vietnamese CITES Management Authority is located in Hanoi in northern Viet Nam. However, in 2009, in response to Viet Nam's latitudinal positioning and lack of manpower capacity in the south, a CITES Management Authority office was established in the southern Vietnamese city of Ho Chi Minh. The southern Vietnamese Management Authority continues to report to the northern office, which compiles data for all CITES listed species traded from Viet Nam before submitting to CITES.

The majority of python farms in Viet Nam are located in the south of the country (Fig. 3). According to the southern Vietnamese CITES Management Authority, records show there are 236,988 individual *P. reticulatus* and *P. m. bivittatus* in captivity within 413 breeding farms/households in 22 southern provinces. Eighty-seven per cent (206,946) of the pythons in these farms are *P. m. bivittatus*, with *P. reticulatus* making up the remainder (30,042). There are apparently only 25 farms in Viet Nam that are breeding *P. reticulatus*. It should be noted, however, that there is likely to be additional unregistered farms that are not reported by PFPDs (Viet Nam CITES Management Authority, 2012). A list of the major python farms and exporters in Viet Nam are listed in Annex II.

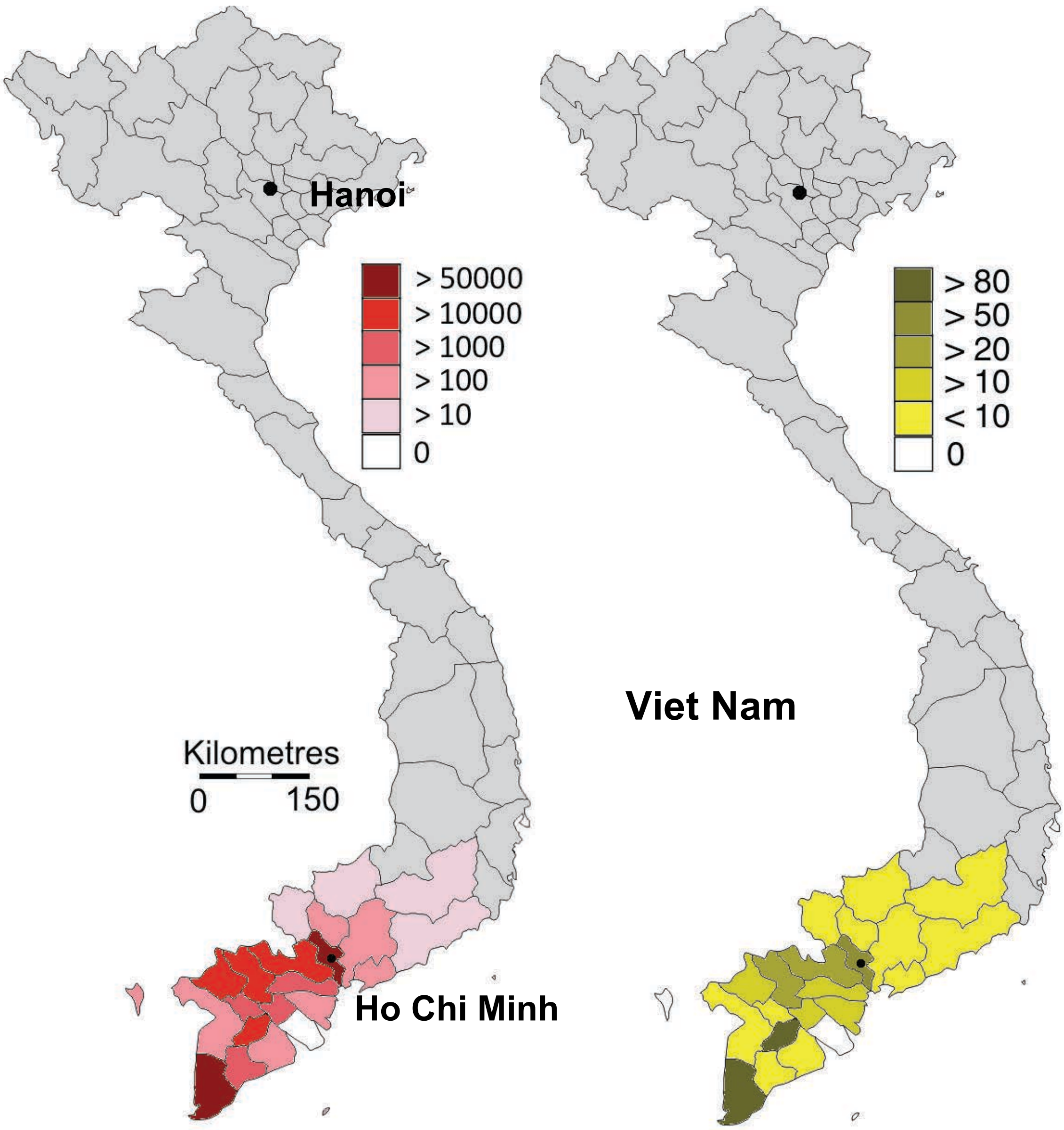

Fig. 3. Locations and relative number of pythons (red) and python farms (yellow) in 22 southern Vietnamese provinces (Source: southern Vietnamese CITES Management Authority; see Section 5.4 for further details). Grey shading indicates that no data were provided for the number of python farms within individual provinces in northern Viet Nam; however, only 73 farms are reported to be located in all of northern Vietnam combined (see Section 5.4).

3.0. HOW ARE PYTHONS FARMED?

This chapter synthesises information on the ways python farming is operated in China, Thailand and Viet Nam and is thus perhaps the most important for understanding the development of broader concepts related to this emerging industry. Much of the information is taken from interviews with python farm owners, relevant experts and from visits to farms themselves.

3.1. Python farming production systems

Each country that produces pythons for skins within captive breeding facilitates employs different methods to achieve the same goal. It is not within the scope of this report to detail the positive and negative aspects of each system, but a general overview is provided in Table 3.

Table 3. Python farming production systems employed in Asia.

Thailand – self contained farming	The single Thai python farm, Si Satchanalai, operates as a fully self-contained facility. All python food is raised on-site and all live pythons remain on-site for the duration of their life.
China – contracted satellites	In China, a single company, Dosho Python, owns all captive pythons on Hainan Island. Breeding stock produce approximately 45,000 hatchlings per year, which are distributed among 640 small farms that are directly contracted to the parent company. Satellite farms pay a deposit for each hatchling python. This deposit is repaid to the satellite farmer when the grown pythons are sold back to the parent company. Dosho pays its satellite farms per kg of python raised and satellites are responsible for the costs of feeding, raising and treating pythons. Every python on Hainan Island is sold back Dosho Python and processed at a central facility in Wenchang, Hainan. In this way, the company has established complete control and transparency over its supply chain. This farming system allows large farms to avoid diseconomies of scale by spreading risk and human resource capacities among a number of smaller stakeholders.
Viet Nam – independent satellites	In contrast to the Chinese satellite farming system, many small Vietnamese farms are independent from the larger farms from which hatchling pythons are sourced. Although some satellite farms are contracted to raise pythons for larger farms, others that buy hatchling pythons are not required to sell these back to the same farm. In addition, many small Vietnamese farms breed small numbers of pythons in addition to raising hatchlings. This independence means that small farms have an opportunity to make higher profits, but it also reduces transparency within the supply chain from farmer to exporter, some of which are more than 400 km apart.

3.2. Breeding

3.1.1. Sex ratios

In general python farmers keep more female breeding stock than males. This is done to maximise reproductive outputs while minimising food and maintenance costs because one male can copulate with more than one female. Sex ratios of males to females were claimed to range from 1:2 to 1:11 depending on the size of the farm and its purpose (raising or breeding)(Natusch, pers. obs. 2012). Several of the smaller household breeders do not keep males for breeding in order to reduce the food costs for parent stock. Instead, they "borrow" males from other breeders or from larger farms, to which they sell the pythons they raise. Most large-scale breeders keep their own breeding stock.

Inset Box 1: Sex determination

Pythons exhibit genetic rather than temperature dependant sex determination (unlike crocodilians). Vietnamese python breeders use the size of the cloacal spurs to determine the sex of mature pythons (Natusch pers. obs. 2012). Cloacal spurs are the small remnants of hind limbs and are often larger in males than females in both *P. m. bivittatus* and *P. reticulatus*. In Thailand, the python farm uses a technique commonly referred to as "popping," whereby pythons are gently squeezed in the cloacal region and base of the tail in order to evert the hemipenes if present and thus confirm whether the snake is a male or female. Finally, Chinese python farms determine sex by inserting a blunt probe into the cloacal bursae and recorded the depth of the hemipenal or hemivaginal pockets for males and females, respectively. In the author's experience, "probing" is the most reliable method for determining sex in snakes.

3.2.1. Breeding introduction

In China, Viet Nam and Thailand, male pythons are introduced to females between October and December, coinciding with the northern hemisphere winter (Fig. 4). This timing is corroborated by the published literature, because the cooling associated with winter months induces copulation (Ross and Marzec, 1990; Barker and Barker, 1994; Natusch, unpubl. data). Males are introduced to females singly and are left with them for 1 to 7 days depending on the preference of the farmer. Some farmers cycle males among the females, so that more than one male copulates with each female, thereby better ensuring fertilization. Several farmers also introduce males for one week, before removing them for a week and then replacing them with other males for a second week, resulting in a three week breeding cycle. Studies of captive pythons (*Python curtus*) suggest that male presence may accelerate female reproductive cycling (DeNardo and Autumn, 2001). Python farmers in all countries reported that female pythons can breed every year; however, they also claimed that in some years approximately 20% of females do not breed due to not reaching breeding condition (i.e., body condition, sufficient fat reserves). Several Chinese farmers inject pythons with passive integrated transponder (PIT) tags to identify individuals and prevent inbreeding and select for desirable traits. The Vietnamese guidelines for breeding also suggest that individuals selected for breeding be marked to avoid inbreeding effects because this may reduce production capacity as well as the vigour of the hatchling stock (Annex IV).

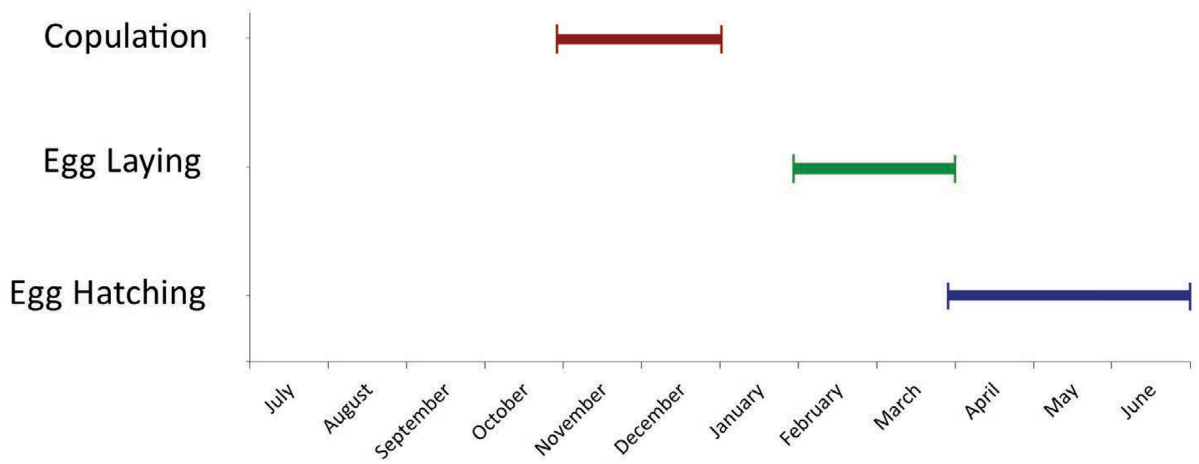

Fig. 4. Summary of the timing of major reproductive events in captive *P. reticulatus* and *P. m. bivittatus.* (Source: Chinese, Thai and Vietnamese python farmers).

3.2.2. Egg laying and incubation

Gestation in both *P. m. bivittatus* and *P. reticulatus* lasts an average of 65 days. Gestating pythons generally shed their skin three to four weeks before oviposition (egg laying). In Viet Nam, some breeders leave females to incubate the eggs within their normal enclosures, while others remove the females shortly before oviposition and place them within well-ventilated mescaline bags (Fig. 5). Some breeders provide a substrate of newspaper for the snakes while others provide nothing. All Vietnamese breeders interviewed in the present study allow the female to wrap herself around her eggs and incubate them naturally, although previous studies indicate that this method is not exclusively used in Viet Nam (WCS, 2008). At the python farm in Thailand, eggs are removed from the female and artificially incubated within a container at 32°C. Chinese python farmers allow females to incubate eggs for two weeks before they are removed and allowed to incubate at ambient temperature without manipulating incubation temperatures or humidity.

