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Overview of venomous snakes management in  
captivity, a case study at planet exotica

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## **Abstract**

Snakes yield among the great public a rather bad reputation, often being seen as slimy, devious and unpredictable creatures. One could say that this fear is taken a step further when talking about venomous species. Venom is a powerful tool present in every branch of the animal kingdom. Reptiles, and snakes more in particular, make no exception to it. A great variety of ophidian species around the globe are equipped with venom having diverse use and properties. Concerning snakes, many of the aforementioned specimens are dangerous if not lethal for humans with a single bite. This can result in unfortunate encounters especially in an era where human expansion leads to more and more contact with wild fauna. Still nowadays, many animals are seen in a pessimistic way because of these events exacerbated by medias but also attributes legends and popular culture gave them. They end up suffering from this bad image while they often are just misunderstood animals, more scared of humans than we are of them. Those prejudices with people and the eventual risk they represent makes venomous reptiles challenging species to hold in zoological settings. Some structures like planet exotica still face off the challenge and keep a wide variety of them to present to the public with the hope to change their minds. Keeping these animals requires a lot of attention in terms of feeding, temperatures, humidity but also many different compositions of terrariums where the balance between animal welfare, requirements, security and public visibility has to be found. A lot of precautions and safety measures have to be taken by the people taking care of them on a daily basis, people who need appropriate formation and teaching but also intricate qualities such as discipline and self-control. The danger that these creatures can represent lead them to work in peculiar conditions and with specific telescopic tools, protocols and techniques of handling and cleaning. This paper will expose in more details all the intricacies of such activities after many months working at planet exotica, observing and discussing with the concerned professionals.

# 1 Introduction

## 1.1 state of the snake in the popular mind

Snakes have always had a peculiar relationship with humans, being stuck in a duality between awe and fear. The snake is the founding diety in many civilisations, present in every cosmogony and mythology. He almost always appears under both contradictory aspects, once power of creation and immortality, then deadly monster cursed with knowledge. In the judeo-christian rappresentation he was the tempting demon responsible for the eternal decay of men. Then, in Mesopotamia, Greece, Indian Amercian culture, Africa or Incas (with Quetzalcoalt), the snake was said to have medicinal powers he would exert on the universe. In the past, the mythical rappresentation people had draws its origins from the ignorance of his true nature. It is also responsible from the delay of scientists to study these animals : most of the time the legends took the place of the observation and experimentation to give explanations (J.P. Chippaux, 2002). Nowadays, the snake is still stuck in this strange in beetween, but there seems to be a prevalence of the negative aspects. For every apode animal or who's memebers are reduced, the negative idea stimulus is triggered. They are seen with fear and the message « snake/danger » prevails among anything else. A simple test was once conducted among pupils : they had to express their feelings towards snakes in an essay. Over 75% of the feelings expressed were ophiophobics, slightly under 25% were neutral for about 1% ophiophilic (A.L. Benedict, 1917). Other investigations suggested that drivers would go out of their way to run over snakes on highways (Langeley et al., 1989). The consequences can be tragic and not just for the snakes. In April 2007, a couple in Croatia was hiking with their 18-month-old baby in a carriage, along with some friends. A male friend saw a Long-nosed Viper (*Vipera ammodytes*) on the side of the path and, concerned it would attack them, kicked the snake high into the air like a soccer ball. Unfortunately, the snake landed in the carriage and bit the baby on the chin. The infant died in spite of prompt medical care (Zoran Tadic, pers. comm.; translated from newspaper accounts). The final render is that the conservation of snakes is more difficult than for other vertebrates and even rational discourse doesn't suffice (Gordon M. Burghardt et al., 2011). This is despite the fact that just like many animals, snakes wield their role in the balance of the ecosytem they live in. One of their major role will be to regulate all the populations of the many animals they prey on and even regulate

population of snake themselves for ophiophagus species. Following the house of card theory, if we take out a single specie from an ecosystem, it can collapse as a whole. Further than this, snakes will hunt and regulate the number of rodents for example that could vehiculate diseaeses and feed on the harvests. And yet people persist in fearing and hunting these same animals.

## **1.2 Conservation status**

With all these ideas vehiculated about snakes, it is already hard to approach the occidental public about conservation of such animals. The task becomes even harder in tropical regions and developing countries where some species are real threats, sometimes the responsible of the loss of a father or a brother. Still, among the amount of venomous species, only about 50 are a real concern of public health because of their abundance, distribution or behavior. It is estimated there are about 6 millions snakes's bites every year, half of them followed by clinical troubles of varous severity. The annual death number is about 125 000, mostly in Asia and Africa (hence countries with poor access to healthcare). The majority of the encounters and bites occur during agricultural activities. (J.P. Chippaux, 2002). These accidents and their bad reputation led to very little if no protection at all from the countries concerned, where they are often just pest or creatures to eliminate with events organized specifically for it. This led to very poor conservation and regulation efforts for those species. For instance, there is no conservation for vipers or cobras in Africa. More globally, with a about 550 venomous species of snakes, only 25 are listed on the annexes of CITES (convention of international tarde of endagered species). Most of them are in annex II, which is for animals not critically endangered but would probably become if their trade wasn't regulated. Only one specie (*Vipera ursinii*) is listed in annex I, which is for the most threatened species as it prevents their trade unless it is for scientific reasons for example. 5 species are listed in annex III, which is for species who's integration was asked by a country already protecting the animal but asking for other partee's help to ensure good enforcement. This could be seen as a first step toward improvement but it is still worth noting that for those 5 species the request comes from the 2 same countries (India and Honduras). It is also alarming to see that species considered critically endagered on the the IUCN red list do not appear on any CITES annex (eg. *Crotalus catalinensis*, *Crotalus unicolor*, *Vipera orlovi*...). Then, as cruel as it may seem, the people according attention to these kind of animals also took part in their decline. Snakes, and reptiles

in general are getting more popular as a new kind of pet and many people hold them in terrariums, some even making a living out of the individuals they sell from reproductions. The interest of terraristics for some species led to hunt and gathering of many snake species in the wild for them to be sold. It is then no surprise that these populations are now at risk such as the *Atheris desaixi*, a bush viper endemic of Kenya. This kind of situation causes further problems even if programmes of conservation and reintroduction would be started. First, the people now owning these kind of animals might (and often) have trouble to reproduce them and then keep the offsprings alive. Secondly, for the sake of rentability of material and resources they invested in the animal, it is better for them to sell them rather than sending them back into nature. Thirdly, the genetics of the animal populations might be very badly managed. It can be really hard to know where some individuals come from and which genetics from which population they are carrying. It sometimes goes back to the second problem when an individual is known to have interesting genetics, the owners will only let them go for a good price. Still, reintroduction programmes of venomous snakes is clearly not yet the biggest actions made. Some goals of the people involved in this are to create protected areas and simply put the species into the CITES annexes. Some examples of conservation in situ was the tracking of king cobras in India. Teams of researchers were capturing and putting transmitters on the animals to follow their movements. It was then found that females remained in the same restricted area whereas males were moving a lot more. This kind of study could help to understand the movement and demographics of venomous species and maybe prevent and avoid unfortunate encounters. Ex situ, most of the work revolves around the education of the great public, a role zoological structures should all be taking part in nowadays.

## **2 Overview of species observed**

### **2.1 general taxonomy**

Snakes are part of the vast class of reptiles. Traditionally reptiles are lizards, snakes, turtles, and crocodiles as well as the less obvious groups of tuataras (or sphenodon) and amphisbaenians. But strictly speaking, reptiles are not that easy to define. Phylogenetically reptiles are not an isolated evolutionary lineage like birds. In fact, crocodiles are more closely related to birds than to lizards, so the birds should be part of the reptile class as well. What we call « reptiles » still represents about 12 000 species (Uetz P. et al.,2021). Among them,

snakes, lizards and amphisbenes are characterised by a scaly skin that gathered them in a group zoologists consider homogeneous : the squamates. Squamates started to separate from archosaurians (dinosaurs, crocodiles and pterosaurs) around 250 millions years ago. Lizards started to diversify around this period. The evolutionary radiation (we mean by that the diversification of shapes) answered the adaptation needs to very diverse feeding behaviors : vegetarians and carnivorous but especially the changes in shape and resistance of the preys. It imposed a strong cephalic musculature and adequate dentition. Specialists now agree to say that snakes derive from the varanids, unless they have a common ancestor with them. Particular retinal structures hint that the separation between lizards and snakes was about 150 million years ago. Among the many hypothesis today, it is admitted that the primitive forms were burrowing species who progressively lost their limbs. The reduction of the said limbs strenghtened further the adaptation needs of the bones and muscles of the skull to allow the contention and deglutition of preys. This is how many bones of the skull articulated between each others and became mobile to allow a wide buccal opening facilitating the deglutition of preys who's diameter is far superior from the one of the snake's body. (J.P. Chippaux, 2002) Among the rich variety of snakes, many families developed another powerfull tool for predation and defense : venom. Nowadays, about 2700 species of snakes have been identified with about 550 being venomous and sparse among different families and sub-families.