Inset Box 2. Breeding annually

It is often assumed that the energetic demands of reproduction result in female pythons being unable to reproduce annually. However, python breeders in China, Thailand and Viet Nam claimed to obtain viable clutches of eggs from the majority of females each year (~80%). Data from published literature and python breeders suggests that it is indeed possible for females to reproduce annually (Ross and Marzec, 1990; V. Odinchenko, pers. comm. 2011). However, provisions must be made to increase female condition as rapidly as possible after reproducing in order to realise effective breeding in successive years (Madsen and Shine, 1999).

Clutch size is strongly influenced by maternal body size. Figure 6 presents a linear regression for the number of eggs produced for a given body size of each of the two python species in this study. However, it should be noted that these figures were taken from several sources (Pope 1961; Murphy and Henderson, 1997) and therefore individuals may have been in differing reproductive conditions. Clutch sizes for female pythons in China, Thailand and Viet Nam are presented in Table 4. The consensus among Vietnamese python breeders about clutch sizes for each species is;

- 15 kg females produce approximately 30 to 35 eggs per clutch
- 20 kg females produce approximately 40 to 45 eggs per clutch

It is interesting to note that Si Satchanalai python farm in Thailand claimed that the mean clutch size produced by females is approximately 40 eggs for both species, despite the individuals at this farm being significantly smaller than those in Viet Nam. By contrast, Chinese python farmers claimed that mean clutch size for *P. m bivittatus* is closer to 25 eggs.

Fig. 5. Copulation, gestation and egg incubation by captive pythons in semi-natural and cage settings.

Table 4. Mean, minimum and maximum clutch sizes and incubation times for the two python species bred by farmers. (Source: python farmers in China, Thailand and Viet Nam. N = number of farmers that provided data for each species).

Species	N	Mean clutch size (eggs)	Clutch size range	Mean incubation time (days)	Incubation time range
Python molurus bivittatus	38	30	10 – 70	55	50 – 70
Python reticulatus	8	33	10 – 100	60	55 – 71

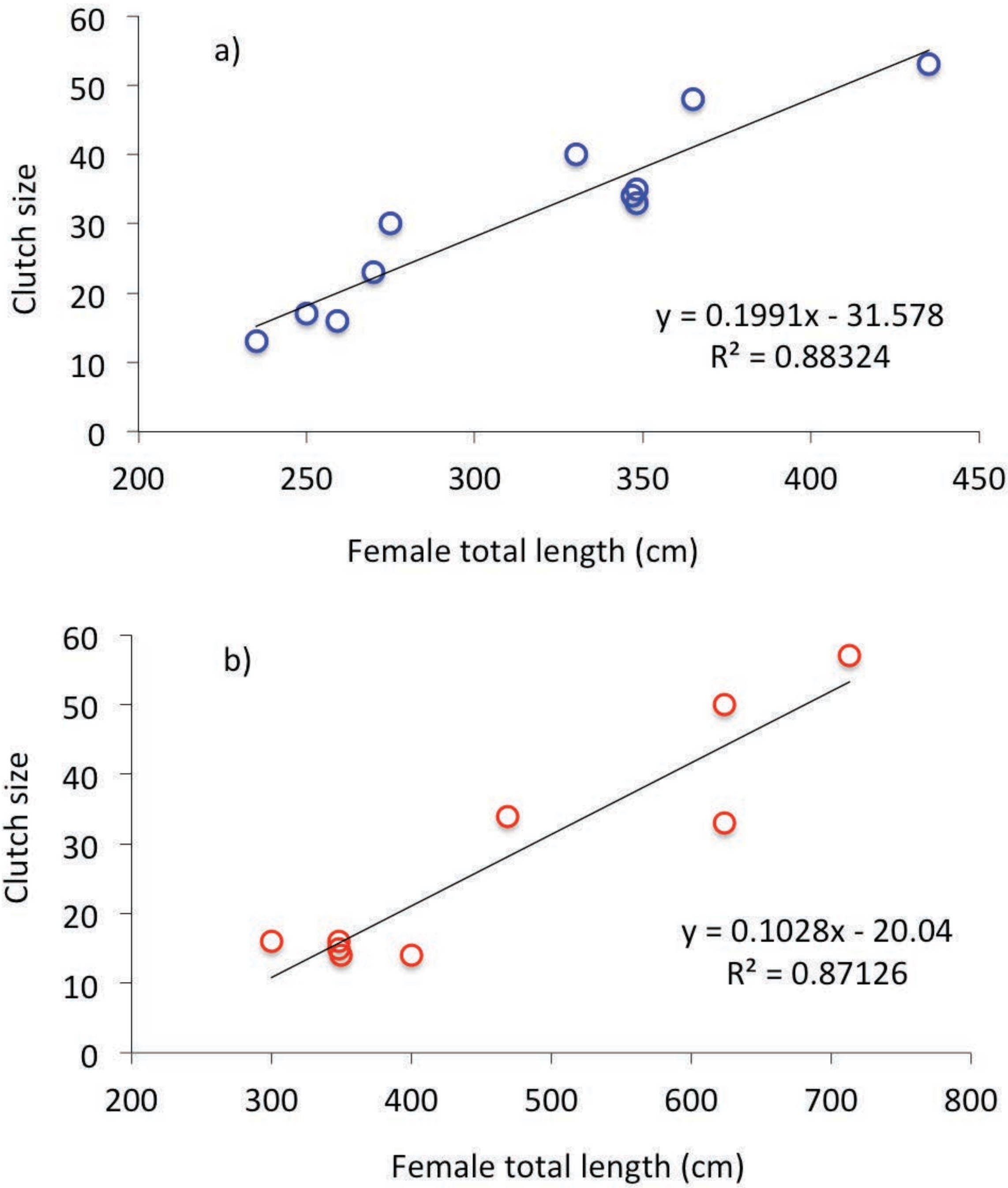

Fig. 6. Linear regressions of clutch size vs. total length for *P. m. bivittatus* (a) and *P. reticulatus* (b). (Source: Murphy and Henderson, 1997 and references therein).

Inset Box 3: Egg laying

One very large-scale Vietnamese python farmer described a situation whereby he only kept breeding females for six years because, after this period, their reproductive potential began to decrease. Although larger snakes are capable of producing larger clutches of eggs, the farm owner explained that the hatching rate and the vigour of hatchlings from clutches produced by very large and/or old females was inferior compared to hatchlings produced by smaller/younger females. Although it was impossible to substantiate this claim, it is conceivable that there is an "equilibrium size" for females where their reproductive output is highest. Field studies on the reproduction of wild water pythons (*Liasis fuscus*; Shine and Madsen, 1996) suggests that the amount of food required for very large females to reach reproductive condition is significantly greater than for smaller females, and may not outweigh the benefit of higher reproductive outputs.

3.2.3. Hatching

Egg incubation lasts for approximately two months (Table 4). After this period, the hatchling snakes begin to emerge from the eggs and are removed from the mother to avoid suffocation (if maternally incubated). Hatching rates vary among farmers and are usually dependent on the size of the operation. For example, small household breeders often reported a 100% hatching rate; however, large scale breeding farms indicated a hatching rate of 75 - 90%. Interestingly, some of the small and large scale breeders indicated that hatching rates were as low as 30% when they began farming, but increased with the procurement of additional knowledge gained from other breeders. The Thai python farmer indicated that hatching success was highly variable among years, perhaps due to the artificial incubation method employed. In addition, ambient temperature extremes among years may result in significant variation in hatching success, as females are unable to choose adequate microclimates within their captive environment to incubate eggs. Once the small pythons hatch, they are kept together within small enclosures (Fig. 7).

Inset Box 4: Hatching rate

One Vietnamese python breeder, Mr. Nguyen Thong Quang, claimed that he was having difficulty realising 100% hatch rates because the incubating mother would expel urine, wetting the eggs, and resulting in them becoming mouldy. To solve this problem, he only provided the female with water twice during the incubation period. This methodological change has resulted in 100% hatch rates nearly every season since.

3.2.4. Hatchling mortality

Hatchling *P. m. bivittatus* and *P. reticulatus* typically weigh between 90 and 140 grams. Chinese and Vietnamese breeders claimed that mortality over the first two weeks after hatching is low (around 5% in normal years). The Thai python farm indicated that they lost 10-20% of hatchling pythons within their first six months. In Viet Nam's satellite farming system, hatchling pythons are sold within the first two months, though this timing varies among breeders. Larger hatchlings (those sold at two months as opposed to within the first two weeks) fetch higher prices. For example, the average price of two-week-old hatchlings is USD 11-15 whereas two-month-old hatchlings can fetch USD 20-25.

3.2. Housing

3.2.1. Breeding stock

Adult *P. m. bivittatus* and *P. reticulatus* are housed individually, except when breeding. The Vietnamese national technical standard for farming pythons indicates that cages should allow access from the top, with dimensions measuring 80 cm x 50 cm x 200 cm (Annex IV). However, enclosure size varied among farms, with some being elaborately built while others are more rudimentary. Many large farms in Viet Nam use cages made of galvanized steel that open from the top. Several of these designs are equipped with gutters to allow wastewater collection. Other farms, including those in China and Thailand and many smaller Vietnamese farms, often build their own enclosures out of wood with wire mesh sides for ventilation. One smaller household breeder kept his stock within plastic milk-crate type enclosures. See Figure 7 for examples of different enclosure setups.

Inset Box 5: Males or Females?

Vietnamese and Thai python farmers claimed there was no preference for either sex of python when it came to rearing for slaughter. This is corroborated by growth rate data for wild pythons - male and female pythons experience similar growth rates until sexual maturity is reached. However, after this point, females grow faster while males slow their growth (Madsen and Shine, 1996). Because most individuals raised for skins are slaughtered before they reach sexual maturity, there is no preference for either sex (see section 4.4.1. for approximate slaughter sizes). This situation is not true for Chinese farmers. Because the Chinese musical instrument market demands large skins, Chinese farms prefer to raise females that reach larger sizes and grow more rapidly than males after reaching maturity (Zhang Liling pers comm. 2013).

3.2.2. Hatchlings and raising stock

Hatchling pythons and those being raised for skins are often kept within the same sized enclosures as the adults, while others are given smaller enclosures made of either wood or galvanized steel. In Thailand, hatchling pythons are kept individually within stacked, rack-style plastic containers allowing easy access for feeding and cleaning and maximisation of available space (Fig. 7). In China and Viet Nam, hatchlings and small juveniles are kept together (with up to 50 individuals per cage) for the first few months of life (Fig. 7). As the pythons grow, the number within each enclosure is reduced. There does not appear to be any exact science to the number of large snakes within a single enclosure; instead, it is related more to the space and/or number of enclosures at the farm or household. Preferably, however, the number within any enclosure should be small enough to reduce injuries when feeding due to the python's strong feeding response (to prevent them eating one another). The density of pythons per cage, as recommended by the Vietnamese national technical guidelines for python breeding, is presented in Table 5.

Table 5. Density of pythons per cage (measuring 80cm x 50cm x 200cm), as recommended by the Vietnamese national technical standard for python breeding (Annex IV).

Python size	Individuals per enclosure
< 0.5 kg	8 - 12
1 - 2 kg	4 - 6
2 - 5 kg	2 - 4
> 5 kg	1 - 2

Fig. 7. Different types of enclosures, materials and setups used for housing pythons.

3.3. Feeding

3.3.1. Food types

The types and amounts of food given to captive pythons vary with body size, species, purpose, and farm location. For example, pythons being raised for slaughter are fed smaller food items more frequently than breeding stock. The types of food given to different python life stages are presented in Table 6. The location of farms also influences the diet of captive pythons due to differences in food costs between urban and rural areas. For example, python farms located in Ho Chi Minh City feed pythons on poultry offcuts sold by local slaughterhouses. In contrast, rural farmers, particularly in Ca Mau province, feed pythons rats and mice (typically not available in the city) caught and sold by local people. Small-scale python farmers are often able to capture sufficient numbers of rats to feed their own stock. Several farm owners, as well as the southern Vietnamese CITES Management Authority, claimed that fish are regularly fed to pythons, but this was not observed. Chinese python farmers feed sausages to pythons. Sausages are filled with chicken, pork and fish dependent upon availability and prices, and are made by the python farmers themselves. In contrast to the outsourcing of python food in China and Viet Nam, Si Satchanalai python farm in Thailand breeds its own rats to feed pythons and is therefore self-contained. The geographic variation in food availability and price thus plays a significant role in the economic profitability of python farms, dependent on their location.

Table 6. Food types fed to farmed pythons. Numbers represent how many farms of those visited feed particular food items to each python life stage.

Food type	Hatchlings	Raising stock	Parent stock
Chicken head/necks	2	7	4
Whole baby chickens	22	22	10
Whole chickens	-	-	11
Whole baby quail	5	2	-
Rats	21	31	24
Whole ducks	-	-	16
Piglets	-	-	2
Sausages		10	4

3.3.2. Feeding procedure

Python sub-adult and breeding stocks are fed individually within their enclosures. In Viet Nam, all pythons are initially offered food and, if they do not eat, the food item is often left within the enclosure for the snake to consume later. In order to induce self-feeding in raising stock, chicken necks are scented using the feathers of baby quail (Fig. 8). Chinese python farmers have developed a protocol for feeding sausages to pythons. First, a feeding response is stimulated using a dead chicken. As each python ingests the chicken, workers guide a long thin sausage (up to 50 cm) into the mouth of the python. Pythons continue their natural feeding response and the sausage is consumed (Fig. 8). Hatchling pythons of all species generally do not feed until they have undergone their first skin shed, which typically occurs 5-10 days after hatching. Nearly all python hatchlings readily feed on mice, but fewer take to eating chicken necks as easily. Thus, staff “assist feed” hatchlings by opening their mouths and gently pushing the chicken necks into the open oesophagus. Generally, a natural feeding and swallowing response takes place, and the hatchling python begins to consume the food independently (Natusch, pers. obs., 2012).

Fig. 8. Food types and feeding procedures for captive pythons farmed for skins. Clockwise from top left: farm staff feeding sausages to pythons; quail raised for food; pythons eating sausages; rats captured for food; python eating chicken offcut; staff feeding chicken to hatchling pythons (photo credit: Thai Truyen, Viet Nam).

3.3.3. Feeding regime

The feeding frequency for pythons varies depending on the farm, the life stage and purpose for which the individual is being grown. On average, most individuals are fed weekly (Table 7).

Table 7. Feeding regime and prey types for different life stages of rearing pythons.

Food type	Hatchlings	Raising stock	Parent stock
Chicken head/necks	2/4 – 7 days	10 – 20/week	10 – 20/2 weeks
Whole baby chickens	2 – 3/4 – 7 days	5 – 8/4 – 7 days	-
Whole chicken	-	-	1/2 weeks
Whole baby quail	2 – 3/4 – 7 days	-	-
Rats	2/ 4 – 7 days	5 – 10/4 – 7 days	2 – 5/2 weeks
Whole ducks	-	-	1/2 weeks
Piglets	-	-	1 part/2 weeks
Sausages		Not measured	Not measured

3.3.4. Hatchlings

The Vietnamese technical standard for python breeding recommends feeding small amounts of food frequently. For example, they suggest feeding two-to-three quail chicks or one chicken chick every 4 to 5 days (Table 7). Other farmers feed small rodents or chicken necks at similar intervals. In Thailand, food sizes are considerably smaller than in Viet Nam, with Thai farmers feeding pinkie rats (new born rats weighing around 7 g) every few days. This much smaller food item may slow growth early in life (see Section 4.1.1.).

Inset Box 6: Feeding

The general consensus among all python breeders visited was that *P. reticulatus* is significantly more difficult to begin feeding than *P. m. bivittatus*. Juvenile *P. reticulatus* will not readily take to chicken heads and necks, preferring to consume live or freshly killed prey. One farmer who kept both python species fed live mice or rats to the pythons. Four Vietnamese python farmers claimed that *P. reticulatus* were easiest to feed at night due to an increased feeding response at this time. Clearly, this attribute makes keeping this species more labour intensive than *P. m. bivittatus*. In contrast, two python farmers claimed that *P. reticulatus* were easier to keep because they had fewer health issues than *P. m. bivittatus*. These farmers demonstrated the ability of adult *P. reticulatus* to readily take chicken heads during the day, explaining that they had trained them from hatchlings (Fig. 8; Natusch, pers. obs., 2012).

3.3.5. Parent and raising stock

Pythons being raised for skins are fed rats, chicken heads or sausages as frequently as possible to induce rapid growth. Although a number of feeding rates are provided in Table 7, the general consensus among farmers from all countries is that pythons are fed as much food as they are willing to eat. Pythons being raised for skins are also fed different items at varying times depending on their life stage. For example, in China small pythons are fed 2 – 3 small chicks every 4 – 5 days. As the individual grows the amount increases until pythons are being fed 5 – 8 chicks every 5 – 7 days. Once pythons reach approximately seven months of age sausages are included in the diet. Although breeding stock is fed as infrequently as possible in order to reduce food costs, breeding females are fed sufficient amounts of food to reach adequate body condition to reproduce annually.

3.4. Cage maintenance

Cages receive relatively little “wear and tear” from the pythons themselves, so cage maintenance is minimal. Several farmers claimed to make their own python cages from wood, but also stated that metal cages last longer than wood. Most farmers still used the cages they had begun farming pythons with. One farm owner claimed that wooden cages could be used for more than 10 years before having to be replaced.

3.5. Hygiene

Hygiene varied among farms, but, in general, was high. Several farms had cages designed to collect wastewater using a gutter system (Fig. 7). Other farms had accumulations of python shed skin and scat within cages where adult pythons were kept. However, most farms would remove scats and shed skins as part of a daily cleaning regime. Cages at many farms are sprayed with disinfectant to prevent bacteria build-up. Although no dead pythons were observed, hygiene measures may not be adequate to prevent disease outbreaks. Specifically, the proximity of cages may result in the rapid spread of disease if an outbreak occurs in the captive population. However, increasing the distance between enclosures may not be a viable solution because space is already a limiting factor for many farms. Several farmers explained that cases of respiratory infection often spread quickly among pythons because of difficulties involved with detection and early quarantine of infected individuals.

Self contained farms that breed rats and chickens, in addition to pythons, require strict hygiene to prevent disease outbreaks within the food population. Fatal disease outbreaks within the food populations of self-contained farms have the potential to significantly reduce python production capacities if an alternative food source cannot be found. In addition, diseases carried by rats can infect human operators, further increasing the need for adequate levels of hygiene within these facilities.

3.6. Disease and veterinary care

There are several diseases that captive pythons are susceptible to, and these, along with their suggested treatment, are listed in Table 8. The most common illness in captive pythons is respiratory infection, largely due to limited opportunities to thermoregulate within the captive environment as well as sudden fluctuations in ambient temperature. Vietnamese farmers explained that pythons sometimes suffer from respiratory infection, but very rarely are animals lost. However, Chinese and Thai python farmers claimed that respiratory infection is common with an estimated 20% of pythons becoming ill and roughly 15% of those dying annually. This difference may reflect the lower winter temperatures in China and Thailand compared to Viet Nam. Once infected, pythons need to increase their body temperature in order to recover. However, the inability in captivity to thermoregulate via basking may promote infection depending on levels of hygiene, humidity, latitudinal position and winter temperatures. To combat this, farmers in all countries provide pythons with direct access to sunlight for short periods each day (either by transporting them outside, or opening the roof of the facility). In addition, Chinese farmers heat enclosures using ceramic lamps, and provide insulation using blankets.

Python farmers in all countries indicated that they provide snakes with veterinary care in the form of medicine. Most were typical antibiotics that are administered to parent stock if respiratory illness is suspected. In addition, in Thailand, precautions are taken leading up to winter in order to mitigate the number of cases of respiratory illness. Interestingly, the Thai python farm has had trouble with parasites killing pythons. Parasitologists at Chiang Mai University identified the parasite as a *Strongyloides* spp., a type of nematode worm common in many animal species (E. Malucchi, pers. comm., 2012). The stress of captivity coupled with a closed environment predisposes many animals to heavy parasite infections, and strongyle infections are common when poor hygiene results in highly contaminated environments (Merck Veterinary Manual, 2012).

Table 8. Diseases and parasites common to captive *P. reticulatus* and *P. m. bivittatus* (Source: Jacobson, 2007; Merck Veterinary Manual, 2012).

Disease	Description	Cause	Symptoms	Treatment	Prevention	Notes
Respiratory illness	An illness common to many captive reptiles that are unable to adequately thermoregulate	Caused by inappropriate temperature regimes or sudden climatic changes	Excess fluid around the mouth, wheezing (particularly at night) and opaque eyes	Administration of medicine usually into food given to pythons; specifically Streptomicin	Allow pythons to thermoregulate by moving them into sunny areas or providing artificial heat during the day	Respiratory illness was not observed in pythons in farms in Viet Nam; however, two farm owners claimed to have lost parent stock to this illness. The illness was reported to be very common in China and Thailand
Intestinal enteritis	Infection of the intestine	Infections of the intestines caused by eating rancid food or food containing pathogens. Can also be exacerbated by inappropriate thermal regimes that do not favour digestion	Blood within python excrement	Antibiotics approved by a veterinarian	Appropriate thermal regimes. Feeding fresh food	This was not observed and no farmers indicated problems due to this illness
External parasites	Infestation of the skins with mites or ticks	Contact with wild-caught pythons	Ticks: large bulbous tick bodies protruding from beneath the scales Mites: appears to be a white dusting upon the scales, however, can sometimes be black	Ticks: can be removed individually with tweezers. Mites: soak python in warm water, or rub the skin with 70% alcohol, avoiding sensitive areas	Do not allow contact with pythons that may be wild-caught, or with captive pythons from other farms where wild caught pythons are kept	No external parasites were observed on any of the pythons in captivity within breeding farms
Internal parasites	Strongyle infection within the stomach, intestines and lungs	Most commonly through ingestion of faeces of infected animals (rats), but also through unfiltered groundwater or directly through the skin.	Severe weight loss and lethargy. Pneumonia may result if strongyles have infected the lungs	Fenbendazole at dosages approved by a Veterinarian	Adequate hygiene	Python farmers in Thailand reported losing large numbers of snakes to *Strongyloides* infection

3.7. Slaughter

Removing python skins requires killing of the individuals raised in farms. Therefore, use of humane and effective slaughter practices is important to ensure pythons do not suffer before death occurs. Employing humane methods of slaughter is also important to increase consumer confidence that python products have been sourced from humanely slaughtered snakes. According to a study carried out by the Swiss Veterinary Office on Humane Killing of Reptiles (Expert Panel, 2013), none of the methods used by China, Thailand or Viet Nam (described below) are currently considered "humane". It should be noted that, with the exception of chemical euthanasia, humane slaughter methods for reptiles include only those where destruction of the brain is achieved. It is strongly recommended that immediate training and support is given to python farmers in all countries so that they can implement the recommendations from the international report on humane treatment and slaughter techniques.

3.7.1. China

In China, pythons from all 640 farms are brought alive to a single slaughter facility operated by Dosho Python Company. The facility is clean and well managed, and pythons are killed by decapitation. The report published by the Swiss Veterinary Office for the humane killing of reptiles concluded that decapitation is not the most humane method of slaughter due to high resistance to hypoxia experienced by ectotherms (meaning that even without oxygen the brain can remain conscious for some time). Therefore provisions should be made to implement more humane slaughter methods at the Chinese facility.

3.7.2. Thailand

In Thailand, pythons are slaughtered by immersing the individual in a body of water and waiting until it has drowned. On average, the farm owners estimated that the pythons take 15 – 20 minutes to die. The Analysis on Humane Killing Methods for Reptiles concluded that drowning is not a humane form slaughter (Expert panel, 2013). According to the farm owners, if pythons are killed in this way, it is easier to remove the skin than if they were killed using another method. The reason given is that the skin of drowned individuals does not contract when they are killed.

3.7.3. Viet Nam

There is a single technique used for slaughter by all farms in Viet Nam. The mouth and anus are taped shut and the alimentary canal is filled with air using an air compressor. It is not entirely clear how the snakes die; however, death may occur due to rupturing of the vital organs or suffocation. Nevertheless, pythons remain conscious for approximately 15 minutes before death occurs (for additional information see Kasterine et al., 2012). The Vietnamese state that pythons are slaughtered in this way is because they believe it is more humane than brain destruction or decapitation because blood is not observed. When it was explained by the authors that western consumers might view this slaughter method negatively, the Vietnamese CITES Management Authority expressed that they were open to suggestions for alternative methods of slaughter.

4.0. IS PYTHON FARMING VIABLE?

This section examines the commercial feasibility of breeding pythons. To do this, two important questions must be answered - is it (1) biologically and (2) economically feasible to breed pythons of the sizes required, and in the timeframe required, to make it commercially viable? In other words, can a single python be bred, raised, slaughtered and skinned to make a profit from the sale of its products (skin, meat, etc). Intuition might suggest that farming large-bodied, carnivorous and poorly understood pythons on a large scale is not biologically feasible. Moreover, the time, expertise and resources needed to rear pythons for a relatively low return for each product might yield it economically unviable (Snyder et al., 1996; Auliya, 2011; Kasterine et al., 2012). The assumption that breeding pythons commercially is not feasible has been strengthened by reports of some "python farms" being used as a front for selling illegally wild-caught pythons as "captive-bred" (Nijman and Shepherd, 2009; Lyons and Natusch, 2011). Herein we provide information, with examples, to help determine whether it is biologically and economically feasible to commercially breed pythons for skins to supply the international high-end fashion industry.