The *Elapidae* family regroups notably marine snakes, cobras, mambas, kraits, coral snakes and a few other genres. One distinguishable sign are large cephalic scales (J.P. Chippaux, 2002). Marine snakes taxonomy is not exhaustive but it is commonly considered that there are about 50 species of them. Compared to their other relatives, they have a few adaptations to their environment such as a latterally flattened tail. It is supported by elongated vertebral spines both dorsally and ventrally and will allow the tail to function as a paddle, helping the snake in its underwater locomotion that requires lateral support. They are also equipped with valves allowing the closure of mouth and nostrils preventing the entrance of water. Nostrils also presenting a very dorsal localization. These species are only found in the Indian and Pacific oceans in shallow waters, rarely more than 30 meters deep. Their area of repartition then depends on many parameters such as currents, temperature and salinity. Most of them tend to eat fish but some have been observed to also feed on fish eggs or small crustaceans.

Cobras regroup many genres for about 40 species and sub-species. The king cobra is the longest among them but also the world's largest venomous snake with a maximum of 6 meters of length. Cobras are well known for their hood. On each side of the cervical vertebrae, a series of elongated ribs are able to rise under the action of a muscular lever. It then tightens the skin of the neck whose scales spread. An egg shape hood then appears behind the head. When at rest, the « neck » of the cobra is not wider than its head as the hood disappears forming lateral cutaneous folds. This behaviour translates the degree of stimulation or acts as an alarm. It is a signal meant to impress the observer before he eventually gets attacked. The general posture of the cobra at this moment is also very characteristic with up to 1/3 of the body raised. Some species also have the ability to spit their venom. This is a defense system meant to blind and that can substitute the bite. Some species like *Naja nigricollis* are very adapted while some not at all (*Naja melanoleuca*). Indeed, the venom jet has from one species to another a variable trajectory depending on the conformation of the excretory orifice or the venomous canal of the fangs. On the most adapted species, the range can go up to 2 meters. Cobras have very diverse feeding behaviours but they mostly eat frogs and small mammals. They are also subject to ophiophagy (feeding on snakes) to different degrees depending on the species. *Ophiophagus hannah* (king cobra) is highly ophiophagous as its name suggests. Cobras are mostly terrestrial animals but some species also present burrowing (*Naja nigricollis*), arboreal (*Pseudohaje* genus) and fresh water semi-aquatic behaviour (*Boulengerina* genus).

Mambas are snakes generally measuring about 2 meters but that can still reach sizes up to 4 meters. 3 of the 4 known species are green, the last one being dark. They are exclusively African and thus form a small group of congeneric species. The 3 species of green mambas are very arboreal, their body is slender and the tail tapered. When feeling threatened, the black mamba rises, widens a narrow hood and opens wide his mouth whose inside is pigmented in black. Any sudden movement can provoke the bite or the mamba will take advantage of the immobility of the aggressor to flee. These animals mostly feed on small mammals, frogs and lizards. Arboreal species also hunt birds.

Kraits (or bungars) are a group of about 12 congeneric species confined in the oriental region. They have an external morphology very homogeneous : flattened head with small, blacked-



iris eyes, absence of neck, body of triangular sections and widened dorso-medial scales. Kraits also feed on small mammals, lizards and frogs.

Coral snakes present a succession of live colors (red, orange, yellow, black, white) whose aspect vary from one specie to another (simple or double rings). Their name is due to the vermilion red participating to the general coloration. Each specie presents a characteristic pattern of number, relative proportion and sequence of these colors. These particularly showing colors have a warning role towards the observator. Many (eg. *Calliphis melanurus*, *Leptomicrurus* sp.) also rise their tail when feeling threatened, revealing a sometimes very bright red sub-caudal surface. This hinders the attention of the predator. Coral snakes are of relatively small size, not going further than 1.5 meters. Their body is massive, cylindrical, tail is short and their head is egg shaped, not very distinct from the neck. Coral snakes represent about 160 species for at least 10 genera. They can be found in America, Asia, Africa and a few in Australia. Most of them adopted a burrowing behavior. Many can be found in vegetal debris, stones and sand. Still, most of them are not real burrowing animals actually able to dig. Coral snakes are essentially ophiophagous. They bite their prey strongly and do not let go, which ensures a total envenomation. (M. Goyffon, J. Heurtault, 1995)

The *Viperidae* family could be subdivided into two main sub-families: *crotalinae* and *viperinae*. The distinction has been made early on as a simple examination allowed to separate the ones having a loreal pit (*crotalinae*) and the ones who do not (*viperinae*). The muzzle of *crotalinae* presents a loreal region (delimited by the superior lip and a line going from the nostril to the eye). The zone is pierced by a loreal pit whose opening is really distinct even at bare eyes. Further examination allow to see a second opening situated among the anterior angle of the eye, the pre-ocular pore. Depending on the specie, the size, shape, position, general axis of the loreal and pre-ocular openings can vary. The loreal pit opens on two superimposed chambers. The external chamber, the largest, is covered by the epidermal layer in continuity with the one from the head. On the bottom of this chamber is deployed a concave membrane about 10 micrometers wide. It is rich in sensorial nerve endings from the ophthalmic and supramaxillary branches of the trigeminal nerve (supporting most of the head's sensitivity) (J.M. Leston, 2009). The internal chamber communicates with the exterior via a canal and is also covered with the epiderm of the head. These pits are temperature discriminating mechanisms. Other snakes like boids also evolved independently this faculty,

but in the case of *crotalidae* they also have the additional function to detect air vibrations (G. K. Noble and A. Schmidt, 1937). This allows them to spot homeotherme animals like mammals and birds. This pit is sensible to the variations of infrared radiations emitted by any object hotter or colder than its surrounding environment with a degree of precision of 1/1000 °C. It is a very important feature for nocturnal hunt both to spot preys but also avoid predators. Concerning their general anatomy, crotalinae have a stocky body, short tail and a roughly triangular flattened head followed by a thin neck. Their size vary between 0,5 (eg *Crotalus transversus*) and 3,6 meters (*Lachesis muta*). *Crotalinae* mostly feed on mammals of small to medium size (mice, rats, rabbits...) and youngs tend to prey a lot on lizzards. Some species also have specific preys like birds (*Bothrops* sp.) or fishes (*Agkistrodon piscivorus*). *Crotalinae* can be found in North and south Amirica as well as in Asia in many different biotopes. Some members of the family also exhibit the « rattle ». Despite its fame, only the *Crotlalus* and *Sistrurus* genuses posses this crepitaculum. These animals have at birth a peculiar caudal apical scale which will thicken with the first moults. Another scale will developp within this scale with the successive moults and the scale retract at their apex forming the organ. This allows the cohesion of the rattle but also its growth with each moult. Adult individuals can emit with it a sound heard as a continuum from a human perspective. This is a signal meant to discourage eventual predators and threats to not go any further or run away. When feeling threatened, the snake usually starts to ring their tail while folded on itself. If the threat doesn't go away, they will ring their tail louder and adopt an offensive posture. They will rise the anterior part of their body and shape it as an horizontal S. They will do rapid tongue movement and hiss. In this case they are ready to strike but can still opt for the flee option. (M. Goyffon, J. Heurtault, 1995)

The *Viperinae* family as mentioned before, could be easily separated from *crotalinae* as they do not posses any pit organ. In a general manner, *Viperinae* have a massive body, wide head and short tail. Their size range from 0,3 meters (*Vipera ursinii*) up to 2 meters (*Bitis gabonica*). Some species tend to have their muzzle straightened up with some of them being an actual rostral appendix (eg. *Vipera ammodytes*). Others also show peculiar ornamentations or « horns » on the head with variable positions. They can be nasal (eg. *Bitis gabonica*), supraocular (eg. *Bitis cornuta*) or both (eg. *Cerastes cerastes*). The coloration of the scales is very variable but can show some consistences among certain groups. *Viperinae* can be found

in Europe, Asia and Africa where most of them adopted a burrowing style of life, the *Atheris* genus having the only arboreal species. These animals hunt on the lookout and their prey will depend a lot on their way of life. Arboreal species will feed mostly on birds, others will prefer lizards and rodents will some also consume invertebrates. (M. Goyffon, J. Heurtault, 1995).