4.1. Biological feasibility

Many factors determine the feasibility of commercially raising a species in captivity, including the species' biology, such as productivity, age and size-specific survivorship, vulnerability to disease and the cost-effectiveness of captive breeding. *Python reticulatus* and *P. m. bivittatus* are among the world's largest snakes. They have broadly overlapping distributions; however, *P. m. bivittatus* is absent from many Indonesian islands, but occurs further north than *P. reticulatus* with some populations extending into southern China (Auliya, 2006; Jacob et al., 2009; Barker and Barker, 2010). Both species are generalists in their habitat requirements and can be found in open savannahs, dense rainforests and swamps (Groombridge and Luxmoore, 1991; Auliya, 2006). They are sedentary for long periods of time, often relying on ambush to capture prey, before killing by constriction and ultimately suffocation. Both species feed primarily on live mammals and birds (Shine et al. 1999; Corlett, 2012). They are oviparous (egg laying), with females typically coiling tightly around eggs until hatching occurs, but this is not required for successful incubation (Ross and Marzec, 1990).

In general, *P. reticulatus* and *P. m. bivittatus* are well-suited to captive propagation and were among the first species of snakes to be routinely bred in captivity in the United States and Asia (Pope, 1961; Murphy and Henderson, 1997). Below are a number of biological attributes of these large pythons that make them suitable for captive breeding in large numbers for skins:

- Fast growth rates (see Section 4.1.1.);
- High reproductive output (see Section 3.1.3.);
- Gain and maintain condition easily (see Ross and Marzec, 1990);
- Do not require large space (see Section 3.2.); and
- Generalist diet (see Section 3.3.).

4.1.1. A most crucial variable: python growth rates

Perhaps the most common argument to question the veracity of captive breeding of pythons for skins is that, despite growing quickly, *P. reticulatus* and *P. m. bivittatus* cannot grow quickly enough (and require too much food) to sustain a viable economic output. This debate has been fuelled by the statements from Viet Nam, the largest exporter of purportedly captive-bred python skins, that snakes can be reared to a slaughter size of three metres within one year (this is the approximate size desired by the fashion industry; C. Bianchini, pers. comm., 2012). To examine this claim, the present report sought confirmation from a number of well-known python breeders worldwide who have expertise in keeping and rearing both *P. reticulatus* and *P. m. bivittatus* (see Inset Box 7). Each respondent indicated that it was indeed possible to rear both males and females of both species to three metres within one year. Moreover, respondents often indicated that it was possible for pythons to reach this size in fewer than 12 months. However, not one of the respondents believed that pythons could reach three metres if fed only featherless chicken heads and necks (see Inset Box 7).

Inset Box 7: Expert opinion

A standardized survey questionnaire was sent to 39 well-known python breeders worldwide (mainly in Europe and the USA) to gauge their opinion on whether it was possible for *P. reticulatus* and *P. m. bivittatus* to be reared to three metres in length within one year. Twenty-six (67%) of the breeders were unwilling to complete the questionnaire because they believed it was morally wrong to farm pythons for skins, and six (15%) did not respond. Therefore, responses were collected from only seven (18%) anonymous python breeders. The results are presented in the table below.

*Power-fed indicates that pythons are fed large amounts in order to maximize growth.

Questions	*P. m. bivittatus*	*P. reticulatus*
Sample size	6	7
Mean number of years working with these species?	19.5 years	15.7 years
• Can males be "power fed" to reach 3 metres within one year?	Yes (all responses)	Yes (all responses)
• Can females be "power fed" to reach 3 metres within one year?	Yes (all responses)	Yes (all responses)
• Can males be "power fed" to reach 3 metres within one year on a diet of featherless chicken heads?	No (all responses)	No (all responses)
• Can females be "power fed" to reach 3 metres within one year on a diet of featherless chicken heads?	No (all responses)	No (all responses)
• Mean number of months respondents think that males would take to reach 3 metres if "power fed" on a diet of rats	11.5 months	11 months
• Mean number of months respondents think that females would take to reach 3 metres if "power fed" on a diet of rats	11 month	10.5 months

Despite fast growth rates being physiologically possible, is it true that these pythons are raised to three metres in length within one year on a regular basis in Asian farms? This question has a somewhat more complex answer. Python farmers in Thailand claim that it takes 1.5 to 2 years for a python to reach this size. In Viet Nam, however, live pythons are sold and slaughtered depending on body mass rather than length. According to all Vietnamese python farmers interviewed for the present report, pythons are slaughtered between 6 to 10 kg in mass; however the average python weighs approximately 8 kg.

In order to determine the corresponding snout-vent lengths[4] of live *P. m. bivittatus*, we measured the mass and lengths of individuals claimed to be of slaughter size. Based upon these measurements, the average length of an 8 kg *P. m. bivittatus* is approximately 238 cm (standard deviation = 0.08, n = 8). We also examined two larger individuals measuring 300 cm and 316 cm in length. The mass of these pythons was 15 and 19.4 kg, respectively. Vietnamese python farm owners stated that this is much larger than the typical slaughter size. They also stated that while large pythons are slaughtered if there is demand, they most often represent breeding stock rather than slaughter stock and are thus much larger than the average trading length. To further confirm the relationship between body length and mass we combined these data with those from published records (Pope, 1961; Murphy and Henderson, 1997) of captive snakes and data provided by Professor Stephen Secor, University of Alabama, Tuscaloosa, AL, USA. This resulted in a useful measurement sample from 284 *P. m. bivittatus*. Figure 9 illustrates the curvilinear relationship between length

[4] Snout-vent length is used in this instance because the tail portion is discarded from the finished skin.

and mass in *P. m. bivittatus*[5]. The equation describing this relationship can be used to standardize measurement techniques (length vs. mass).

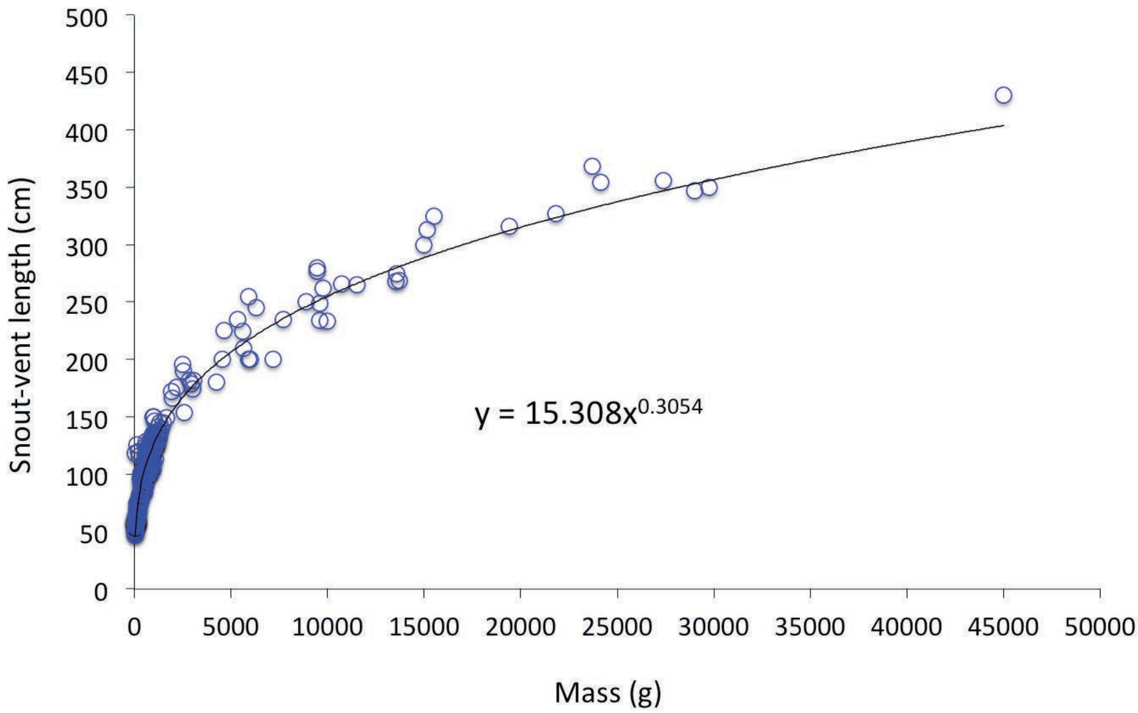

Fig. 9. Relationship between snout-vent length and mass for 284 *P. m. bivittatus*. (Source: Pope, 1961; Murphy and Henderson, 1997; Natusch, unpubl. data; S. Secor, unpubl. data).

Using this equation, it appears that the majority of *P. m. bivittatus* bred for their skins in Viet Nam are not actually 3 m in length when slaughtered, but closer to 2.3 m (8 – 10 kg). This was corroborated by a number of python farm owners when persistently queried about the length of snakes. In addition, farmers interviewed by Vietnamese media stated that pythons reach only 2 to 2.5 m (or 5 to 10 kg) within one year (although one article claims that good python farmers can raise snakes to weigh 6 kg within six months; Annex III). Chinese scientists and python farmers suggested that Vietnamese claims are probably true. The Chinese stated that although most *P. m. bivittatus* grow to a mean weight of 7 kg within one year, they have recorded exceptionally fast growing individuals to reach 10 – 12 kg.

The Vietnamese estimate that pythons are slaughtered at three metres in length may have arisen for two reasons: (1) farmers never measure the length of pythons in their care and thus the actual lengths of slaughtered snakes are exaggerated, and (2) python skins are stretched throughout the drying process and are measured before being exported to determine individual skin price. It appears that Vietnamese farmers have been reporting the estimated length of stretched (and potentially overstretched) and dried skins rather than the lengths of the live snakes themselves (Table 9). In agreement, Micucci and Waller (2007) showed that Anaconda skins stretch to approximately 15% longer than the live animal and can account for a 25% increase in skin size if forced or excessively stretched to maximize value (T. Waller pers. comm., 2012). The same is true for wild reticulated pythons captured for the skin trade, as their skin stretches 10-20% larger than the snout-vent length of the live individuals (Natusch, unpubl. data). It is thus not unreasonable to suggest that three metre skins can be produced from 2.5 m pythons. In conclusion, although it may be possible to rear both *P. reticulatus* and *P. m. bivittatus* to three metres (the skin size in highest demand from the fashion industry) within one year, in reality, this is unlikely to be occurring for all pythons in Viet Nam and is not claimed to be occurring in China or Thailand. More accurate data on the relationship between length, mass and age will be important for clarifying the attributes of slaughtered snakes, particularly for *P. reticulatus.*

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[5] It should be noted that the data provided relate only to *P. m. bivittatus*. There are only limited data available for captive *P. reticulatus*.

Table 9. Skin stretch magnitudes for pythons of known body size in Viet Nam (Data provided by Vietnamese python farmers).

Sample size	Mass (kg)	Total length (cm)	Skin length (cm)	Stretch (cm)
5	3	140 - 150	180 - 200	40 – 50
5	10	230 - 250	300 - 330	70 - 80

4.2. Economic feasibility

As well as understanding the biological feasibility of breeding pythons for skins, the case for commercial captive breeding must also be evaluated. Concern has been raised about current exports of python skins using a CITES captive-bred source code due to uncertainties surrounding the economic viability of captive breeding pythons in large numbers for their skins (Auliya, 2011; Kasterine et al., 2012). For example, some believe that the cost of feeding and housing python parental stock and growing sub-adults to slaughter size is greater than the final sale price for each skin (Kasterine et al., 2012). In order to explore the economic feasibility of python breeding a number of case studies are provided.

4.2.1. Case study: Chinese and Vietnamese python breeding

Data related to the expenditure and income of Chinese and Vietnamese python farms were gathered through direct interviews with the python farm owners. Because several sources have claimed that the cost of feeding pythons outweighs the final cost of an individual skin (summarised in Kasterine et al., 2012), Tables 10 and 11 provide a detailed breakdown of the cost of various food sources in China and Viet Nam. Where possible, sample sizes, mean prices and price ranges are provided.

Inset Box 8: Python production efficiencies

In physiological studies, production efficiency is the percentage of ingested energy that is channelled into growth. Calculating production efficiencies based upon data provided by farm owners, and comparing these to known efficiencies for snakes, can be used to crosscheck if the information provided on feeding regimes is consistent. Using data provided by the Vietnamese python farmers in Inset Box 9, production efficiencies for pythons are as follows:

Vietnamese farmers report that 26 kg of rats are required to raise a python from hatching size (100 g) to mean slaughter size (8 kg) (see Inset Box 9). This reflects a food conversion rate of approximately 31% (or 3.25 kg of food for every 1 kg of python). In China, researchers at Hainan University have shown that 3.1 – 3.3 kg of food is required to produce 1 kg of python (Zhang Liling, pers comm. 2013). Production efficiencies for other snakes and pythons range between 30 – 40% (Vinegar et al., 1970; Smith, 1976) and are 40.7% for *P. m. bivittatus* specifically (Cox and Secor, 2007). Thus, information provided by farmers for python food consumption is realistic to achieve desired growth rates. Interestingly, in order for python production not to be economically viable, production efficiency would need to fall below 19% (approximately 43 kg of rats or 5.4 kg of food for 1 kg of python; based on food costs alone and a sale price of USD70).

Table 10. Cost of various food sources for pythons in Viet Nam. N = the number of records for each food source. (Source: Vietnamese python farmers).