Many other genera of snakes in other families also exhibit venomous properties like colubridae. The *Boiga* species are known to cause medically significant bites (Scott A. Weinstein, David A. Warrel, Julian White, Daniel E. Keyler, 2011) but we will not discuss them into further details as the structure of the case study does not host any of them.

## **2.2 Venom apparatus overview**

The venomous apparatus is a complex device associating a specialized gland synthesizing a toxic secretion (the venom) and a hurtful device (the venomous fang) able to inoculate the venom in the organism of the prey or aggressor. In snakes, this function is particularly elaborated. Venoms are thought to come from a specialization of the digestive secretions, maybe pancreatic, most probably salivary, ensuring originally the digestion of the tissues. The role of saliva is double : it lubricates the bolus and starts the digestion process. Then, venoms would have developed the ability to kill and immobilize the prey with specialized toxins to facilitate the contention and deglutition of the prey rendered hard with the absence of limbs. It could thus be argued that the role of defense of the venom is accessory, even though it is what concerns humans the most. The evolution of the venomous apparatus concerns simultaneously on one hand the position and morphology of the fang, on the other hand the structure of the gland and venom composition. Generally, it is admitted that the venomous fonction appeared relatively late in evolution and progressively from a differentiation of the salivary glands (J.P. Chippaux, 2002). From morphological and biochemical basis, it is now admitted that the venomous apparatus from the major families concerned had a separate evolution : the proterodont way with *Elapidae* and the opisthodont way for notably *Viperidae*, *Colubridae* and *Atractaspididae*. We could picture an aglyphe snake as a starting point (not having any venomous fang). Proterodonts are snakes whose teeth of the maxillary bone are decrescent in size in a caudal direction whereas opistodonts have their teeth crescent in size following the caudal direction. In both evolutionary ways, the appearance of a groove or a canal along one or many teeth will allow the penetration of the saliva in the prey. According to the species, this will remain a simple gutter (grooved fangs) or will form a complete isolated

duct (canaliculated fang) which will allow the pressurised inoculation of the venom. In both evolutionary ways, the fang will progressively individualize itself from the other teeth of the maxillary. This separation, more or less marked, between fangs and normal teeth is called diastema. Proterodont way privileges maxillo-prefrontal support, which is probably weaker but helps in the prehension of the prey. This evolutionary way led to the proteroglyphe snakes, notably cobras and mambas. The fangs are located at the front of the maxillary bone, they are fixed (non-mobile) and the canal is fully closed. The opistodont way led to opisthoglyphe snakes. The fang is grooved (groove usually large), located at the back of the maxillary bone at the level of the eye or after. This configuration is notably found in venomous *Colubridae* and represents lower risks for humans. In fact, the snakes would have to chew and bite for a moment before even being able to reach the flesh with its fangs. Concerning the prey, the modality of inoculation is also not very efficient as the venom will usually penetrate it by gravity or capillarity during the contention or deglutition. The opistodont pathway also led to solenoglyphe species, a much more advanced configuration typical of *Viperidae*. The maxillary is considerably shortened and carries only the venomous fang with the replacement ones ready to take the place of the one in action if it falls. The venomous fang is canaliculated and can reach quite huge sizes. Consequently, it became mobile around a prefrontal articulation. At rest the fang is horizontal and deploys at the moment of the bite. Concerning the origin of venomous glands, for snakes it is probably a peculiar specialization of labial glands. The evolution of superior labial glands towards more complex glands secreting enzymes would have happened at the same time of modifications of the skull bones, muscles and teeth. Further than the developing ligaments allowing the very wide opening of the mouth, the appearance of a maxillary musculature allows for some species the compression of the glands. For the *Elapidae*, this gland is surrounded by a fibrous sheath. It migrated caudally to the eye, in the temporal region where it appears pear-shaped on both sides of the head. It is a lobulated gland composed of many serous cells disposed in acini. The central lumen is relatively small and the secretions are stocked in cytoplasmic granules before reaching the lumen whose volume will increase. Additionally, accessory mucous glands are disposed along the efferent duct. The efferent duct is linked to the excreting canal which opens at the base of the fang. The expulsion of the venom will be done by contraction of temporal mandibular muscles. The venomous apparatus is quite different for *Viperidae* : the bones of the skull are very loose, allowing the fang to rise forward (but also to swallow larger preys). The fang is

perfectly canaliculated and very long, allowing a profound penetration. A mucosal sheath surrounds the tooth and a strong musculature does the same around the venomous glands to ensure pressurised release of the venom. These muscles are specifically designed for this purpose and derive from temporal muscles. The gland, located in the temporal region, is subdivided in lobes, each having a lumen allowing huge storage of venom. The excreting canal has bulges secreting mucus and opens directly at the base of the fang. Concerning the synthesis of the venom in general : it goes through a rapid first phase before stabilizing, which will correspond to the maximum capacity of the lumen. The time of production is roughly a week but it is subject to many variables. Of course the species and the state of the individual comes into account but other things are to consider. The quantity of venom inoculated can range between 10 and 50% of the whole storage. This is species dependent but also variable with the context of the bite. For instance, it seems that some pit-viper species released larger quantities upon defensive bite rather than predatory ones. Being defense or offense, the venoms can have many properties. It is a complex mix of proteins that could be divided in two categories : enzymes and toxins. Enzymes have two major differences with toxins : the product of their reaction (responsible of the toxicity most of the time) does not have immunogenic properties on the receiving organism. There is thus no specific antibody production possible. Then, their toxicological effects depend mostly on the time during which the enzymatic reaction occurs in the organism rather than the quantity injected. Their effects are thus mostly affected by time. Enzymes in the snakes's venom have different tropism and specificities. Most of the time they can cause cytolysis, accelerate a metabolisme (of phospholipids or glucose for example) but also act on blood coagulation. They can increase the fluidity of the blood causing internal or external hemorrhages or on the contrary cause the formation of blood clots that will cause cerebral or cardiac infarcts to the prey. The venom of *Viperidae* is rich in enzymes and we refer to these kind of affects as hemotoxic and cytotoxic venoms. Toxins on the other hand have the property to set to a specific receptor, most of the time on membranes. Their toxicological effect is thus proportional to the quantity injected and the availability of receptors. Other factor will still intervene like the affinity of the toxin to its receptor or the speed of diffusion of the toxin which is very often linked to its size. Their tropism can be neurologic, cardio-vascular, muscular or undifferentiated. They will cause paralysis, heart or respiratory failure, blindness in some cases. The Venom of *Elapidae* is rich

in toxins and we refer as them as neurotoxic venoms (J.P. Chippaux, 2002). With this in mind, one would easily understand the challenges such species represent to hold in captivity.

### **2.3 Presentation of the structure**

The founder and director of planet exotica, Marc Jaeger, has a long passion with reptiles and snakes in particular. He had the chance as a kid to travel a lot in Africa (Kenya and Tanzania notably) where he could encounter directly the species. He owned his first snake a 5 years old and things never stopped until they were about 400. A choice had to be made between this kind of career or something else and itinerant exhibitions were organized to show the collection. Seeing things were on a good way, he started to look in many different places to settle. The opportunity presented itself in Charente maritime in the south west of France. The city of Royan is a coastal city, very touristic during summer. Among the many attractions, the city hall once invested 10 millions into a glass house. This was the creation of « jardins du monde » (gardens of the world). It hosted a great variety of exotic plants and butterflies. The project never really succeeded and was closed by the city in 2011. It is in 2013 Mr. Jaeger took back the edifice and terrain, completely emptied and abandoned. It took quite some time and effort to put things back on track especially since the authorizations to own and present the kind of animals he had were not the same in France as in Switzerland. In just a year, all the papers and authorizations had to be made before he could finally open in 2014 under the name of planet exotica. For the purpose of covering this argument, the work has been observed in the structure from August 1st 2022 to December 10th 2022. It hosts a huge variety of animals, all reptiles with the exception of marmosets, spiders, scorpions, frogs and the mini farm in the exterior gardens. Many taxa are represented : geckos, chameleons, crocodylians, turtles and many more. Among them, snakes are the most represented in the parc. The director always had a fascination for them, venomous species in particular. Planet exotica now has the greatest collection of venomous snakes exposed to the public in Europe. This kind of statement made people very sceptical at first but now that the structure is installed and has its reputation, it is actually a selling point that attracts people. The reputation snakes have is a double-edged sword in this case. People like to play with themselves and their fear. They will go out to look for them and it seems that their visit actually contributes to their change of mind most of the time. Many of them end up being fascinated by their beauty. Teaching

people about animals suffering from their reputation is one of the main goals of planet exotica and is enforced with many pedagogic presentations. Other principles serve as pillars to the parc such as research and knowledge gathering. The parc once associated with the CNRS (centre national de recherche scientifique, « national center of scientific research ») for studies on the sound and communication based on young crocodile offsprings (*Osteolaemus tetraspis*). About snakes, knowing and developing the best techniques to hold and reproduce them is part of the everyday tasks for many species. In total, the structure has about 364 animals. Venomous snakes are about 107 for 22 species. The numbers are subject to a lot of variability considering deaths, births and arrivals. Leaving the outdoors of the parc aside, the structure can be subdivided into three regions of interest : the tropical glasshouse, the desertic glasshouse and the husbandry facility. The tropical glasshouse is the largest and hosts the species requiring a more humid environment. The edifice is heated to obtain temperatures between 25 up to 38 degrees. Many apertures are available to eventually regulate the said temperature and provide some circulation and renewal of air. The glasshouse is also equipped with foggers that are usually activated once to twice a day, in the morning and in the afternoon. The desertic glasshouse is directly connected to the first one and obviously hosts the species originating from more arid environments. The desertic glasshouse hosts a wider range of species and individuals of venomous snakes than the tropical one. The husbandry facility can be further subdivided : the thawing room is where the freezers containing all the preys are. The laboratory where many essentials are kept : tools, veterinary drugs and material, archives, animal moults etc. The quarantine where animals who just arrived are hosted for observation. The husbandry facility itself is where newborns are held as well as sick animals under observation but also « stock » animals, ready to go into one of the two glasshouses. The quarantine is not visible to the public but the animals in the husbandry are visible from a distance. The majority of venomous snakes are held in the husbandry part.

## **2.4 Species hosted**

The underneath tables are the inventory of venomous snake species present in the parc. Most of them are from the *Elapidae* and *Viperidae* families. Counts were done in October 2022 and according to the major locations. Deaths can occur, arrivals are frequent as well as displacements between husbandry, quarantine and one of the glasshouses. Also, the number

of individuals is not representative of the number of terrariums. Most of the animals are single housed in the husbandry while some can be together up to 4 in the glasshouses.

Husbandry :

<b>specie</b>	<b>Common name</b>	<b>Number of individuals</b>
<i>Dendroaspis angusticeps</i>	Eastern green mamba	5
<i>Crotalus durissus</i>	South american rattlesnake	1
<i>Crotalus adamanteus</i>	Eastern diamondback rattlesnake	2
<i>Naja kaouthia</i>	Monocled cobra	13
<i>Naja naja</i>	Indian cobra	2
<i>Crotalus atrox</i>	Western diamondback rattlesnake	2
<i>Trimeresus popeirum</i>	Pope's bamboo pit viper	1
<i>Bothriechis schlegelii</i>	Eyelash viper	12
<i>Hemachatus hemachatus</i>	Ring-necked spitting cobra	4
<i>Crotalus enyo</i>	Baja california rattlesnake	3
<i>Vipera ammodytes</i>	Nose-horned viper	7
<i>Crotalus vegrandis</i>	Uracoan rattlesnake	1
<i>Agkistrodon contortrix</i>	Eastern copperhead	7

Quaranteen :

<b>Specie</b>	<b>Common name</b>	<b>Number of individuals</b>
<i>Naja kaouthia</i>	Monocled cobra	2
<i>Crotalus adamanteus</i>	Eastern diamondback rattlesnake	2
<i>Crotalus horridus</i>	Timber rattlesnake	2
<i>Crotalus durissus</i>	South american rattlesnake	1



Tropical glasshouse :

<b>Specie</b>	<b>Common name</b>	<b>Number of individuals</b>
<i>Bothriechis schlegelii</i>	Eyelash viper	3
<i>Crotalus durissus terrificus</i>	Cascabel rattlesnake	3
<i>Dendroaspis angusticeps</i>	Eastern green mamba	2
<i>Naja kaouthia</i>	Monocled cobra	2
<i>Bungarus fasciatus</i>	Banded krait	1
<i>Bitis gabonica</i>	Gaboon viper	2

Desertic glasshouse :

<b>Specie</b>	<b>Common name</b>	<b>Number of individuals</b>
<i>Crotalus atrox bisbee</i>	Western diamondback rattlesnake	3
<i>Naja naja</i>	Indian cobra	1
<i>Crotalus adamanteus</i>	Eastern diamondback rattlesnake	1
<i>Dendroaspis polylepis</i>	Black mamba	2
<i>Pseudechis colletti</i>	Collett's snake	1
<i>Crotalus viridis oreganus</i>	Northern pacific rattlesnake	1
<i>Cerastes cerastes</i>	Saharan horned viper	1
<i>Agkistrodon contortrix</i>	Eastern copperhead	4
<i>Crotalus enyo</i>	Baja california rattlesnake	1
<i>Deinagkistrodon acutus</i>	Hundred-pace viper	2
<i>Crotalus vegrandis</i>	Uracoan rattlesnake	2
<i>Hemachatus hemachatus</i>	Ring-necked spitting cobra	2
<i>Naja kaouthia</i>	Monocled cobra	2
<i>Vipera ammodytes</i>	Nose-horned viper	3

### 3 Management of venomous species

#### 3.1 Legal aspects

Considering the potential hazards already discussed, the ownership of venomous reptiles is, as many other species, under regulation. The cases and requirements can change a lot from

one country to another, for example Germany is much more flexible on the concerned species. With this case study, the case of France will be looked into further details. As they are wild exotic fauna, they require many certificate to be held, furthermore, many are classified as dangerous species. The decree of the 21st of november 1997 is a text of law defining two categories of structures hosting non domestic species (structures other than for farming and the sale, transit of hunted species who's hunt is allowed). The document contains also an annex of species considered dangerous : *Elapidae* and *Viperidae* obviously figure on it. Thus, to be allowed to own such an animal the « certificat de capacité » or CDC (which could translate to « certificate of ability ») is mandatory. This document will assess that the person concerned has all the knowledge and technical competences to hold the animal. It ensure the owner knows the physiology, biological needs and welfare requirements of the species. It serve as a guarantee that the animals will be held in decent conditions (or at least that the owners know how they should be held). CDCs can be subdivided in domestic and non domestic categories with yet again different types : CDC of breeding facility, CDC of transit and sale and CDC for the presentation to the public. As the name implies the sale and transit CDC will grant the right to sell and ship the animals legally. The breeding facility CDC will grant the right to hold and breed the animals. Just to be eligible to send a dossier for this certificat, many hours of formation are necessary. The gold standard revolves around 70 hours of formation, subject to variability with regions. Among them, 20 will be theory, 50 of practical training in recognised structures. The candidate also needs practical experience and has to build a dossier to prove his knowledge about the species, its requirements and how to hold it correctly. This will be send to the DDPP (direction departementale de protection des personnes « departmental direction of the protection of people »). This is a regional institution that will examine the dossier, then a veterinary commission will check the installations and the knowledge of the person before delivering the certificate. The CDC presentation to the public can be considered as the ultimate step as it grants the rights of the previous two. It is the one necessary for zoological parcs and concerns fewer people. It is also no surprise that it requires more conditions. In this case, after examination, the DDPP sends to dossier to Paris where a commission is held gathering veterinarians, zoo directors and associations representatives. The dossier will go under another examination and the verdict is sent back to the DDPP where the prefect has the final word to deliver the certificate or not. For a zoological parc, another document will be necessary : « l'autorisation d'ouverture d'établissement » or AOE