Food costs	N	Unit	Mean Price (USD)	Range (USD)	Pieces per unit
Chicken head/necks	7	kg	0.90	0.75 – 1.00	20
Whole baby chickens	3	Individual	0.85	0.75 – 1.00	1
Whole chicken	7	kg	1.25	1.00 - 1.50	1.5
Whole baby quail	1	Individual	0.04	N/A	1
Rats	16	kg	1.60	1.00 – 2.00	7 - 10
Whole ducks	9	kg	1.50	1.50	1.5
Piglets	1	kg	0.5	N/A	?

Table 11. Cost of various food sources for pythons in China. (Source: Chinese python farmers).

Food costs	N	Unit	Mean Price (USD)	Range (USD)	Pieces per unit
Whole baby chickens	1	Individual	0.08	0.05 – 0.16	1
Whole chicken	3	kg	1.25	1.00 - 1.50	1.5
Sausages	4	kg	1.60	1.20 – 1.70	N/A

Three specific case studies for the economic viability of python breeding in China and Viet Nam are presented in Inset Box 9. To analyse these data, and facilitate understanding of the financial flow structure of farms, a model was created using STELLA Modelling Software (Isee Systems, USA). The report has included examples ranging from small-scale satellite farms to large-scale farms and exporters.

It should be noted that the present report is relying on data presented by python farm owners themselves. Calculations are based upon major costs. For example, most python breeders did not begin with large-scale farms, but rather built up substantial infrastructure over many years. Therefore, the establishment costs associated with python farming are unknown. Although additional costs occur (e.g., cage maintenance), according to farm owners these are negligible and vary considerably from year to year. Furthermore, prices presented are only indicative because price fluctuates from year to year and is often dependent on demand.

Inset Box 9: Case studies for the economic viability of python breeding in China and Viet Nam

Case study 1: Python farm, China

- A case study is provided for a Chinese satellite farm raising 400 pythons
- Chinese satellite farms are not required to purchase their pythons because they remain the property of the parent company, Dosho.
- The farmer begins raising pythons on a diet of small chickens before introducing sausages at approximately six months of age.
- The farm farmer does not employ any staff because his family are able to care for the pythons. The python farmer also works for the government, but farming pythons contributes approximately 70% of his annual income.
- The python farmer claimed to earn approximately USD 25,000 per year from python farming, which is roughly corroborated by the figures below.

Estimated Income	Estimated Expenditure
Grown python sale **400** (grown pythons) x **7 kg** (mean mass at sale) x **13.20** (USD paid per kg) = **36,960**	Food cost **400** (raising stock) x **5** (mean # chicks/week) x **26** (weeks/six months) x **0.08** (USD/chick) = **3,640** **400** (raising stock) x **0.45** (kg/sausage/week) x **26** (weeks/six months) x **1.6** (USD/kg sausage) = 6,240 **400** (raising stock) x **10** USD (estimated cost of additional expenses per python. E.g., Heating, cage maintenance, other) = **4,000**
Total income = USD 36,960	**Total expenditure = USD 13,880**

Inset Box 9 continued: Case studies for the economic viability of python breeding in Viet Nam

Case study 2: Python farm, Viet Nam

- This facility is one of the largest python farms and skin export companies in Viet Nam. The farm is located in Ho Chi Minh City and sells the majority of hatchlings produced to satellite farms.
- In addition to selling python skins, python gall bladders (for domestic medicinal use) and meat (for domestic consumption) are also sold.
- The farm keeps mainly *P. m. bivittatus* (only 40 *P. reticulatus*) and has a parent stock consisting of 500 females and 300 males. Approximately 10,000 skins are exported from this farm annually. Half of these are purchased as skins from traders that slaughter snakes produced by other farms, while the remaining half are bought as live pythons from contracted satellite farms. These live individuals are later slaughtered at the farm.
- The farm's main client countries are China, Italy and Spain. According to the farm owner, the larger, higher quality, skins are sold to China for use in musical instruments, whereas smaller, "thinner" skins are sold to Europe. Because the skins sold to China are taken from large breeding stock rather than smaller raising stock, they have not been included in this analysis, but represent an additional income.
- The farm provided no indication of annual profit from the sale of skins.

Estimated Income	Estimated Expenditure
Parent stock hatchling sale **500** (breeding females) x **0.8** (80% successful reproduction) x **30** (eggs per female) x **0.8** (80% hatching rate) = **9,600** (hatchlings) x **14** (USD/hatchling) = **134,400**	Parent stock food cost **800** (parent stock) x **10** (chicken heads/fortnight) x **26** (fortnights/year) x **0.9** (USD/kg for chicken heads) ÷ **20** (Number of chicken head/kg = **9,360**
Meat sale **5000** (pythons) x **4** (weight of python meat per snake in kg) x **2.5** (USD/kg) = **50,000**	Staff cost **25** (staff) x **150** (USD/month) x **12** (months) = **45,000**
Gall bladder sale **5000** (pythons) x 1 (USD/gall bladder) = **5,000**	Skin purchase **5000** (skins) x **80** (USD/skin) = **400,000**
Skin exports **10,000** (skins) x **90** (USD/skin) x **0.95** (5% export tax/skin) = **855,000**	Live python purchase **5000** (live pythons) x **70** (USD/individual) = **350,000**
Total income = USD 1,044,400	**Total expenditure = USD 804,360**

Inset Box 9 continued: Case studies for the economic viability of python breeding in Viet Nam

Case study 3: Python farm, Viet Nam

- This farm is a large producer of *P. m. bivittatus*. They do not export python skins, but produce large numbers of hatchlings that are sold to satellite farms.
- The farm keeps 470 pythons as breeding stock (400 females and 70 males).
- At the time of our visits the farm was also currently raising 1,500 smaller pythons.
- The farm is owned and run by a husband and wife team, together with five full-time staff. Python farming is their sole source of income.
- The farmers gave no indication of annual profit from python farming.

Income	**Expenditure**
<u>Parent stock hatchling sale</u> **400** (breeding females) x **0.8** (80% successful reproduction) x **30** (eggs per female) x **0.8** (80% hatching rate) = **7,680** (hatchlings) – **1,500** (hatchlings kept) x **14** (USD/hatchling) = **86,520**	<u>Food cost</u> **470** (parent stock) x **1** (duck/fortnight) x **26** (fortnights/year) x **1.5** (USD/kg) ÷ **1.5** (ducks/kg) = **12,220** **1500** (raising stock) x **5** (rats/week) x **52** (weeks/year) x **2** (USD/kg) ÷ **10** (rats/kg) = **78,000**
<u>Grown python sale</u> **1500** (grown pythons) x **70** (USD/Individual) = **105,000**	<u>Staff cost</u> **5** (staff) x **250** (USD/month) x **12** (months) = **15,000**
<u>Total income</u> = USD 191,520	**<u>Total expenditure</u> = USD 105,220**

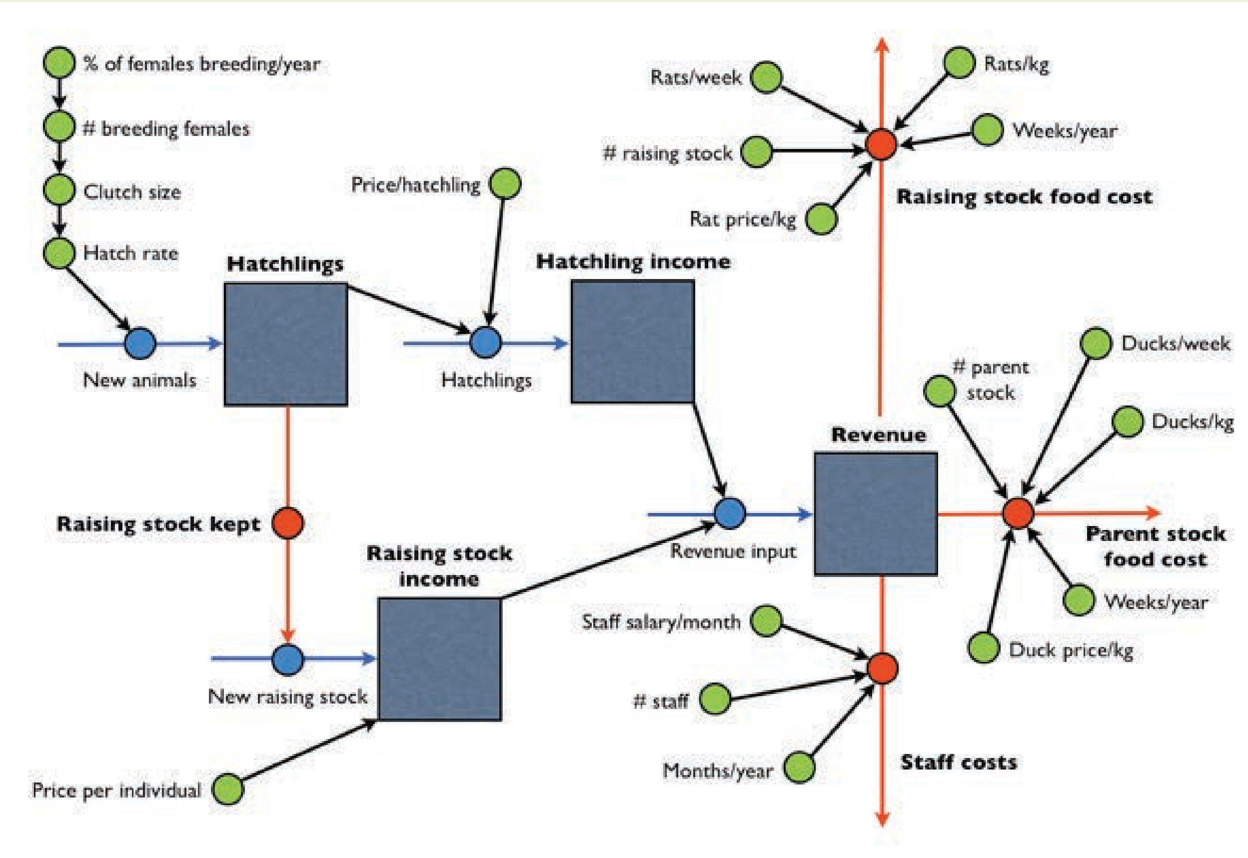

Fig. A. A basic farming revenue model describing major sources of income and expenditure (created using STELLA modelling software).

- Blue squares = stocks
- Orange circles = costs or outflows
- Blue circles = income or inflows
- Green circles = converters or vital rates based upon data obtained during the present study

Notes on the figures used for the present analyses

Successful breeders: Valued at 80%. Most small farms claimed that female breeders produced clutches every year, however, some larger farms indicated that approximately 20% of females did not breed annually because they had not reached breeding condition.

Clutch sizes: Valued at 30. Clutch sizes vary depending on female size; however, this has been conservatively valued towards the lower end of mean clutch sizes.

Hatching rates: Valued at 80%. Many farmers claimed that they experienced more successful hatch rates; however, the number has been valued at the lowest provided by all farms.

Hatchling sale: Valued at USD 14. Sale prices for hatchlings were quoted between USD 11 and 25 per individual. However, the most commonly quoted sale price was USD 14.

Grown python sale: Valued at USD 70 in Viet Nam and USD 13.20 per kg in China.

Meat sale: Values used are those provided by the individual farm owner.

Python meat mass: According to farmers there is 4 kg of meat on the average python slaughtered.

Gall bladders: Values used are those provided by the farm.

Skin exports: Skin export prices given in Viet Nam varied among python export companies. Some indicated that prices were as low as USD 65/skin, while others claimed average prices of USD 80–90/skin. When queried after all data were compiled, it was claimed that the difference arose due to some farmers providing mean prices over a number of years, whereas others provided prices from the current year. Python exporters provided skin export prices of USD 27.5-32.5/metre. Thus, skin export figures herein are based upon an average of USD 30/metre for a 3-metre skin, which is the mean size of skins exported into Europe (C. Bianchini, pers. comm., 2012).

Export tax: Viet Nam imposes a 5% export tax on each skin exported.

Expenditure data summary

Food costs: Food costs have been summarised in detail in Tables 9 and 10. Specific costs given within the case studies are those claimed by the farmer.

Feeding regimes and unit quantities: Amounts of food offered to pythons and the quantity per unit are provided in Tables 7, 10 and 11. Specific amounts given within the case studies are claimed by the farmers.

Staff costs: Figures used are those provided by the farm owners.

Skin purchases: The farm owner indicated that skins were purchased from traders for USD 25-30/metre depending on quality.

5.0. WHAT IS THE RELATIVE CONTRIBUTION OF CAPTIVE-BRED SKINS SUPPLYING TRADE?

The trade volume data presented in this report have been taken either from the CITES Trade Database (2014) or directly from CITES Management Authorities in source countries. Data obtained from the CITES Trade Database show that since 2005 nearly all imports of *P. m. bivittatus* skins have originated from individuals raised in captivity (Fig. 1). However, the vast majority of imported *P. reticulatus* skins are sourced from wild individuals in Indonesia and Malaysia (Fig. 2). Since 2005, skins from *P. reticulatus* bred in captivity only account for 24% of all trade (2,405,673 specimens).

5.1. China

Chinese python farms produce approximately 40,000 skins from captive-bred *P. m. bivittatus* per year. However, the Chinese domestic market for leather (30,000 skins) and musical instruments (10,000 skins) absorbs all of these skins. In the future, Dosho Python Company may expand its operation to service the international market for luxury fashion goods.

5.2. Lao PDR

Lao PDR has historically exported only small numbers of skins (several hundred). However, since 2009 exports of python skins have risen dramatically (Table 12). This situation is of concern. While the Lao PDR Management Authority claims that only a single python farm is present in the country, there is no evidence that pythons are produced there. Further information on the breeding capacity of this farm, and ideally a mission to verify this is necessary; however, so far attempts to visit the farm have been unsuccessful.

Table 12. Recent captive-bred python skin exports from Lao PDR (Source: UNEP-WCMC CITES Trade Database).

Year	*P. m .bivittatus*	*P. reticulatus*
2009	0	5,000
2010	0	20,000
2011	29,500	96,000

5.3. Thailand

Figures presented within the CITES Trade Database indicate that Thailand's only python farm exports relatively small numbers of *P. m. bivittatus* and *P. reticulatus* skins annually (Table 13). Thus, exports of python skins from Thailand currently represent only a small fraction of all skins exported globally as captive-bred.

Table 13. Recent captive-bred python skin exports from Thailand (Source: UNEP-WCMC CITES Trade Database)

Year	*P. m .bivittatus*	*P. reticulatus*
2009	0	10
2010	1,600	1,176
2011	6,353	1,069

5.4. Viet Nam

Despite extensive legislation and regulations in place in Viet Nam to monitor wildlife farming (WCS, 2008; Thomson, 2008), there is little transparency nationally in reporting of key figures related to pythons. Because of this it is very difficult to provide precise or reliable information on the relative contribution of truly captive-bred specimens originating from Viet Nam.

For example, the significant increase in reported export volumes between subsequent years is noteworthy (e.g., the number of *P. m. bivittatus* skins exported between 2010-11; Table 15). Moreover, the relatively small number of *P. reticulatus* housed within farms in Viet Nam during 2011 raises doubts about the capacity of these farms to produce the number of skins exported annually (Tables 14 and 16). The Vietnamese CITES Management Authority states that the increase is due to the stockpiling and subsequent release of skins accumulated over several years. Although this may indeed account for the observed increase, the present study was unable to determine the veracity of these claims.

Regardless, there are many farms in Viet Nam genuinely raising captive-bred *P. m. bivittatus* and *P. reticulatus*. For example, a conservative estimate of the production potential for *P. m. bivittatus*, based solely upon the number of breeding females personally observed by the authors within Vietnamese farms during the present study is: **3,173** (breeding females) x **0.8** (probability of female breeding in a given year) x **30** (eggs per clutch) x **0.8** (probability of hatching) x **0.9** (probability of surviving to slaughter size) = **54,829** (all values are taken from python farmers, see Section 4.2.1.). However, if Viet Nam does indeed have the number of farms and pythons that are reported, then this figure will be much higher. Therefore, it is entirely possible that Viet Nam is producing the number of pythons claimed, and at this stage there is no evidence to the contrary. However, the possibility of laundering skins from neighbouring countries is very real, so it is critically important that Viet Nam increase monitoring and reporting of its trade figures to CITES to provide verification of its python farming capacity (for further discussion see Section 5.1.2).

Table 14. Numbers of farms and live pythons in Viet Nam as of 2011 (Source: Vietnamese CITES Management Authority).

Question	Southern Viet Nam	Northern Viet Nam
Number of registered python farms in Viet Nam	413	73
Total number of captive *P. m. bivittatus* in Viet Nam	206,946	Unknown
Total number of captive *P. reticulatus* in Viet Nam	30,042	Unknown

Table 15. Vietnamese export data for captive-bred *P. m. bivittatus* compared to CITES records of import and export (Source: Vietnamese CITES Management Authority and UNEP-WCMC CITES Trade Database).

Year	Vietnamese Total	CITES Export Data	CITES Import Data
2009	59,197	68,451	52,320
2010	60,962	96,243	80,608
2011	218,699	197,864	137,621

Table 16. Vietnamese export data for captive-bred *P. reticulatus* compared to CITES records of import and export (Source: Vietnamese CITES Management Authority and UNEP-WCMC CITES Trade Database).

Year	Vietnamese Total	CITES Export Data	CITES Import Data
2009	77,004	95,354	73,097
2010	112,096	111,958	114,581
2011	120,183	121,763	126,916

5.5. Do python farms facilitate the laundering of wild-caught pythons?

Are wild-caught pythons being laundered through breeding farms and exported under the guise of being captive-bred? It is the opinion of the authors that it would be naïve to assume that wild-caught snakes were not still being collected in small numbers. It is likely that people living in close proximity to rural, forested areas opportunistically collect pythons to supplement their captive breeding efforts. This opinion is also held by the Vietnamese CITES Management Authority and the Ca Mau Provincial Forest Protection Department and parallels the observations of Stuart (2005). However, the number of individuals removed by this type of wild collection is likely to be low within China, Thailand and Viet Nam, and it is unknown whether wild pythons are mixed and exported alongside captive-bred skins. For example, pythons are equally likely to be removed from the environment by local people catching them for pets, or killing them for meat or out of fear. Furthermore, the wild python population in Viet Nam in particular is likely to be very low due to habitat loss and historical collection (Vietnamese Red Data Book, 2007), and it is thus unrealistic to suggest that the numbers of skins exported by Viet Nam annually are from the wild.

Wild harvesting of pythons was prevalent in Viet Nam for decades up until 1998. Therefore, an important question is: what happened to the wild-caught pythons when captive breeding came into existence? The answer to this may help indicate the extent of laundering (if any) of wild skins through breeding farms. For example, one might expect that wild-caught pythons collected before farming was established are now being laundered as captive-bred. Although some levels of trade may be in wild-caught individuals, it is unlikely that they form a large proportion of annual captive-bred exports. Trade data for Vietnamese exports of wild pythons have historically been at relatively low levels (approximately 20,000 p.a.) before captive breeding became commonplace (Fig. 10). An annual quota did not limit this level of harvest. It is thus unrealistic to suggest that the presently high levels of skin exports (>100,000 p.a.) from Viet Nam are being sourced from wild pythons (Fig. 10).

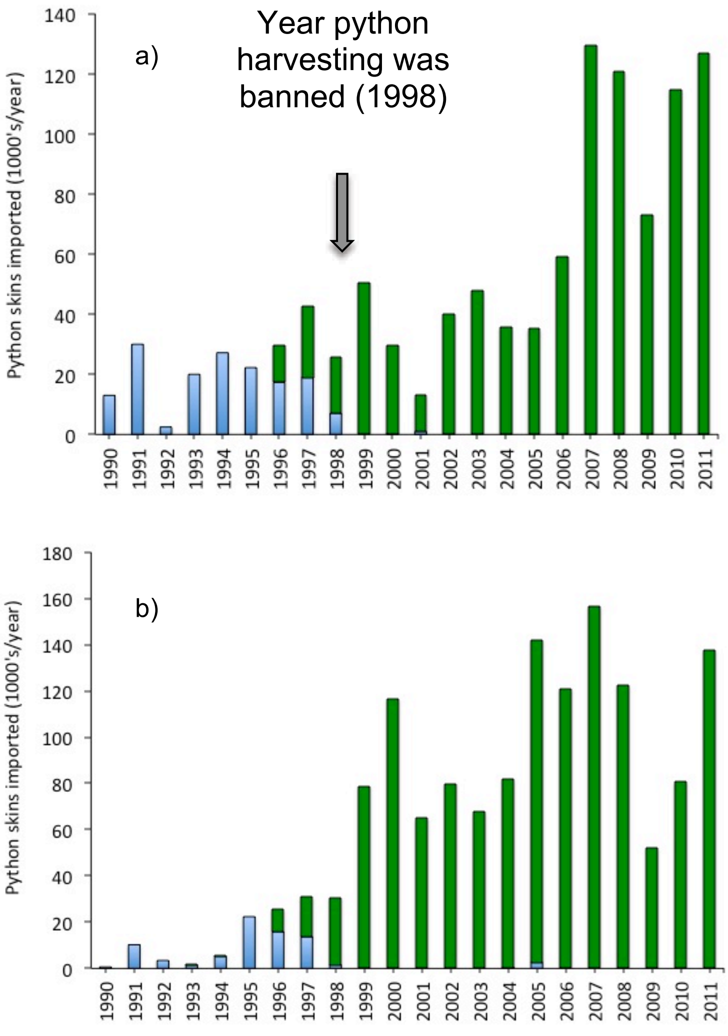

Fig. 10. Reported imports of *P. reticulatus* (a) and *P. m. bivittatus* (b) skins from wild (blue) and captive-bred (green) sources from Viet Nam between the year 1990 and 2011 (UNEP-WCMC CITES Trade Database, 2014).

Internet searches of Vietnamese websites revealed a large number of domestic articles about python farming. The present report located nine such articles with various titles including: “Python breeding experts unbeaten,” “Raising pythons for export” and “Get rich from python breeding” (URL links to each article are presented in Annex III). Is such domestic media coverage further verification of the feasibility of python breeding in Viet Nam? This requires further investigation.

There are reports of a number of Cambodian pythons farms near the border of Viet Nam. Because Cambodia does not export python skins itself, it is possible that these are sold across the porous border into Viet Nam. However, the source (e.g., captive-bred vs wild-caught) and number of snakes sold into the Vietnamese market in this manner remain unknown. Nevertheless, given the ease of breeding pythons in captivity within Viet Nam, and the fact that no live python or skin seizures have been reported at key border areas, skins sourced from outside of Viet Nam are unlikely to constitute a large proportion Vietnamese skin exports.

5.6. Do exporting countries launder illegally collected skins among themselves?

There are anecdotal accounts that wild python skins may be falsely declared as captive-bred and exported among Asian source countries. For example, the sudden increase (Table 12) in skin exports from Lao PDR are cause for concern given that no python farming operations have been reliably reported from that country. Falsifying export claims for python skins – by indicating that skins are from captive-bred sources - may be one way for neighbouring Range States to move skins of wild origin. This may particularly be the case when the Range State has exceeded its national quota for wild harvested skins. Because it is currently difficult to definitively clarify the source of python skins exported from Asia (in terms of source country and source code), it is not possible to rule out the laundering of wild skins as captive-bred. Therefore, countries producing pythons in captivity should endeavour to provide adequate proof that its claimed exports are indeed sourced domestically, and that they are able to link them to captive breeding facilities in the country.

6.0. IS THERE POTENTIAL FOR A RANCHING PRODUCTION SYSTEM TO SUPPLY PYTHON SKINS FOR THE INTERNATIONAL MARKET?

6.1. Background

Ranching is defined by CITES as "*rearing in a controlled environment of animals taken as eggs or juveniles from the wild, where they would otherwise have had a very low probability of surviving to adulthood. In the context of CITES, this term is used mainly in relation to populations of Appendix-I species of animals that are no longer endangered and that are transferred to Appendix II in accordance with Resolution Conf. 11.16 (Rev. CoP15), so that they may benefit from this form of management. In order to achieve adequate controls of trade in ranched specimens, parts and derivatives thereof are identified through a uniform marking system approved by the Conference of the Parties. This system may differ from species to species. Ranched species currently include only crocodilians, primarily ranched for their skins*".

Several reptile species that supply the international trade for skins and leather goods are produced using a ranching system. Ranching has long been seen as an effective tool for alleviating harvesting pressure on wild populations (Hutton and Webb, 2003). It also provides a reliable source of income for local communities and may promote conservation of wild populations as it relies upon selected harvest of these populations (Hutton et al., 2001). The use of ranching for *P. m. bivittatus* and *P. reticulatus* in Southeast Asia has not yet been explored. However, ranching may provide several economic and sustainable use benefits and is worthy of detailed analysis. Moreover, there are demonstrated ranching successes for a number of other reptilian models, which are examined herein.

6.2. Case studies

6.2.1. Crocodiles

Ranching of crocodilians is a widespread management practice, which provides wild-caught specimens for international trade and provides commercial incentives to conserve adult crocodilians in the wild. Ranching of crocodiles has been successful in several countries on different continents with variable socio-economic levels, technical capabilities and crocodilian species. Crocodile ranching has come to be seen as a highly precautionary method of harvesting, because it relies primarily on harvesting eggs and/or the earliest life stages that regularly experience high mortality in the wild (Hutton et al., 2001). Biological studies in the USA, Australia, Papua New Guinea, Venezuela and Zimbabwe all demonstrated that crocodilian populations could sustain moderate harvests, particularly of eggs (Webb et al., 1987; Ross, 1998; Hutton et al. 2001). Associated development of captive rearing technologies and harvesting efficiencies has meant that crocodile ranching has provided considerable benefit to local communities and landowners, and has promoted the conservation of wild crocodiles and their habitats (Webb et al., 1987; Ross, 1998; Hutton and Webb, 2003). However, the conservation benefits of ranching regimes for crocodiles have not been universal. In Madagascar, concerns were raised that traders launder the skins of wild-caught crocodiles in a manner not in accordance with CITES, leading to export restrictions imposed by CITES until better controls and enhanced traceability are put in place (CITES, 2009).