(authorisation of opening of the structure). Asking for this document will require the CDC of the rappresenatnant of the structure but alos many other informations such as the aim of the structure (in this case preesentation of the animals), the equipments of the structures, the hours of opening and closure, security protocols and plans as well as conditions of functioning (incomes of water and waste disposal for instance). To make it short, this document will focus more on the structure itself rather than the person like the CDC would. The AOE will also then contain the list of the animals the person is allowed to present in terms of species but also number of individuals of each. The AOE will also be examined by the DDPP and can go under further controls if the structure will host dangerous or protected species. Concerning this, further burocracy can be necessary as endangered species have to be registered on the I-FAP list and will also need CITES documents. I-FAP or « identification de la faune sauvage protégée » (identification of protected wild fauna) allows to identify and register the animals. It is a prevention act meant to reduce stealing, traffic and risks in case of loss. But we will not go into much details about these because as discussed before, there is very few protection for the species we are talking about.

### **3.2 Formations and qualifications**

As mentionned above, formations are necessary to own a venomous specie of snake. Technically, anyone with of course the knowledge and skills for such kind of contention and maintenance can teach it to someone else. But to be recognised as legitimate in the dossier of a candidate, he shall go through a structure recognized as a center of formation, held by people already having their CDC. Some third party can be involved in certifying your structure as center of formation with for instance « qualiopi » working around 32 criterias. Planet exotica takes part in this kind of formation and seldomly hosts a few people hoping to get their CDC. The part of the formation they cover here is spread on two full days. 3 people in planet exotica are habilitated to work and manipulate venomous species and other renowned specialists join for the time of the formation. It still contains a part of theory but is mostly about practical training. The activities are planned in advance to make sure everyone will be able to make the most out of it. For instance, further tables, material and transport crates were prepared in the laboratory and husbandry part to ensure avialability. Also, nearby the entrance of the laboratory an iron hutter was put down, thus creating a safe and isolated zone not accessible to the public. This zone was covered temporarily with carpets and then used for

manipulations with the animals. It allowed more space for manoeuvre and safety (considering the number of people present) but also less stress and trauma for the animals. As much topics as possible are covered during these two days and people are split into two groups of about less than 10 people. This allows better management but also better teaching as they are separated according to their skill level : one group more advanced than the other. This also allows more safety and efficiency as the professional obviously stays at all times with the trainees in case anything bad happens. During the manipulations, the professionals will be here to ensure safety and tell all the rights or wrongs of the trainee. For instance, when teaching the 2 keepers of the parc working with venomous snakes, the director Mr Jaeger starts by observing the attitude and skills with « regular » snakes. Then a first try for something minimal can be done with venomous. It is important to go step by step and when the time comes for true manipulations they are done under rigorous observations. He will stop on every little detail not fully respected and will eventually go a step back into the process to make sure everything will be learned correctly. It can be easier to teach someone who had no experience with venomous snakes before because he will be blank on the way of working with them and with this in mind he can be taught correctly with the right reflexes. On the other hand, someone with previous experience might have bad attitudes that will be harder to forget. Concerning planet exotica, another aspect is interesting to note : one of the keepers working in this sector was chosen because of his reluctance to work with them. This can seem confusing at first but the thought process is that someone with such apprehensions will be much more careful and diligent. It happens that people carrying a lot of interest for these species take too much confidence with them to the point of forgetting good practice and protocols. In fact, the state of mind and the temper of the person themselves are capital. One needs to be very diligent and skillful and before touching on the venomous subject, he is observed to see if he executes orders and protocols correctly. These will be crucial when working with dangerous animals. The person needs to be both calm but reactive when needed, have a good self control. An aspect that can't be left untouched is the physical shape of the person. When manipulating snake, someone has to be able to carry them at the tip of the tools, be able to manoeuvre smoothly to not let the animals fall (this will be discussed into further details later). Lesser known but yet important : the state of mind of the person. He or she needs to be in a correct, motivated mood towards improvement. It sadly happens that people with dark thoughts end up committing suicide with the beast they own or work with.

These kind of tragedy make a lot of noise and then end up in the medias and newspaper than contributing to fill in the bad reputation of these animals, which is the opposite goal of zoological structures. Lastly, being mentally healthy or not, more or less skilled : « they are never ready ». Although there will be similarities between some non venomous and venomous species or between one venomous specie and another, the person will always keep learning.

### **3.3 Terrariums composition**

The way animals are hosted is also subject to protocols or even laws to a certain extent. The decree of law of the 25 march 2004 states the general rules and characteristics of permanent zoological structures presenting their animals to the public. It goes through a lot of requirements such as security, public education, conservation roles of the structures but also the way the animals will be hosted, in this case terrariums. It will have to respect general characteristics such as first of all preventing entrance and escape. It has to prevent the escape of the animals inside for the safety of the workers and the public but also the animal itself. Snakes should not be underestimated in their abilities to crawl, lift or slide objects. Concerning entrances, the terrariums has to prevent the ingress of any other animal, especially predatory one or pests that could vehiculate diseases. In a more general way, the text of law states that the animals inside should not even be disturbed in any way by outside animals. In planet exotica, most of the terrariums are composed of a base, cieling and 4 windows as lateral surfaces. The one facing the public and keepers carries the signaletics of dangerous and venomous animal. In the husbandry and quarantine, the surface facing the keepers are two windows that can slide on each others to create the opening. The security is granted in many ways. To begin with, the windows are basically made out of two, sticked on each others with a thin transparent plastic membrane in between. This means that in case anything breaks the glass, it will not shatter and crate an opening. It will crack but remain in one piece, attached to the plastic. Also, any window has a doble security before it can be opened. First comes the lockers from which only the keepers abilitated have the keys. Then the terrariums in the husbandry have a twisted metal stick holding the windows closed that has to be manually taken off to allow the glass to slide. In the glasshouses, the windows require a suction cup to be opened. They will be placed on the window and act as the handle to completely take it off. In the case of venomous snakes, a window taken this way can

eventually even act as a shield. More than this, glasses allow a good visibility for both the keepers and the public. Still, usually the back side is covered for the esthetics and tranquility of the animal but we will go I to further details about this later. Glass is also simple material to clean and compared to wood for instance it doesn't allow the proliferation of parasites. It is still important to provide some openings in the terrarium to ensure a good circulation of air, otherwise microorganism proliferation can be fast (especially considering substrat, humidity and temperature). Usually, there is one opening on the top and one on the bottom. About the size, general reccomandations exist, we usually stick to at least 2/3 of the total lenght of the animal but snakes usually being very shy animals, specific cases exist. In the case of juveniles for examples, a space too vast with not enough hiding spots can lead to stress. The terrariums will then of course be equipped according to the needs of the specie. The temperature partially maintained by the general heating of the glasshouses. Further isolation can be done using polyester pannels. Still, lamps or heating carpets can be provided. The lamps are placed at one extremity of the terrarium which will be referred a the « hot spot ». The hot spot will be at the « preferential mean temperature ». Snakes are ectotherms animals, which means they do not regulate metabolically their body temperature. Theirs will vary with their surroundings and they will regulate themselves behaviourally. Their optimal temperature usually ranges between 28 and 30 °C, temperature that they will seek at their hotspot, usually set at their optimal temperature plus 2°C (P. Gérard et al., 2009). The acces to heat should never be direct as they have a poor sensitivity to the burning sensation, especially on the ventral surface (due to the fact that in nature, heat comes mostly from the sun so from above and not from an object). The lamps are thus not directly accessible and covered with grids to prevent injuries. If they get too hot, they will be able to cool themselves by going away form the hotspot or in their water bowl. The water has to be replaced frequently to remain clean as the snakes can bath in them but can also excrete their feces in. With the high temperatures, it can quickly turn into microbial cultures which is to avoid. The bowls are also changed frequently and left to bath in vinegar, bleach and rinsed before being re-used again. Water bowl with their evaporation also contribute to the hygrometry (amount of water in the air). The terrariums are seldomly watered for this purpose but also for the plants inside but it is important to not abuse of this. A substrat with too much water can lead to pathologic conditions such as necrotic ulcerative dermatitis on the ventrals surface. If the hygrometry is insufficient, it is better to increase the size of the water bowl rather than watering more. Both

hygrometry and water bowl contribute to the good on going of the moult. Snakes will moult (lose their old skin) regularly, the frequency depending on the species and the age (younglings grow more so moult more often). A snake about to moult can be identified by his dull colors and palish eyes. They are most likely to bath during this period to help the skin to get off. The skin going off in one single piece is an indicator of a correct moult and humidity. The other general aspects of the terrariums will help the moult. Having hideouts, plants, rocks will give points of anchor to the snake to take off the skin. These elements should still not be random. They have to fit the behavior and ecology of the species. Higher terrariums with lots of branches are made for arboreal species like *Dendroaspis dendrolagus*. More rocky surfaces, sand and fewer vegetation fit desertic species like *Crotalus adamanteus*. It is really important to have places to hide because snakes are very shy and can be easily stressed. This is thus also important to keep in mind the number of individuals in one terrarium and have enough place and spots to hide. The ideal hideout should be stable, of adequate size, adapted to ecology of the species, easy to clean and still allow the keepers to see the snake. The substrate also has a lot of points to cover at it both has hygiene, welfare and esthetic purposes. Placing more substrate at the back of the terrarium can give the optic illusion to the public that the terrarium is wider. It will also give a bit more space to the animal. Sand can seem like a good option but it will only be used for species actually living in it like *Cerastes cerastes*. Otherwise, the grains can be ingested with the preys accidentally and create lesions on the mucosa of the mouth. Shards of bark appear as a much better option for many tropical species while pebbles can do the job for other species of more tempered regions. The shards of bark will keep a good amount of humidity and compared to potting soil, they are much less prompt to host parasites. The shards still have their limit : for very young individuals, and accidental ingestion with a prey can give gastrointestinal occlusions (P. Gérard et al., 2009) . This is why very young snakes are kept on paper towel for a moment in the husbandry part of the parc. Animals who just arrived have the same treatment for their time of quarantine as it allows to spot eventual parasites much more easily. The terrarium can be considered as the basic unit of work in planet exotica, then come a lot of rules.

### **3.4 Tools, equipment and protocols**

Any animal kept in captive environment will require some form of attention but many other things are to be considered in this case. As already discussed, the people working with them have to meticulously respect some good practice rules and have to be aware of them. A first simple rule is of course that only the habilitated people will handle the tasks related to these snakes, consequently only these people have the keys to open their terrariums. Still, a rule of thumb is not to work completely alone. They work in pair, with someone in their vicinity or at the very least with a talkie-walkie in them to be able to call for help in case of any problem. Still, working with someone around has a flip side. The person opening a venomous terrarium has to be aware of its surroundings and make sure no one is too close or putting himself at risk. A golden rule for the others is to never ever pass behind the keeper when the terrarium is open for their own safety but also to leave the field for the venom worker to back off in case. The person passing should always wait. It is also important to not distract the keeper working, avoid talking to him and respect what he says. Then, before opening any terrarium, it is crucial to know where the animals are : the keeper spots the location of all the animals present inside and with the case of snakes it is also better to know where are their heads (the position in which they hide can often render it harder than we think). A second rule directly related to the position of the animals is to always keep your eyes on them once the window is opened. Even when catching a tool or anything else, the care takers should know at all times where the animals are and what they are doing to react accordingly. The keepers thus work with a « venom » chariot with the necessary tools on it. There is one for the husbandry and one for the glasshouses with further material available in the husbandry, displayed on some walls. Starting from basics, the chariot has a suction cup to open the glasses as mentioned before. The chariot has basic hygiene products such as vinegar, it can be used to clean the windows of terrariums. This is important for hygiene and esthetic reasons for the public. A lot of attention has to be given in some cases, like when the windows are flipped. Regularly, the keepers flip the windows exposed, meaning the side facing the interior of the terrarium will now be in the exterior. The windows have to be correctly cleaned as it is not excluded some traces of venom will be left, especially in the cases of a spitting specie like the *Hemachatus hemachatus*. Coupled with vinegar, they carry at all time disinfectant. This will be used on all the tools when switching from one terrarium to another to avoid diseases transmission. Getting into the more specific, the keepers have protective equipments they shall wear at all times as soon as they plan to open a terrarium. It includes a pair of special gloves designed for



this purpose. These gloves are made out of really strong material (kevlar) and are designed by specific brands such as « snake professionals ». They cover the whole hand and part of the fore-arms almost to the elbow. They are meant to withstand the bite of several animals with of course snakes so another rule is to always have them up when opening a terrarium. The same goes for the greaves, also made out of reinforced material. They will cover the upper part of the shoe and the leg up to under the knee. Then, any keeper (even not working with venomous species) should be wearing security shoes with reinforced tips. One last specie specific equipment to consider is the visor. This one should be equipped when working with the *Hemachatus hemachatus* for his spitting abilities and blinding venom. These equipments are crucial to the safety and something to consider carefully also in the budget. For instance, the greaves range between 150 and 200 euros while a pair of gloves is about 500 euros, has to be imported from the united states and a new one is usually bought every year. About the rest of the material, consider that everything will be elongated and telescopic, the goal being to keep as much distance as possible between the animal and ourself. Actually, nothing in general protocols forbids to handle a venomous snake with your bare hands but planet exotica requires to work with tools even with the gloves equipped. The hook is the basic tool in the handling of snakes. It is a rigid metal rod with a non sharp nor pointy hook at one end and a handle at the other. They exist in different sizes as they are meant to adapt to the diameter of the snake's body to displace or carry it. « snake catchers » also exist, they have a clamp at one hand that can be closed manually with a trigger on the other extremity. They technically can be used to grab snakes but it's not the optimal choice for their safety and stress so keepers actually use them to grab objects in terrariums such as water bowls or moults. A home made tool are the telescopic spoons : a simple spoon attached at the end of a stick, this is used to collect faeces and dirty substrat around. Some other tools exist but are mostly used in specific scenarios like the pinner. This tool has its extremity shaped as a « U » and a rubber band is tensed in between. It is used to block the head of the snake when it is on the ground to then catch its neck for examinations for example. The same goes for the tubes. They are transparent tubes (of different diameters to fit the specie) in which the snakes can be inserted. Once the head is in a tube, it will render it harmless and the tubes can be moved along the body to expose only a desired surface for an examination once again. This is mostly used for veterinarian interventions as it is very complex to place the animal in the tube. Going back to the equipments of the chariot, keepers carry a trash bin and small plastic boxes for waste

disposal. Regular cleaning might seem a harmless task at first but yet again attention is needed. All the feces collected and dirty substrat are put in trash bin and are never touched directly and are only collected with spoons. In fact, it can happen that some snakes break or loose their fangs. In those scenarios the fang either falls but they often swallow it and it ends up in the faeces. It is important to keep in mind that a fang can keep traces a venom for quite a long time so they are still dangerous and the different laws and regulation do not state anything in particular for this peculiar case. Planet exotica thus set its own rules by sticking to its general good practice of never touching directly the animals or their surroundings. The faeces are picked up and thrown away, the fangs and moults found are picked up with clamps and placed in plastic boxes to be shown to the public with a pedagogic aim. These same rules apply for a complete clean up and disinfection of a terrarium with no more snake inside. It has to be done wearing at least plastic gloves and using a small shovel and brush to collect the substrat. Lastly, the case of incidents like escapes needs to be adressed. For the quaranteen and husbandry, they have multiple doors to access them so the snake shouldn't be able to cross them all and the animal shall be retrieved with the standard methods of handling and the problem of how he escaped is adressed. If the snake escapes while keepers are working in, they should follow the orders of the keeper in charge of the venomous, even if he says to leave him and close the doors. If an animal from the glasshouses escapes, the parc has to be evacuated before anything else (the structure is conveniently equipped with microphones). The worst case scenario of accident is of course the bite, which never happend in planet exotica. Emergency numbers are displayed and avialable : standards numbers for emergencies in France, CAP (centre anti poison « anti venom center ») of Angers and Marseille, BSA (banque serum antivenimeux « antivenom serum bank ») and even emergency helicopter transport. If this ever happens, the very first thing to do is to put the snake back in his terrarium or a transport crate with the appropriate tools to avoid another accident. If not possible, the snake can be put down using a CO2 foam extinguisher. The victim has to be calmed and layed down, then the emergencies number can be called. The latin name of the animal has to be given to help establishing the cure. A potential bandage can be made but it doesn't have to impair the circulation. In fact, any potential tourniquet has to be taken off like rings or belts. Processes such as aspiration, incisions, cauterizations, suction systems are urbans myths and are not to do. Actually, « aspirations » of the venom could just give another victim as the mouth is often prompt to micro injuries in which the venom could reach the