6.2.2. Royal python (*Python regius*)

In 1991, a ranching program was developed for royal pythons (*Python regius*) in the West African nation of Ghana (Gorzula et al., 1997). Densities of royal pythons on farmland in Ghana average 3.3 pythons/ha, and local people “ranch” this species by collecting wild gravid females in December/January and releasing them at the end of April/May after they lay and hatch their eggs in captivity. The estimated annual production capacity of this ranching practice was 20,000 hatchlings (Gorzula et al., 1997). Unlike *P. m. bivittatus* and *P. reticulatus*, *P. regius* are relatively small animals and all hatchlings from this system are exported for the pet trade in Europe, Japan and the USA.

In order to regulate the ranching of pythons, and ensure the conservation status of the species, the Ghana Wildlife Department introduced a number of measures:

- Restricting the number of gravid females that each ranching company would be allowed to collect in the wild for any particular year (In 1996 this totaled 3,540).
- Ensuring that all of the captured females would be returned to the area where they were captured after they had completed laying.
- Insisting that 10% of all surviving hatchlings from each company would be released back into the wild.

Adult wild-caught royal pythons are in less demand than hatchlings because they do not adapt well to captivity and often do not feed. Hatchlings acclimate to captivity within a short period of time. A major criticism of importers is that wild-caught adults and ranched hatchlings are frequently infested with parasites, particularly ticks and mites. This may have a negative conservation effect because of the spread of ticks and mites acquired in captivity by ranched females to wild populations. A 1997 report on the trade of royal pythons found that this trade provided very little direct benefit to people in rural communities, mainly due to the small price paid for hatchling snakes (4 – 10 USD) (Gorzula et al., 1997). Nevertheless, using this management system trade in royal pythons has been ongoing in the West African countries of Benin, Ghana and Togo for more than two decades without negatively impacting local populations (Gorzula et al., 1997; Harris, 1999).

6.3. Does ranching occur for *P. m. bivittatus* or *P. reticulatus*?

Contrary to the data presented in the CITES Trade Database (which indicates that no Party reported trade in ranched specimens of these species), the Malaysian state of Sabah claims to have exported ranched specimens of *P. reticulatus* since at least 2009. However, when questioned further about the details of the ranching program, the Sabah Wildlife Department as well as the exporter and python collectors themselves explained that very few individuals were truly ranched because the collection and skinning of wild-caught animals is relatively easy. During four-months of fieldwork in Sabah by the authors of the present report, *P. reticulatus* were observed being brought to rudimentary enclosures where they are allowed to shed their skin before being slaughtered. This situation does not conform to the definition of ranching under CITES source code “R”, which requires feeding and growth of the individuals in captivity over a longer time period. Interviews with CITES MA staff and python traders in other python range States examined during this study did not reveal ranching approaches being carried out.

6.4. Is ranching of large pythons viable within Asian Python range States?

The biological and economic prospects of ranching *P. m. bivittatus* and *P. reticulatus* varies among countries with wild python populations, and its success relies on several major assumptions:

1) A thorough knowledge of the species’ biology;
2) Adequate monitoring to ensure the system is not used to harvest wild pythons in an uncontrolled and unsustainable manner; and
3) Governance system in place (as described with the *P. regius* above) regulate ranching – related to monitoring, as above.

Any ranching approach for large pythons will be more akin to the system in place for *P. regius* than that currently used for crocodilians. Python eggs are difficult to find in the wild, and cannot be collected in sufficient numbers to supply the trade. Therefore, ranching can be carried out in two ways:

1) Capture of wild hatchlings and sub-adults that are to be raised to slaughter size within a captive environment, and
2) Capture of gravid females that are allowed to lay and incubate their eggs (alternatively incubation can be achieved artificially), before raising the hatchlings to slaughter size within a captive environment.

Any range state can adopt a ranching system for species listed in Appendix II as long as the specimens that are exported have satisfied Article IV of the CITES Convention regarding non-detriment findings and legal acquisition. Experience shows that closely monitored populations of long-lived species of reptiles can sustain legal, regulated harvest of some proportion of eggs, hatchlings, or adults with negligible effects (Harris 1999; Ross, 1998; Shine et al., 1999). The present report suggests, therefore, that although ranching may be viable for both species of python, it would be best suited for *P. reticulatus* in range States that already engage in high volumes of wild harvest of this species. For example, because large numbers of gravid female *P. reticulatus* are harvested annually in Indonesia and Malaysia, there is an opportunity to allow females to oviposit and incubate their eggs before being slaughtered. The resulting hatchlings could be kept and raised to slaughter size themselves. This may provide a conservation benefit by decreasing the number of mature pythons needed from the wild to meet industry demands. Several Indonesian slaughterhouses allow gravid females to hatch eggs before being slaughtered. The traders sell the resulting hatchlings into the pet trade, where returns for juveniles far outweigh the final sale price per skin. Similarly, a slaughterhouse owner in Malaysia allows females to hatch their eggs in captivity. The hatchlings are then released back into the wild to aid population recruitment. He does not raise any snakes to slaughter because he claims that the associated time and cost cannot be recouped from the sale of skins (Natusch, unpubl. data).

Although ranching *P. reticulatus* may be viable, it is important that the following caveats should be considered:

1) Establishment of a ranching approach in Indonesia and Malaysia would require a paradigm shift away from wild harvesting. Because the costs and time involved in ranching are far greater than wild harvesting, any form of ranching would need to be introduced using an amalgamation of wild harvest and ranching systems, as well as an industry commitment toward sustainable utilization;

2) The ranching of royal pythons in Africa is a success because it only requires eggs to hatch before the hatchlings are exported for the pet trade. However, when pythons are ranched for skins they need to be raised to slaughter size. This invariably requires:

    - A thorough knowledge of python husbandry, food costs, and a cultural disposition towards snake husbandry, the capacity for which is currently minimal in Malaysia and Indonesia;
    - The establishment of significant infrastructure in which to house pythons and their food; and
    - A sound governance process for regulating ranching at the national level.

3) Ranching wild individuals has the capacity to increase the risk of introducing parasites and/or disease into the ranched (or raised) population, resulting in lower returns due to slower growth rates and loss of individuals; and

4) If a significant investment in ranching occurred, but failed, it is likely that various other forms of illegal trade (and/or increased harvest pressure on wild populations) would be stimulated to recover investment.

Because many of the costs and techniques used for ranching are similar to those of closed-cycle captive breeding, the natural progression of python ranching is towards true “farming” when/if it becomes economical to breed and raise them in captivity. Because the present report suggests that the economic feasibility of breeding pythons in captivity is sufficiently robust, captive breeding may be a more sound approach than ranching because stakeholders can ensure complete control over each stage in their production system. When asked about the prospects of ranching pythons in Viet Nam, the Vietnamese CITES Management Authority claimed that it would not be feasible for two reasons: (1) there are simply not enough wild pythons in Viet Nam for it to be biologically or economically viable, and (2) the cost and ease of producing pythons in captivity precludes implementation of a ranching approach. These are valid points. In conclusion, despite some potential advantages over both wild harvest and captive breeding systems, the capacity, infrastructure and paradigm shifts needed to implement a robust and successful python ranching program may be impractical to implement in the short to medium term.

7.0. HOW DOES PYTHON FARMING CONTRIBUTE TO PEOPLES LIVELIHOODS?

Wildlife farming has been promoted in developing countries as a novel form of employment and means of poverty alleviation (Revol, 1995; WCS, 2008; Nogueira and Nogueira-Filho, 2011). For local people there are many benefits derived from the production and trade of pythons, and captive breeding has contributed significantly to the income of households and communities (Do et al., 2003). However, some conservationists have cautioned that the benefits of wildlife farming for poverty alleviation may not outweigh the benefits provided from the sustainable harvest of wild populations and may undermine the sustainable development of rural people relying on wild populations for subsistence and the conservation of important areas of biodiversity (UNCTAD, 2011). For example, Indonesia estimates that 150,000 individuals receive income from the capture of pythons (Indonesian Country Report, CITES Asian Snake Trade Workshop)(for more information see Section 7.4). However, while wild harvest can provide significant livelihood benefits, because of uncertainties about continued reliance on wild populations, captive breeding may provide a sustainable income source in countries where wild harvesting is not possible.

7.1. Direct benefits to farm owners and staff – A Vietnamese example

According to the Vietnamese CITES Management Authority there are 414 registered breeding farms in Viet Nam. However, the discrepancies in the python farming data provided by Viet Nam suggest that many farms (particularly small satellite households) are unknown to provincial authorities. Studies of other species farmed in Viet Nam also suggest this may be the case. For example, Brooks et al. (2010) recorded 449 registered porcupine farms in northern Viet Nam's Son La province alone. Given that python farming is one of Viet Nam's largest wildlife industries (WCS, 2008), it seems unlikely that there are fewer python farms in Viet Nam than there are porcupine farms. Therefore, we suggest that the actual number of farms owning and breeding pythons in Viet Nam is higher than records indicate. The southern Vietnamese CITES Management Authority conceded that this was probably true and suggested that there may be approximately 15% more than official figures indicate. Given the number of hatchlings capable of being produced annually, and thus distributed among satellite farms/households, we suggest that the number of unrecorded/unreported farms is probably much greater still.

Inset Box 10: Livelihoods

Breeding and selling pythons is the main source of income for Mr. Pham Ngoc Quang, a 54-year-old retiree from Hue Mon district of Ho Chi Minh City. Mr Pham currently keeps two female and one male *P. m. bivittatus* that produce roughly 50 hatchlings each year. Mr. Pham feeds the hatchlings for two months before selling them for USD 20 each. Food costs for the hatchling are negligible (because he catches rats himself), resulting in a profit of approximately USD 1000 per annum. This is Mr. Pham's only source of income. He lives with five other people in his household and fully supports himself and his wife with the money earned from python farming. This is a common situation in Viet Nam, where python farming is relied upon for the livelihoods of many poor and rural people, not just large farms and exporters.

Python farming in Viet Nam is considered to be economically more lucrative than traditional agricultural practices because it provides cash income (rather than merely subsistence)(Nguyen and Nguyen, 2008). Nevertheless, only five of the 26 Vietnamese python farm owners visited during the present study received an income solely from pythons. The remainder farmed a number of other species including: turtles, tortoises, porcupines, crocodiles, water monitors, monkeys and pigs. One python farmer operated a restaurant in the front of his house and kept 100 pythons in a room upstairs. For farm owners that received income from additional sources, the mean contribution from farming pythons was 60% (range: 10–90%). A figure commonly quoted by python farmers, and published in Vietnamese media articles (Annex III), is that after accounting for the cost of hatchlings and food, farmers earn approximately 40% profit per python raised. In addition to the predicted and actual incomes of python farm owners presented in Inset Box 9, a report by WCS (2008) states that the mean annual revenue for four python farms was USD 15, 987 (range USD 3,950-37,267). This is significantly higher than the Vietnamese annual wage of approximately USD 1,500 (World Bank, 2012).

Inset Box 11: Python farming incentive scheme

Viet Nam has an incentive scheme in place for rural people to begin python farming. The program is administered by the Vietnamese Farming Association (VFA), which assists local people in farming pythons by providing technical support and knowledge on python husbandry, either at the person's house or in the city. The VFA also holds free workshops in major cities to teach python husbandry using information taken from the CITES Management Authority's python breeding technical guidelines for Viet Nam. Finally, the VFA provides a monetary loan of 20 million Vietnamese Dong (~ USD 200) to local peoples to begin python breeding. Payback of this no-interest loan must begin after the first year of breeding.

Despite these figures, the poor understanding of the number of python farms in Viet Nam, and the diversity of geographic locations and farm sizes, precludes determination of the overall direct contribution of python farming to the livelihoods of peoples and communities. Nevertheless, the data presented in Figure 3 in Section 2.7 illustrates the relative importance of python farming per province in Viet Nam.

Inset Box 12: Vietnamese media articles revisited

All the Vietnamese media articles located during this study portray python farming as a means of poverty alleviation and alternative means of employment for rural communities and households. The python breeders interviewed for these articles explain that, unlike other forms of agriculture or production, python farming is easy, not labour intensive, requires very little space and provides relatively high returns. Python farming has also been promoted to older generations and retirees due to the ease of making money from little work. Some farmers explained that they could breed pythons and still work at a full-time job.