blood vessels. Administration of anti-venom on the place of the accident rather than in the hospital is to avoid. It can not even be done in planet exotica as the anti-venom are not directly available. It seems to be in the popular mind that a bite can be cured easily with the right anti-venom but the situation is not so easy. Anti-venom production is a very niche field, leading to complications. For instance, products have been developed in Asia for the species present locally. But the processes were not made according to European standards. It would thus need a kind of « equivalence » to be accepted in France. But the french organization that would need to do it doesn't have the necessary funds to do so since it is quite expensive. So asian anti-venoms are basically unavailable in France. For Australian snakes, the doses are manufactured locally. They are already expensive per se but the shipping adds to it as it has to be shipped in specific refrigerated containers. Also, a single dose costs about 8000 euros and several doses are necessary to only disengage the life prognosis of the victim. For many reasons, it is better to follow the practices listed above when working and manipulating these species.

### **3.5 Handling**

Some handling rules have already been quickly mentioned before. One of the standard rules is to always keep your eyes on the snake and use the appropriate tools and methods. In general, we want to adopt a calm behavior to avoid stressing the animal too much. The more a person will be confident, the less stressed the animal can be. The movements with the tools have to be smooth and we have to avoid as much as possible collisions as these animals can be very sensitive to vibrations. Being calm is the starting base, but the keepers need to be reactive if necessary. Snakes can be very evasive and fast creatures and a mistake can be unforgiving with venomous species. Being able to adapt and switch to a more fast-paced behavior can sometimes be necessary. This has also to be incorporated to the species specificity and individuality of animals. In fact, when manipulating snakes in general, we can find similarities from one species to another but some still have their uniqueness. Cobras for instance tend to be easily impressed and will try to bluff on the first occasion by deploying their hood and attempting to strike. They also have a good eyesight compared to other snakes so they are much more reactive to the sight of the handler. On a different note, species like *Crotalus horridus* are harder to manipulate because of their scales composition that makes them a lot more slippery and harder to carry. Further caution is necessary for *Deinagkistrodon*

*acutus* as they can strike from behind a hiding spot with a parabola trajectory. Things can further change with individuality of the animals. Some can be more easily stressed, more relaxed and much more. People working here witnessed a cobra constantly seeking at striking a blue element. Concerning the actual handling techniques, all should be done only if necessary for their well being and safety reasons. A snake can be moved or taken out if he has to be transferred, if the terrarium has to be completely cleaned or if he needs medical care. Manipulations can be free handing, tailing or with hooks. Free handing is pretty self-explanatory, it is done with bare hands but this technique is not used in planet exotica for venomous species as the risk is too high even with equipments. The tailing is a technique in which the weak hand of the keeper will grasp the tail of the snake at the level of the cloaca. The strong hand will have the hook carrying the snake a bit behind the neck. When grabbing the hook, part of the handle is placed underneath the wrist to give strength and stability when lifting the animal. The starting point of this technique is, with the hook, approach the tail of the snake from yourself. If the snake is on the ground, keep yourself behind him and turn around according to his movements. Place the hook on the ground under the lower jaw and let it slide under the ventral surface until the half of the body more or less. Then the hook can be raised to grab the tail. This allows to remain standing up and not lower yourself to the level of the snake. Then repeat the process with the hook and raise it when behind the neck. This technique allows to somewhat « block » the snake by gently holding its tail. It also gives him two holding points and prevents him from twisting, falling or breaking his spinal cord (which can happen when taking a too centered point of anchor). Lifting the animal should be pretty fast and smooth as if he sees himself still close to the ground he will try to reach it. If the snake starts facing the keeper or tries climbing along the hook towards him, he can just lower the hook and the animal usually replaces himself. The same rules and concepts apply for the manipulation with double hooks which are the most used ones. Keepers just need extra skill and experience as this time the tail is free and his movements are less impaired. Manipulations with a single hook are possible but have to be expeditive and decisive. When lifting correctly the snake with a single point of anchor, he can just round himself around it and can be carried. When lifting a snake with a hook, it should always be oriented towards the ground or at least horizontal, never with the hook higher than the handle. This is to avoid the snake falling off the hook and sliding along the metal pole directly toward the hand of the handler. This constraint implies a minimum of physical condition to keep your arms and shoulders firm

when trying to reach an elevated terrarium. As mentioned before, clamps can also be used but they are not the best for animal welfare and might stress the animal, making the manipulation harder. With all these manipulations, snakes can be displaced in their terrarium or taken out. When out, venomous species are placed in boxes then sealed. A signal panel is placed on it to prevent accidental openings. It will indicate the presence of a live, venomous animal and the name of the species. For veterinarian interventions, the animals can be placed on the ground on a foam mattress. Then the pincer tool is used to immobilise the head. The animal is then grabbed right behind the head and another keeper can hold and support the rest of the body. Then, if an animal got aggressive or on the defensive after a manipulation, watering him a bit can calm him down as it will lower his body temperature. Other tricks and installations can be used to render some work easier or safer. Simply luring the snake on the opposite side of the glass to be opened can work. More complex, in the *Dendroaspis polylepis* terrarium has been installed a metal shutter that can completely separate it in half. This can either isolate each of the two individuals in one part or both on one side. A nicely welcomed precaution for the fastest snake on the ground. Still, this kind of installation is quite expensive with a budget of about 1600 euros. Lastly, the training is something that can hardly be used for snakes. We could say to a certain extent that they can be somewhat habituated or at least anticipate some events. For instance they can know that at a specific hour the only thing that will happen once their terrarium will be opened is just a change of water bowl. Moreover, their feeding behavior makes the typical training methods (working around food for positive reinforcement) pretty much obsolete.

### **3.6 Feeding**

The feeding is a crucial part for any animal in captivity and for venomous snakes it is also a moment of close contact to be aware of. We briefly discussed before the feeding behaviors of the species present in Planet Exotica. The preys ordered by the structure are provided by « Saint Laurent », a company specialized in delivering products to zoological structures. All the venomous snakes will feed on rodents. Rats and mice are available at different states of maturation allowing a greater diversity of sizes to fit the one of the snake. Feeding them with complete rodents also means they won't need UV complementation with lamps. They can be subdivided into different tiers according to the said size and weight : 5 to 8g, 12 to 20g, 25 to

35g, 50 to 90g, 150 to 250g. Still, the expertise and judgment of the keepers comes into account as the preys are not very strictly calibrated by the provider and a small « big rat » can be a big « small rat ». When received, they preys are already dead and frozen. This is better from a technical point of view as the keepers do not need to run an entire breeding facility and they can just conserve the rodents frozen and sorted out. Dead preys are also better from an ethical and security point of view. It avoids stress to the prey and lots of potential injuries. The rodent could out of self defense bite the keepers or the snake. It can also happen that if a snake refuses to eat, the rodent ends up killing the snake. The worst case scenario of accident would be that while attempting to bite a moving prey, the snake misses and strikes the keeper instead. The feeding of the venomous snakes in planet exotica is about every 10 days (recently more). On these occasions, the preys are left to thaw in hot water during the day and the feeding occurs in the evening for the simple reason of having the parc empty. Opening terrariums for such kind of things is not feasible and too dangerous with visitors around. The standard cautions for venomous snakes apply for the feeding, especially as they tend to anticipate it thanks to their strong sense of smell and some are already in position when the keepers arrive. Rations were made by the director and are adjusted with the keepers observations. The preys are presented to the animals with clamps and the keeper will wait for the strike. Even with dead preys, they keep the instinct to strike and inject their venom as its elements can also be important for digestion. Already here, many species specificities are to be considered. Cobras react a lot to movements so it is better to move slightly the prey when presenting them. A challenge with them can be in terrariums hosting several individuals. Their ophiophagus tendencies can lead to conflicts (note that the issues will not be envenomation as a specie is immune to its own venom). They thus have to be separated if necessary, feed them quickly, give enough quantity and stay for surveillance while they swallow the prey. If one finishes before another, the keeper makes sure he will not interfere. When striking, cobras will keep the prey in their mouth (because their venom is usually very fast-acting), so if an individual in single housed, he can be left alone and another prey can even be deposited. *Viperinae* species will rely a lot on smell and movement, once they struck, they will wait a moment before swallowing the rodent. This wait coincides with the time it would take for the venom to neutralize the prey in nature. Further preys can be left in the terrarium in those cases. *Crotalinae* species rely on their pit organs to spot their preys but dead preys will not produce any heat. This is why in those cases they are dipped in hot water before being

presented. As for *Viperinae*, they will leave the rodent lying on the ground for a moment before swallowing it. For arboreal species like *Dendroaspis dendrolagus*, preys need to be presented directly. Arboreal species keep their prey in their mouth when striking because letting them go would mean the prey falls on the ground and the snake would be vulnerable trying to reach it. For *Dendroaspis polylepis*, keepers make sure to turn their light on as it is mostly active during the day (the feeding occurs in the evening). Once the feeding is completed, a surveillance tour can already be made or it should be done at the very least the day after. The preys not eaten should be retrieved for hygiene and esthetic reasons. The law still doesn't say anything about the disposal of the preys struck with venoms so utmost care should be taken with them. Also a prey struck can only be given to the same specie to avoid the venom effects. Refusals and regurgitations are not very common but can still happen for many reasons. An animal can refuse to eat if he is too stressed, too hot, seeks mating or is about to moult or lay eggs (they squeeze the digestive organs).

### **3.7 Management of the collection**

Births and arrivals are usually warmly welcomed events. Both of them as well as deaths and departures need correct management to have an overview of the animals present in the parc but also stick with regulations in place. This is also why a complete inventory of the animals present in planet exotica is made every month. Concerning deaths, the corpse of the animal should be retrieved as soon as it is spotted to avoid pathogens proliferation which we already described as enhanced with the thermal and hygrometric parameters of certain tarrariums. Sick animals are usually isolated in quaranteen or husbandry part at planet exotica so they can be observed more easily. But, with the general behaviors of snakes (tendencies to hide and not to move a lot), it can be harder to identify a dead animal so this is why the routines tours and check up are very important. The general rules of manipulation still apply with a dead animal as other snakes can be present in the terrarium but the dead animal itslef remains dangerous in the same way we mentionned already with fallen fangs. The corpse is placed in a rigid plastic box in which will be joined the death scheme. The box still has to be manipulated with plastic gloves, this time mostly for hygiene purposes and avoid diseases transmission. The paper identifies the animal with the specie's common and latin name, chip number, state of the corpse, date and hour of death. Pictures of the animal are taken when he is found and when examining the corpse. The director of planet exotica will conduct the examination,

take eventually further pictures or samples to find the cause of death of the animal. These will be sent to a specialized veterinarian. The corpse is then placed in a freezer for this purpose. Different bodies are kept here until a knacker comes for them. Still, this is not all the animal's final destination as many will be retrieved by a specialized worker making skeleton models then used for pedagogic display in the museum parts of planet exotica. A transfer document still has to be made in this case. Concerning births, first of all, the breeding is controlled with the placement of animals. If no reproduction is wanted, animals are single housed. Otherwise some can be put together just for a moment until breeding is observed. Those reproduction have to be regulated as documents such as the AOE state the number of animals a structure is allowed to display and the parcs even have to « predict » how much offsprings they will have. If a female is thought or identified as gravid it can be fed more than the usual to provide for her needs. Once the eggs are deposited they are retrieved to be placed in the incubators of the husbandry part. This will allow a better surveillance of the eggs as well as the hatching. Also, the terrariums might be fit for an adult species but not for the offspring in terms of biological needs but also safety. Smaller snakes could crawl through places and adults couldn't go through and escape. Also young snakes will need smaller places to hide and as mentioned before : too large places might lead to stress. Having the eggs in the incubators makes it really easy to see when the snake hatches and the birth certificate can be made. It contains informations such as the species's common and latin name, number of offsprings, date of birth, gender and parents if possible. The snakes are already venomous at birth so once again the same precautions apply. Considering their size, a chip cannot be placed directly as it is too big compared to the current size of the animal. It will have to be done much later, usually in the last third of the body on the left, note also that also the chip readers are elongated when working with these species. It is nowadays common to then have exchanges of individuals between parcs. The shipping methods of reptiles in general are quite different than other taxa. Venomous snakes are usually placed in fabric bags whose opening will be twisted to then be sealed with two cable clamps. This bag is then placed in a transport crate, usually polystyrene because in case of accident it can deform and absorb shocks rather than breaking like wood would do. The usual signaletics of live, dangerous and venomous animal signaletics are then placed on the box as well as destination and coordinates of the owner. Concerning transport itself, the vehicle has to be authorized and even modified accordingly. Their needs to be a top and bottom aeration and air propeller, complete heating as well as being able to have



temperature probes for each transport crate. On the arrival side, the bag is never touched directly with bare hands, always with clamps. To open it, the opening of the bag is placed on the direction the keeper is facing. A hook is then placed on the bag, before the cable clamps and the keeper will stand on the metal pole of the hook. This position will create a kind of third seal to the bag. This way, the cable clamps can be cut, the keeper stands back, retrieves the hook and grabs the bag with a clamp then let the snake out on the ground. The typical handling methods are then used to put it in the terrarium. A snake arriving will, as already explained, end up in quarantine before being finally exposed to the public, hoping it will fulfill his purpose towards visitors after so many trials.

## **Conclusion**

Keeping animals in captivity is an enduring every day challenge taken to a whole new level when talking about species like venomous snakes. Almost every single little task requires on a daily basis focus and attention necessary for the welfare of the animals and the safety of the workers. This safety is guaranteed through very specific material and handling techniques needing skill, practice and correct teaching. Even though it can sound like a lot of constraints, it brings a stimulating turn to the tasks of an animal care taker as well as diversity to the public. Venomous snakes are still under-represented in zoological structures while they are from the species desperately needing visibility to be correctly understood and protected. People and structures still hang on to these practices and keep pushing the knowledge we already have as there is room for improvement. Bigger collection of animals can be expected but also better communication or even pedagogic animations displaying their strengths, beauty and abilities. The path might still be long, but the management of venomous snakes in captivity still has great days ahead of it with the protection of these misunderstood creatures driving it.

## **Bibliography**

A.L. Benedict (1917) « Ophiophobia »

Annexes I, II and III of the CITES valid from the 22 June 2022

« Arrêté du 25 mars 2004 fixant les règles générales de fonctionnement et les caractéristiques générales des installations zoologiques à caractère fixe et permanent, présentant au public des spécimens vivants de la faune locale ou étrangère. » French text of law (decree of the 25 march 2004 fixing the general rules of functioning and the general characteristics of fix and permanent zoological structures presenting to the public live specimens of local or foreign fauna).

G.K. Noble, A. Schmidt (1937) « The structure and function of the facial and labial pit of snakes »

Gordon M. Burghardt, James B. Murphy, David Chiszar, Michael Hutchins (2011) « snakes ecology and conservation » chapter « combating ophiophobia »

IUCN red list

Jean Philippe Chippaux (2002) « Venins de serpents et envenimations »

J.M. Leston (2009) « functional anatomy of trigeminal nerve »

M. Goyffon et J. Heurtault (1995) « La fonction venimeuse »

Peter Uetz, Jiri Hosek, Paul Freed, Rocio Aguilar « Reptile database », <http://www.reptile-database.org> accessed october 2022

<http://www.reptile-database.org/db-info/introduction.html>

<http://www.reptile-database.org/db-info/snakes.html>

Philippe Gérard et al. (2009) « Atlas de la terrariophilie volume 1 : les serpents »

Scott A. Weinstein, David A. Warrel, Julian White, Daniel E. Keyler (2011) « venomous bites from non-venomous snakes »

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