Many larger python farms employ staff that clean, help breed, feed and slaughter pythons (Fig. 11). The number of staff employed is dependent upon the size of the farm. Most small farms and satellite households engage family members to keep, breed and feed pythons, and they do not employ any staff. One of the farms/exporters visited employed 25 staff. They are often given food and accommodations in addition to a monthly salary. Python farming is a direct contributor to the livelihoods of families in addition to the individuals working on the farms. Nonetheless, it is difficult to assess the absolute number of python farm staff employed in Viet Nam. Although several large farms may employ >10 people, small scale satellite farms form the majority of python farms in the country, and thus reliance on staff is probably minimal. WCS (2008) reached a similar conclusion in their Vietnamese wildlife farming report. For comparison, the Chinese python farming company, Dosho, contracts smaller satellite farms to raise pythons. The satellite farms visited during the present study were all family run, and it was explained that this is normal in China. Because of this, the Chinese python farming industry employs few staff; however, the direct livelihood benefits to families (and each household) are great.

Fig. 11. Staff at Vietnamese (left) and Chinese (right) python farms cleaning cages and feeding animals.

7.2. Associated industry

7.2.1. Middlemen and traders

The majority of python skin exporters in Viet Nam are located in Ho Chi Minh City. Although some exporters slaughter snakes, others do not, which means they are unable to buy live pythons that are transported from other provinces. Therefore, middlemen or traders visit and buy live pythons from satellite farms in provincial Viet Nam, slaughter them, and then sell the skins to the large exporters located in Ho Chi Minh City. Despite this ancillary industry in Viet Nam, python slaughter and transport is run by a relatively small number of individuals. For example, in Ca Mau, the Viet Nam province with the greatest number of pythons and python farms, there are fewer than 10 middlemen/traders. One middleman indicated that he makes approximately USD 11 per individual when he buys a live python for slaughter.

7.2.2. Rat catchers

Interestingly, in response to high demands for food from wildlife farmers, a number of Vietnamese families make a living as professional rat catchers. This apparently only occurs in certain provinces, such as An Giang and Ca Mau, where local people set traps in order to catch rats from nearby towns and rice fields. They stated that they could catch approximately 150-250 rats per day/night. Current rat prices range between USD 1-2/kg. Given that there are approximately 10 rats/kg, this would equate to a daily income of USD 15-30 – a figure that appears to be relatively high compared to other forms of income generation. In Binh Long Commune, An Giang Province, there are approximately 100 households that capture rats to sell to python farms. Despite this, it is unknown how many families catch rats for a living. However, it is this associated industry that allows python farming to be so lucrative in provinces such as Ca Mau and An Giang. Furthermore, many small-scale (satellite) python farmers set traps to catch their own rats, thus minimising python food costs and maximizing profits. In addition to the economic benefits to python farmers and rat catchers themselves, this industry likely plays a beneficial ecological and agricultural role to communities in general due to the harvest of these pest species, which compete with native species, consume crops and spread disease.

7.3. Food security

Wildlife farming has been promoted to improve food security for rural communities because of the opportunity to consume meat products (Revol, 1995). However, python farms are primarily producing skins to meet demands for luxury fashion items, rather than to ensure basic food security for local people. In Thailand, there is little demand for python meat, and the vast majority is thrown away or used to feed dogs. Several communities in Viet Nam and China consume python meat. Nevertheless, it appears that the meat is consumed as an upmarket culinary delicacy rather than a staple protein alternative. Although underutilized as a source of food security at present, pythons have great potential as a protein source because of their rapid rates of growth and high production efficiencies.

7.4. Attempting to estimate the relative contribution of python farms to household incomes?

Although python farming may be a relatively easy and novel way to make an income in rural areas, what is the relative contribution of python farming compared to other production systems? The benefit to people under the Vietnamese satellite farming system is significantly greater than the self-contained farming system practiced in Thailand because their independence provides more opportunities to make higher profits. Self-contained farms provide minimal employment opportunities because the supply chain is captured by a single facility rather than involving a number of individuals to breed, raise, buy, slaughter, skin, transport and export pythons and their skins.

Arguably, python farming provides income opportunities to considerably fewer people compared to the industry devoted to the wild harvest of pythons in other source countries. For example, assuming that each python farm in Viet Nam was the sole income for ten individuals (e.g., five farm owners and five staff), if there were 1,000 python farms in Viet Nam, this industry would provide a direct benefit to approximately 10,000 people. By comparison, Indonesian estimates for the number of people involved in the capture of 157,000 wild pythons is approximately 150,000 individuals (Indonesian Country Report, CITES Asian Snake Trade Workshop, 2010). However, from these figures it is apparent that for most individuals in Indonesia, python related employment is not their sole source of income. Indonesian figures may also be somewhat exaggerated. In Argentina only 300 people are involved in the production of approximately 4,000 skins from the wild harvest of yellow anacondas (*Eunectes notaeus*) each year (Waller et al., 2011). It should be noted, however, that python farming likely offers a more secure form of income than wild harvesting because of the logistical impediments and other uncertainties involved in the capture of wild snakes.

8.0. PYTHON FARMING: CONCLUSIONS AND RECOMMENDATIONS

The overall and most important conclusion of the present report is that commercial farming of *P. m. bivittatus* and *P. reticulatus* for skins appears to be biologically and economically feasible, and is confirmed as currently being undertaken within several countries in Asia. In other words, it is biologically feasible to breed and raise pythons to the sizes, and within the timeframes, required by trade, and is thus an economically viable business model. Despite this, there remain several uncertainties in export figures provided by source countries. This suggests that there may be cause for concern about the total number of pythons capable of being produced by their closed-cycle captive breeding sources. Earlier studies have shown that, in the absence of strong regulatory measures, monitoring and enforcement, captive breeding farms for pythons can be used to launder illegally collected or traded animals and skins. Therefore, any python breeding farms established for commercial purposes should be monitored by the implementation of reliable certification systems that prevent farms becoming a conduit for illegal activity.

The conservation benefit of closed-cycle python farming to wild python populations remains to be understood and can only be assessed in the absence of continued, unregulated illegal harvest and laundering of wild pythons for farm founder stock. Python farming may confer increased conservation benefits over harvest regimes that negatively impact wild populations. However, commercial production through closed-cycle captive breeding, completely disassociated from the wild, may create commercial incentives favouring extinction (and thus increasing the value of captive stock) rather than favouring recovery of wild populations that could potentially compete in the market place with captive-bred stock. Thus, in the long term, the presence of demonstrably sustainable production systems for pythons (e.g., ranching or wild-harvest) may provide incentive for broader biodiversity conservation and thus greatly outweigh the conservation benefit of purely closed-cycle python farming. In addition, it is unlikely that closed-cycle captive breeding systems will be comparable in terms of the number of people that derive livelihood benefits from participation in this industry, particularly when such operations are self-contained. It is therefore essential that python farming is not promoted in favour of sustainable wild harvesting. A holistic approach to sourcing, whereby captive breeding efforts compliment robust wild harvest systems, is needed to ultimately achieve the social, economic and conservation benefits made possible by this trade.

The uncertainties in the export figures from several source countries (particularly *P. reticulatus* export figures from Lao PDR) are noteworthy and should be investigated further. Moreover, any exports of *Python* spp. skins using a CITES "captive-bred" source code from countries other than China, Viet Nam and Thailand (e.g., Lao PDR, Cambodia, Indonesia and Malaysia) should be viewed with caution because of the absence of evidence that captive breeding farms for pythons occur in these countries.

Nevertheless, although uncertainties remain, closed-cycle captive breeding of pythons can be achieved, and this, and it's associated industries (e.g., rat catching), provide significant income for rural peoples and communities in developing countries. Therefore, instead of implementing measures that restrain trade from countries that are genuinely farming pythons, source countries should be encouraged to expand the capacity surrounding python farming and implement strategies to increase the transparency and governance of this industry. The present report forms an important first step in this process and provides the following specific conclusions and recommendations for increasing the understanding regarding commercial farming of *P. reticulatus* and *P. m. bivittatus* for skins within closed-cycle breeding facilities.

8.1. Key conclusions and findings

Python farming in general:

(1) Pythons can have fast growth rates, and available evidence suggests that both *P. m. bivittatus* and *P. reticulatus* can be raised to the sizes desired by trade (>2 m) within one year using a constant "power-fed" diet of rats, chicken pieces and sausages.

(2) Although the techniques used to farm pythons are very specific and require basic skills training, they are easy to learn and are not particularly labour or capital intensive.

(3) *Python molurus bivittatus* appear to be more suited to captive breeding than *P. reticulatus* because, in general, they are easier to feed, and the majority of pythons being truly bred and exported under CITES source code "C" are *P. m. bivittatus*.

(4) Facilities verified by the authors to be genuinely farming either *P. m. bivittatus* or *P. reticulatus* for skins are currently only located in China, Thailand and Viet Nam, with the majority of farms (and majority of python skin production) being located in southern Viet Nam and Hainan Island, China (97% of all known farms).

(5) There are more humane methods of slaughter than those currently employed by python farmers in China, Thailand and Viet Nam.

(6) The geographic location of python farms plays a role in their profitability due to geographic variation in the costs of labour, staff and python food.

(7) With adequate capacity in place, captive breeding facilities are potentially capable of meeting all current and future demand for *P. m. bivittatus* and *P. reticulatus* skins.

Types of farming systems:

(8) Compared to self-contained python farms, the satellite farming system allows greater numbers of pythons to be raised in a given year and avoids diseconomies of scale by spreading costs and risk among a greater number of stakeholders.

(9) Self-contained python farms require facilities to breed rats and chickens, in addition to pythons, and thus require strict hygiene to prevent disease. Alternatively, python food may be outsourced provided there is an appropriate and reliable food supply nearby.

(10) Establishment of ranching programs for pythons will most likely evolve to become closed-cycle breeding programs due to similarities in costs between the two systems and the unpredictability associated with continued reliance on wild populations.

Benefits to local communities:

(11) Self-contained python farms distribute greater economic benefits to fewer people and communities than python farms that rely upon a satellite farming system.

(12) Although python farming provides income for poor people in rural communities, the number of individuals benefiting from trade is smaller relative to other production systems (e.g., wild harvests in Indonesia and Malaysia).

Sustainability and conservation:

(13) The conservation benefit of closed-cycle breeding farms to wild python populations and habitats remains to be determined and can only be assessed if mechanisms are in place to prevent python farms from laundering wild-caught animals for either replenishment of breeding stocks or direct export.

(14) Closed-cycle captive breeding farms for pythons may undermine rural livelihoods and conservation through sustainable use principles because they do not provide an incentive to protect wild pythons and their habitats, and thus biodiversity conservation more broadly.

8.2. Recommendations

General trade management:

(13) Python skin exports using a CITES source code "C" from countries other than China, Thailand and Viet Nam (e.g., Cambodia, Indonesia, Laos PDR and Malaysia) should be treated with caution until improved data on farms, management and monitoring systems are in place to verify captive production capacities.

(14) To facilitate control and monitoring by national and local authorities, python farmers breeding pythons in China, Thailand and Viet Nam should be encouraged to keep eggshells as evidence demonstrating their ability to breed. These can be collected and destroyed by enforcement officials each year to prevent re-use. Python farms in Lao PDR, and any future breeding operations in Cambodia, Indonesia and Malaysia, should be asked by national authorities to do the same.

(15) It is important that python farming is part of a holistic approach to sustainable trade, which may include management and sourcing from wild harvest systems that promote *in situ* species conservation.

Captive breeding in Viet Nam:

(16) The Vietnamese CITES Management Authority and Provincial Forest Protection Departments should work together to provide verifiable data relating to the number of pythons capable of being legally, sustainably and humanely bred in captivity in Viet Nam to promote transparency and trust within international markets.

(17) Provincial Forest Protection Departments should endeavour to conduct inventories and register all households and satellite farms raising pythons for the skin trade.

(18) The Vietnamese CITES Management Authority should consider making it mandatory for python skin export companies and large farms to provide them with records of all satellite farms supplying them with pythons, and the number of pythons sourced from each, thus enhancing monitoring and traceability.

(19) When available, these data should be routinely analysed by the Vietnamese CITES Management Authority and reported to the CITES Secretariat in order to provide further verification of their captive-breeding capacity.

Captive breeding in China and Thailand

(20) There is higher transparency in the Chinese and Thai python farming systems than in Viet Nam because there are only single companies producing pythons for the skin trade. Strict controls should be maintained in China and Thailand if more/larger farms become established in these countries.

Future research:

(21) Field surveys should be considered in Viet Nam, and neighbouring countries (Cambodia, China, Lao PDR, Thailand), to determine if wild collection of pythons is still occurring, and if so, at what scale and impact to local populations.

(22) Southeast Asian CITES Management Authorities, together with industry and other relevant stakeholders, should research the use of techniques (e.g., stable isotopes) to unequivocally differentiate between the skins of captive-bred and wild-caught pythons.

Farming improvements:

(23) China, Thailand and Viet Nam should consider the recommendations from the study on humane killing of reptiles and employ appropriate slaughter methods that ensure brain destruction.

(24) Industry in Europe and python range States should consider promoting a certification system for farms, linked to a central administration point (e.g., a website), that provides stakeholders with confidence that they are sourcing python skins from verified sustainable, legal and humane sources.

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